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StandardGuide for Making Sustainability-Related Chemical Selection Decisions in the Life-Cycle of Products[1]

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1. Scope

1.1 This guide outlines sustainability factors for product manufacturers to consider when comparing alternative chemicals or ingredients across the life cycle of a product. Such an analysis could be used in product development, answering customer inquiries, or replying to regulatory requests, among others.

1.2 This guide integrates many of the principles of green chemistry and green engineering in evaluating the factors across the social (including human health), economic, and ecological attributes in the use of a particular material and potential alternatives in a particular product.

1.3 This guide provides an outline for the contents of a report of the results of the analysis, including an executive summary, detailed report, and retrospective.

1.4 This guide does not provide guidance on how to perform chemical risk assessment, alternatives assessment, life-cycle assessment, or economic analysis, or how the alternatives decision-making framework will be completed.

1.5 This guide does not suggest in what order the social, ecological, or economic attributes of sustainability should be evaluated or which one is most important. This is a decision of the company performing the decision-making evaluation.

1.6 *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:*[2]

E2114 Terminology for Sustainability Relative to the Performance of Buildings

2.2 *NSF/ANSI Standard:*[3]

NSF/ANSI Standard 61: Drinking water system components–Health effects

2.3 *Other Standards:*

US EPA Design for the Environment (DfE) Alternatives Assessment Criteria for Hazards Evaluation[4]

Clean Production Action GreenScreen for Safer Chemicals[5]

3. Terminology

3.1 *Definitions:* For definitions related to sustainability not defined within this guide, refer to Terminology E2114.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *alternatives decision-making framework, n*—process by which the alternatives are evaluated in any product life-cycle stage/phase with the goal of creating a product with an improved or less impactful result.

3.2.2 *assessment, alternative, n*—the activity of comparing the existing material and the material identified as a possible alternate.

3.2.3 *confidential business information, n*—business details including, but not limited to financial data, business relationships, product ingredients, or manufacturing processes that are unique to and held as proprietary to an organization.

3.2.3.1 *Discussion*—Confidential business information may also be referred to as trade secret information, especially as it relates to product formulation and manufacturing processes.

3.2.4 *data gap, n*—lack of information, quantitative data, modeled data, or estimations based upon read-across evidence used to determine the relative impact measure of an ingredient, process, or product.

[1] This guide is under the jurisdiction of ASTM Committee E60 on Sustainability and is the direct responsibility of Subcommittee E60.80 on General Sustainability Standards.

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[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] Available from NSF International, P.O. Box 130140, 789 N. Dixboro Rd., Ann Arbor, MI, http://www.nsf.org.

[4] Available from US EPA, Safer Choice Program, Office of Pollution Prevention & Toxics, 1200 Pennsylvania Avenue, NW, Mail Code 7406-M, Washington, DC, http://www.epa.gov/sites/production/files/2014-01/documents/aa_criteria_v2.pdf. Safer Choice is the new name for EPA's Design for the Environment Program.

[5] GreenScreen is available from and a registered trademark of Clean Production Action, 1310 Broadway, Suite 101, Somerville, MA 02144, http://www.greenscreenchemicals.org/method/method-documents.

3.2.5 *economic assessment, n*—assessment which takes account of internal and external costs and benefits relative to the organization, generally those that can be valued in monetary terms.

3.2.5.1 *Discussion*—This could include a comparative cost study of production, material, and end-product costs of two or more ingredients, production methods, or products.

3.2.6 *exposure, n*—contact with a chemical, biological, or physical agent by an ecosystem or living organism, and the duration and level of intensity of that contact.

3.2.7 *feasibility, n*—overall ability of an alternative to be used based on human and ecological safety profiles, economics, performance, social benefits, compliance with regulatory requirements, and consumer acceptance.

3.2.8 *green chemistry and green engineering, n*—the philosophy of chemical research and design that encourages creating products and processes that minimize the use or generation, or both, of hazardous substances, hazardous process conditions, resources, energy, wastes, and water throughout the product life-cycle.

3.2.8.1 *Discussion*—Green chemistry and green engineering are often referenced separately. Refer to *Green Chemistry: Theory and Practice*[6] and "Design through the Twelve Principles of Green Engineering"[7] for a more detailed discussion of both.

3.2.9 *hazard, n*—a source of potential harm or damage to life, health, property, or environment due to exposure to a substance.

3.2.10 *impact, n*—an effect, which can be positive or negative.

3.2.10.1 *Discussion*—An impact can be across more than one aspect of sustainability. However, any specific impact should be addressed consistently within the analysis.

3.2.10.2 *impact, environmental, n*—changes on ecosystems or living organisms, other than humans, attributed to a chemical, biological, or physical interaction.

3.2.10.3 *impact, human health, n*—changes to the health or well-being of group of individuals or the entire population attributed to a chemical, biological, or physical interaction.

3.2.10.4 *impacts, social, n*—effects of an activity or hazard on the well-being of a group of individuals, families, community, or other social group.

3.2.11 *life-cycle, n*—the stages of a product or process defined as: (*1*) the raw material production or acquisition stage, (*2*) the material transport stage, (*3*) the manufacturing stage (which includes transportation to the point of sale), (*4*) the use stage, and (*5*) the end-of-life stage.

3.2.11.1 *Discussion*—The terms stage and phase are used interchangeably. Additionally, the stages/phases defined in this guide may be changed by the user for his/her needs. For example, the transport of a finished product to the point of purchase by the user may be included in the use phase, the manufacturing stage, or its own stage/phase. This is completely acceptable within the parameters outlined for the practice of life-cycle assessment (LCA), so long as they are addressed consistently across the analysis being performed.

3.2.12 *manufacturing stage, n*—the segment of the life-cycle under the responsibility of the manufacturer, including activities such as formulation and production, through the transport of the final product to the point of purchase.

3.2.13 *product-chemical pair, n*—specific chemical ingredient or material that is being evaluated in a specific product and use application.

3.2.14 *read-across evidence, n*—data that is inferred from a chemical that is similar in structure to the chemical being considered that can be used to fill data gaps.

3.2.15 *risk, n*—the probability or chance of harmful effects to human or ecological health resulting from exposure to a stressor including any physical, chemical, or biological entity that can induce an adverse response.

3.2.15.1 *Discussion*—Risk is a function of hazard and exposure and therefore actions that impact either will impact risk.

3.2.16 *risk, residual, n*—potential danger that is theoretically possible after taking safety measures or precautions, or both, to minimize exposure to a stressor, such as a chemical, biological, or other agent.

3.2.17 *sensitive subpopulation, n*—a group of individuals, such as the elderly, children, or pregnant women, who are more likely to endure negative physiological impacts from exposure to a hazard than the average individual.

3.2.18 *stressor, n*—a chemical, physical or biological agent that causes stress to an organism.

3.2.19 *sustainability attributes, n*—characteristics and their related effects that identify economic, social, health, and ecologic factors for consideration at each phase/stage of the life-cycle.

3.2.20 *use phase, n*—the use phase is the period in the product's life-cycle from when it is received by the final end user and placed into service until it reaches end of useful life.

4. Significance and Use

4.1 This guide outlines sustainability factors for manufacturers to consider when comparing alternative chemicals or ingredients across the life cycle of a product.

4.2 Methods exist for the evaluation of chemical hazards for product-chemical pairs. These methods are referenced in several regulatory, non-regulatory, and green building schemas and should be conducted as part of an analysis of this type.

NOTE 1—Evaluation methods include, but are not limited to, Clean Production Action's GreenScreen for Safer Chemicals,[5] The United States Environmental Protection Agency's Design for the Environment (DtE) Alternatives Assessment Criteria for Hazards Evaluation (Safer Choice) methodology and the National Academy of Sciences' *A Framework to Guide Selection of Chemical Alternatives.*[8] Regulatory schemas include

[6] Anastas, P. and Warner, J., *Green Chemistry: Theory and Practice,* Oxford University Press, 1998.

[7] Anastas, P.T., and Zimmerman, J.B., "Design through the Twelve Principles of Green Engineering," *Env. Sci. and Tech.*, 37, 5, 94A-101A, 2003.

[8] *A Framework to Guide Selection of Chemical Alternatives*, The National Academies Press, Washington DC, 2014.

laws such as the *Safer Consumer Products Rule*[9] in California or the *Registration, Evaluation, and Authorization of Chemicals* (REACh)[10] regulations in Europe. Green building schemas include the *Leadership in Energy and Environmental Design (LEED)*[11] system by the USGBC, which references these indirectly through third-party certifications. However, neither these assessment tools nor the various schemas that reference them have set guidance for using the data in making decisions on which products and ingredients are ultimately the most sustainable.

4.3 Similarly, many tools exist for measuring economic viability, such as value-models and cost analysis. There are also many tools and techniques for measuring social acceptance of products such as sales trends, voice of the customer and many other types of surveys.

4.4 This guide acknowledges the need for determining a baseline for comparing the performance (environmental, economic, and social) of an existing product-chemical pair in a product with the possible/potential alternatives. As such, when using this guide, companies shall use the same study boundaries for the original baseline case and for all alternative options under assessment. Further, when feasible, the same assessment tools should also be used for all options being analyzed.

4.5 Sustainability is a very holistic and encompassing concept. As such, many factors cross all three attributes of sustainability. While factors may be assigned one way in this guide, it is recognized the user has discretion to assign them to whatever attribute(s) they deem appropriate when performing this analysis. However, the user should consistently categorize among all analyses for the purpose of easy comparison.

5. Social Considerations

5.1 *General:*

5.1.1 This section provides guidance on choosing the social sustainability factors that may be used as input into the alternatives decision making.

5.1.1.1 The alternatives assessment should be used as input into a risk assessment or risk assessments to determine the most relevant of human health impacts for employees, users, and other pertinent individuals. An example of such a risk assessment is NSF/ANSI Standard 61: Drinking Water System Components–Health Effects for potable water systems and applications, though many other assessment methods exist for other industries.

5.1.1.2 Risk should be considered at each of the stages of the life-cycle as factors such as exposure and hazard may differ in each phase.

5.1.2 Social considerations include applicable regulations related to labor, worker health and safety, and other related factors.

5.1.3 A list of social considerations of the alternatives should be created for each life-cycle stage taking into consideration stakeholders, corporate culture, and social norms of the market.

NOTE 2—The list of social sustainability factors will differ from one company to another as corporate culture/values are never identical. A company participating in a specific market space can define for itself what social considerations matter but in some manner internal and external health impacts must be considered.

5.1.4 Social sustainability factors of importance will differ from product to product and in various stages of the product life-cycle.

5.1.5 Identification of some of the social sustainability factors that are of importance may be accomplished via one of many methods, such as through external stakeholder feedback including the community, voice of the customer, or many sales/marketing tools discussed in marketing texts. Those undertaking this analysis should obtain feedback from external stakeholders at each stage of the life-cycle as input to the assessment.

5.1.6 While there are many sustainability issues to consider, one that can significantly impact social factors is raw material availability. Sustainability inherently requires the considerations of ensuring that raw material availability for the needs of future generations is met.

5.2 *Considerations of Social Sustainable Factors at the Raw Material Acquisition Stage:*

5.2.1 While social considerations impact many groups of individuals, at this phase they will revolve disproportionately around the worker. Such sustainability factors may include wages, safety and health of workers, child-labor, slave labor, worker benefits, labor practices, the politics of domestic versus foreign sourcing, and other labor-centric issues.

5.2.1.1 Worker health and safety should include items such as access to personal protective equipment, availability of emergency care, as well as safe management of materials as dictated by risk of exposure and potential impacts.

5.2.2 Socio-political conditions in which raw materials are most commonly acquired, including extraction, mining, or harvest, may be an additional consideration. Areas with issues such as human rights concerns, oppressive regimes, and known areas of terrorist activity should be considerations in determining a material's viability to any corporation.

5.3 *Social Considerations at the Material Transport Stage:*

5.3.1 Safe management of raw materials and wastes should be a consideration in the evaluation at the transport stage of a raw material to protect workers and the general public. Raw materials posing health (that is, toxicity) or physical (for example, flammability or corrosiveness) risks should be evaluated in the assessment.

5.3.2 Additional considerations may involve transport method(s). For example, access to markets, transport connectivity, safety of method and other factors are important considerations as an organization considers how to transport raw materials to production facilities.

[9] *California Assembly Bill 1879 – The Safer Consumer Product Act,* http://www.leginfo.ca.gov/pub/07-08/bill/asm/ab_1851-1900/ab_1879_bill_20080911_enrolled.html.

[10] *Registration, Evaluation and Authorization of Chemicals (REACh)*, The European Chemicals Agency, http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02006R1907-20140822.

[11] Version 4 available from United States Green Building Council (USGBC), http://www.usgbc.org/leed#v4.