



environmental packaging guideline

For the Electronics Industry

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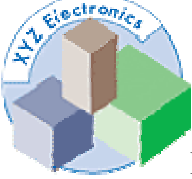
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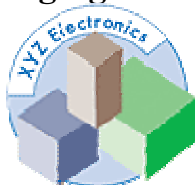
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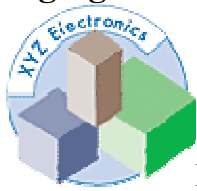
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Ch 1: Introduction

Many factors contribute to the design of electronics packaging, from cost, to marketing, to theft-prevention. One aspect which is sometimes neglected is the impact of packaging on the environment. Government regulations, corporate goals, and consumer preference are making it more and more important to evaluate the environmental qualities of packaging designs. However, environmental impact is a broad and complicated topic which can be confusing to navigate. This environmental packaging guideline is intended to help packaging professionals in the electronics industry understand the environmental impacts of their packaging decisions. It will enable them to make practical choices that improve the environmental performance of packaging designs and processes while meeting all other business requirements.

This guideline replaces the 1992 *R3P2 Handbook for Environmentally Responsible Packaging in the Electronics Industry*. Its updates reflect changes in regulations and practices in the packaging industry over the past 15 years along with new suggestions arising from the latest understanding of environmental issues. It was written by four graduate students at the University of California at Santa Barbara with guidance from packaging professionals at Hewlett-Packard, IBM and AMD.

The Current State of Electronics Packaging

In the past few decades, great strides have been made to reduce environmental impact in the packaging field. Many toxic materials have been phased out, major ozone-depleting chemicals are no longer used, and concepts like Design for Environment (DfE) are becoming more common. However, there is still much that can be improved. The packaging professional is in a unique position to create positive change while maintaining the important services that well-designed packaging provides. Through expert knowledge and creative thinking, the packaging professional can dramatically reduce the environmental impact of product packaging.

The push for more efficient packaging stems from increases in government regulation, consumer demand, and environmental awareness, along with a growing sense of responsibility on the part of today's electronics industry. New technologies have evolved to help meet this demand in the form of new materials, improvements in old materials, more sophisticated recycling of waste, and increased use of recycled materials in new products. In addition, techniques to assess the environmental impact of different options (such as Life Cycle Assessment) have advanced significantly since their popular emergence in the 1990s. They have also given rise to sophisticated pieces of software such as TEAM, Sima Pro, and GaBi (see chapter 10, page 91) that draw on huge stores of data to give high-quality answers to complicated questions. The role of the packaging professional is to use these new technologies and tools as part of intelligent and creative designs.

Why Use This Guideline?

Environmental issues are often complex and require some specialized knowledge to address properly. Approaches that focus on a single issue, such as recycling or toxicity, can give incomplete and even misleading direction. This guideline prepares the packaging professional for the task of reducing the total environmental impact of the packages they design and manage. Reducing environmental impact provides several benefits:

- It decreases the company's responsibility for negative impacts on the environment and society.
- It often provides financial benefits through reduced material costs, shipping costs, and environmental risk.
- It helps create a positive image in the eyes of consumers toward the company and is an integral part of corporate social responsibility.

It demonstrates industry action on environmental issues and can help avoid or shape future regulations. This guideline is also the basis for the Environmental Packaging Certification available through the Institute of Packaging Professionals (IoPP). It provides the information needed to participate in the online training and take the certification exam.

How to Use This Guideline

This document is meant to function as a textbook as well as a reference guide. Each topic builds on previous topics to educate the packaging professional about how environmental impacts occur and how to reduce them. To supplement the main text, a Packaging Scenario runs throughout the guideline, illustrating concepts and giving a concrete demonstration of the packaging design process. It presents a fictitious but realistic scenario of a packaging engineer charged with reducing the environmental impact of a package while meeting other business goals. If the guideline is being used as a textbook, it is recommended that the chapters be read in sequence. However, the guideline is also designed for quick reference for daily use. It includes a thorough index and glossary, and most sections are self-contained or cross-referenced.

Guide to Contents

The chapters of this guideline are designed to provide the reader with the tools necessary to solve environmental packaging challenges.

Chapter 1 is this Introduction.

Packaging Scenario: Introduction lays out the fictitious situation of Randy at XYZ Electronics. This scenario will appear throughout the guideline to illustrate the decision-making process used to reduce the environmental impact of packaging.

Chapter 1: Introduction

Chapter 2 presents a procedure for incorporating environmental considerations into packaging designs.

Chapter 3 discusses types of environmental impact and general strategies for reducing each type of impact.

Packaging Scenario: Options applies impact reduction strategies to the scenario and creates three package designs that Randy will evaluate for his task.

Chapters 4 through 9 present an in-depth discussion of each of the most common materials used in packaging (corrugated fiberboard, paperboard, wood, solid plastic, expanded plastic, and inks) including detailed information on the environmental impacts of each material and specific impact-reducing strategies for that material.

Packaging Scenario: Paperboard considers the environmental impacts of paperboard options in the Packaging Scenario.

Packaging Scenario: Plastics considers the environmental impacts of plastics options in the Packaging Scenario

Chapter 10 discusses how to balance different environmental issues and how these issues interact with other packaging issues.

Packaging Scenario: Conclusion takes the evaluations of impact from the earlier sections and compares them with each other as well as other packaging considerations, ending with a final decision.

Chapter 11 covers how to properly label and describe a package's environmental features.

Chapter 12 concludes with information on how to stay up-to-date on regulations, new materials, and recycling infrastructure.

Finally, a number of appendices are included to provide more detailed information about other topics related to the environment and packaging.

Appendix A: Glossary and Acronym Guide provides definitions for many terms and acronyms found in this guideline.

Appendix B: Material Guides goes into greater detail about the manufacturing process and other background knowledge for fiber-based products and plastics used in packaging.

Appendix C: Recycling Infrastructure gives information on how to discover the existing recycling infrastructure for different shipping regions.

Appendix D: EPEAT reprints the description of the Electronic Product Environmental Assessment Tool, which assists consumers in selecting environmentally preferable electronics. It contains a section on packaging of electronics.

Appendix E: Existing Standards and Guidelines covers the many standards and guidelines that relate to packaging (environmental and otherwise).

Appendix F: Standardized Symbols shows the symbols used around the world to describe packaging and environmental performance.

Appendix G: Planning Template provides an easy checklist to aid in following the packaging procedure described in Chapter 2. It is designed to make sure the right questions are asked in the right order to save the packaging professional time.

Packaging Scenario: Introduction



Randy at XYZ Electronics – Introduction

XYZ Electronics (XYZ) designs and sells computer and electronics products to corporate and consumer markets. XYZ currently sells a printer cartridge for use in its laser jet printers. The cartridge is manufactured by a third party and is shipped in bulk to XYZ distribution centers around the world. Once at a distribution facility, each cartridge is packaged individually and sent to retail and wholesale customers.

The Situation

Randy, a packaging engineer at XYZ, has been tasked by his manager to redesign the consumer packaging used for XYZ's printer cartridge in North America. Currently, a PVC clamshell design is used to package the printer cartridge. The current package has performed relatively well, however a number of significant problems have been brought to the company's attention. These include:

- The environmental impact of PVC clamshell packaging
- Customer dissatisfaction with XYZ's use of "excessive" packaging
- Customer difficulty opening the clamshell packaging
- Safety hazards associated with the jagged edges of the clamshell material – customers have reported cutting themselves when trying to open the package.

Randy's Goals

Randy's task is to redesign the package, addressing the issues listed above. His goals for this project are to:

- Design a package that is easier and safer to handle and open.
- Reduce the environmental impact of the package by:
 - Using less material per package
 - Using material with a lower environmental impact
- Reduce the cost of the package

In addition, Randy must meet all the business requirements and constraints associated with the printer cartridge. These include:

- Protection from compression and vibration for shipment by truck
- Ease of handling in warehouse and during transportation

- Ability to be shipped individually or on a pallet in high density
- Ability to display marketing information on the package
- Inclusion of all relevant packaging labels (recycled content, etc.)
- Compliance with regulations in North America
- Support of XYZ’s Corporate Environmental Policy:
“XYZ Electronics seeks to be a good neighbor to the environment and the communities in which we operate by conserving energy, providing for responsible end-of-life handling of our products, and providing transparent reporting of our environmental impacts.”

How will Randy achieve these goals?

Randy must follow a specific set of steps in order to design a package that is cost effective, easy-to-use, and has a reduced impact on the environment. The following section, “Environmental Packaging Procedure,” provides a step-by-step procedure designed to help accomplish all of these goals. In addition, the remainder of this guideline discusses in detail how Randy and other packaging professionals can achieve environmental improvement in packaging designs while also meeting other packaging requirements.

Throughout this guideline you’ll find this icon [insert Scenario icon here], which denotes information related to Randy’s package redesign task. In subsequent chapters, you will learn about Randy’s options and decisions as he attempts to improve upon the product’s current packaging while reducing the environmental impact of the design.

Ch 2: Environmental Packaging Procedure

This Chapter Covers:

- A step-by-step procedure to help packaging professionals incorporate environmental considerations into package design.

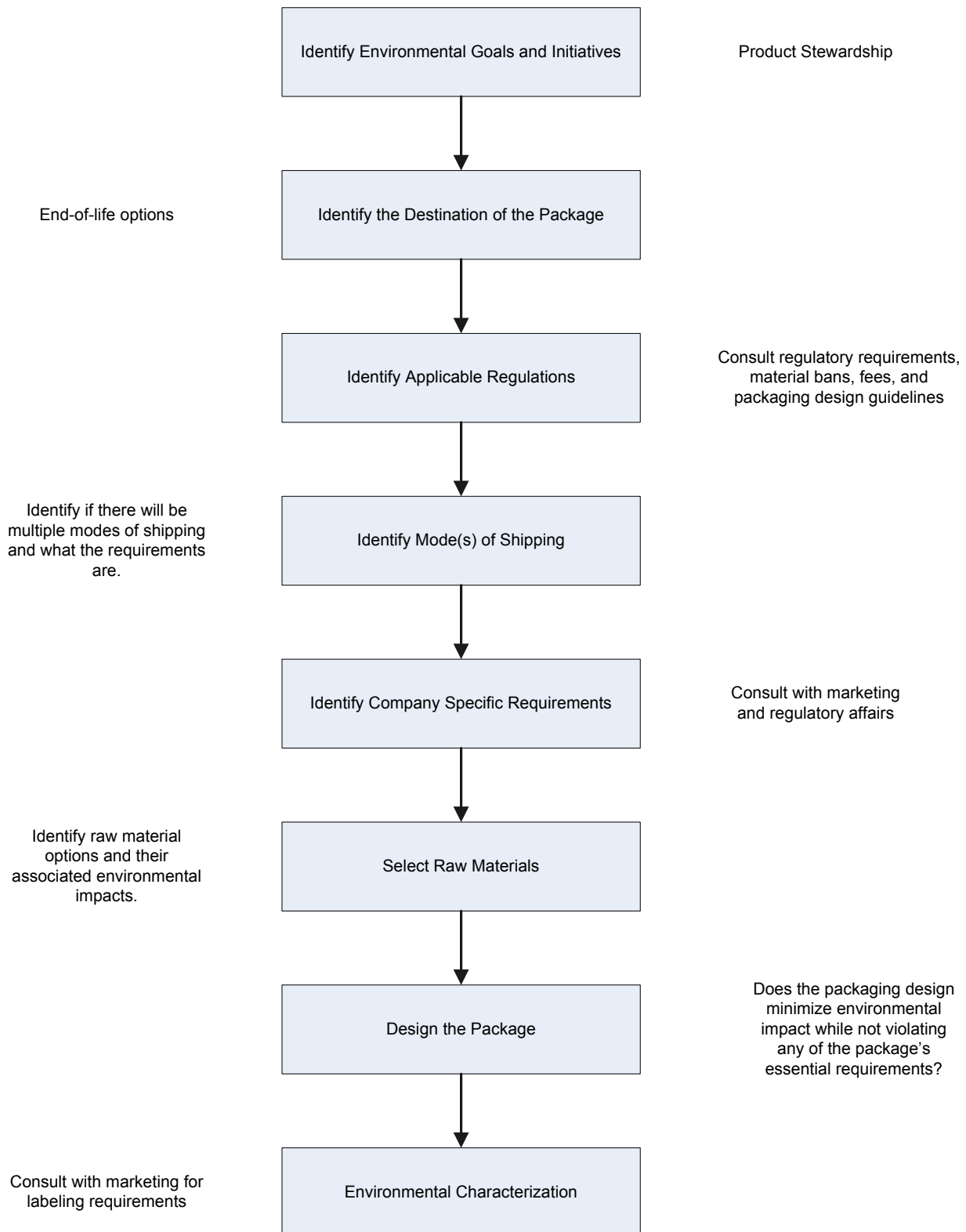
The purpose of this chapter is to guide the reader through the process of designing environmentally responsible packaging. The following methodology may be used to establish an internal, corporate environmental policy or for specific packaging design projects. However, the methodology is not meant to be followed exactly; rather its purpose is to highlight different elements that should be considered each step of the way. Appendix G (pg 172) provides a worksheet to assist the packaging professional through the design procedure.

Environmental Packaging Procedure

A packaging professional has the ability to significantly influence the scale of environmental impacts associated with their product packaging. The decisions made at each step of the packaging design process should be considered on three levels: theoretical, technological, and practical. For example, a package may be theoretically recyclable but might not actually be recycled at the end of its life if the technology is not present, the infrastructure is not present, or it would not be economical to use the technology. Due to the complexity of environmental impacts, environmental design evaluations are often subjective; there are normally not “right” or “wrong” answers when choosing between environmental impacts (see Chapter 10, pg 90, for more information on balancing issues).¹ Answers will depend on factors such as business requirements, corporate environmental goals, and customer awareness of environmental issues. To be complete, the environmental packaging procedure should take into account the package’s total life cycle, including manufacturing, distribution, marketing, consumer use, and disposal.

Note: Although a package’s environmental impact is a significant concern in the package design process, the integrity of the package (and the product it contains) must take precedent over any actual or possible environmental impact. In addition, each aspect of the package design must be evaluated for economic viability. An ambitious program to design environmentally preferred packaging will not be beneficial to the company if it fails due to a loss of protective capabilities or greatly increased cost.

Environmental Packaging Design Flowchart



Step 1: Identify Environmental Goals and Initiatives

The first step in designing environmentally-responsible packaging is to identify applicable company goals and initiatives. The following questions should be considered at this step:

- What is the company's environmental policy? What environmental impacts are of greatest concern to the company?
- How does the company intend to responsibly manage the environmental impacts of a package during use and end-of-life?

Recently, much of the electronics industry has become concerned with the idea of "product stewardship." "Product stewardship means that whoever designs, makes, sells or uses a product takes responsibility for minimizing its environmental impact. This responsibility spans the product's life cycle – from selection of raw materials to design and production processes to its use and disposal."² Additionally, product stewardship should be applied to imported, subcontracted, and original equipment manufacture (OEM) packaging.³ This concept is becoming the foundation for legislative action in the realm of Extended Producer Responsibility.⁴

The following are examples of initiatives that support product stewardship programs (please visit Environmental Packaging International at <http://www.enviro-pac.com/links.htm> for more detailed information on product stewardship requirements):

Design for the Environment (DfE)

Design for the environment is a commitment to reduce a package's environmental impact through inclusion of environmental considerations in the design phase of packaging and product development.

Take-Back and Recycling Programs

Suppliers that have committed to product stewardship often offer Take-Back and/or recycling programs that ensure products are recycled or disposed of in an environmentally responsible manner.

Restrictions on Hazardous Substances (ROHS) Compliance

Companies that ship to Europe or wish to improve their product stewardship should comply with the European Union Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment ("RoHS") Directive, which will take effect on July 1, 2006. The RoHS directive prohibits the sale of electronic equipment containing certain hazardous substances such as lead, cadmium, mercury, hexavalent chromium, polybrominated biphenyls ("PBB") and polybrominated diphenylethers ("PBDE"), in the European Union. Other countries are considering similar legislation.

Supplier Responsibility

A company that has taken stewardship for its product should try to limit its suppliers to those with similar stewardship programs.

EPA's Product Stewardship/Extended Product Responsibility (EPR)

The US EPA has a voluntary program to support product stewardship. Consult the EPA website for information on their Product Stewardship/EPR programs:

<http://www.epa.gov/epaoswer/non-hw/reduce/epr/index.htm>

Step 2: Identify the Destination of the Package

The second step in designing environmentally-responsible packaging is to determine where the package is going. The following questions should be answered at this step:

- What are the end-of-life options (recycling, landfill, incineration) at the destination?
- What are the shipping and storage conditions in the region?
- Are certain materials going to be charged a fee or tax for their environmental impact at the destination?

The regional destination of the package will determine the available infrastructure for end-of-life choices (i.e., recycling). To minimize or eliminate costs faced by the end user (or the company, in the case of take-back programs), end-of-life management should be considered early in the design phase.

The following are considerations to be made when designing for end-of-life:

- **Cradle-to-cradle design**
Design packaging that will be reused or recycled so that the materials will remain in the supply stream instead of ending up in a landfill.
- **Multiple end-of-life options**
Design packaging which gives the end recipient several options, such as reuse and recycling, not simply disposal.
- **Package that can easily be broken down into recyclable components⁵**
When a package contains multiple materials, design it so that it may be easily broken down into component parts for recycling. This is especially important when using a non-recyclable component is unavoidable.
- **Recycling Standards and Capabilities**
When designing recyclable packaging, keep in mind the recycling infrastructure at the package's destination.
- **Reuse**
Design packages for ease of reuse, either by the end user or by the supplier through a take back program.
- **Take-back programs**
Advocate take-back programs when the infrastructure for recycling is not readily available to the end user.

Step 3: Identify Applicable Regulations

The third step in designing environmentally-responsible packaging is to identify applicable regulations. The following questions should be answered at this step:

- What are the environmental regulatory requirements?
- Are regulatory requirements consistent for all destinations?
- If not, can the package be tailored to each destination, or should it be designed to meet regulations in all destinations?

Regulation supersedes all considerations in packaging design and should be considered early in the process.

Regulations will vary from region to region, and it is usually the packaging professional's job to ensure that material choices, design, and other aspects of the package do not violate local regulations at the package's destination. Most regulations will pertain to aspects of material recovery, source reduction, reuse, and labeling. Finally, fees associated with applicable regulations should be considered in evaluating the cost of the package. Consult Chapter 12: Staying Current (pg 109), for more detailed information on staying up-to-date with regulations and fees.

Step 4: Identify Mode(s) of Shipping

The fourth step in designing environmentally-responsible packaging is to determine how a package will be shipped. The following questions should be answered at this step:

- What modes will the package travel through?
- What are the available shipping methods that meet the business requirements (time demands, cost, value of product, etc.)?
- How will the shipping method affect the environmental impact?
- How is the shipping cost determined (by truckload, actual weight, dimensional weight, full trailer load, etc.)?
- How will the shipping method affect the packaging required? Can altering the shipping method reduce the packaging requirement?
- Will there be challenges within the shipping environment such as moisture, high temperatures, lack of automated equipment for proper transport, etc.?

Environmental Packaging programs are generally not subject to environmental regulation however, the products they produce are.

In general, the most energy efficient mode of shipping is preferable. However, the mode of shipping is often determined by business requirements (e.g., balancing cost challenges, reduced inventory/increased turnover, flexibility/customized features/delivery, suppliers/customers locations, etc). Additionally, competition in the electronics industry often influences shipping mode selection in the direction of more time-efficient choices, such as air. However, in areas that are connected by land transport by rail or truck may be sufficiently quick, and these methods are more energy-efficient than air. Finally, for packages that can withstand long time delays, transport via ship or barge is the most energy-efficient option. It is important for the packaging professional to design packages that will be consistent with the mode of shipping selected and, when possible, to choose the most energy efficient shipping option.

The U.S. Department of Energy offers several models to aid in shipping mode selection. Models can be found for tasks such as evaluating large shipping campaigns, optimizing shipping cost or timing options, and evaluating shipping options when shipping to two or more locations. You can learn more about these models at the Department of Energy web site:

<http://www.ntp.doe.gov/index.html>.

Step 5: Identify Company Specific Requirements

The fifth step in designing environmentally-responsible packaging is to identify internal requirements; marketing, regulatory affairs, and/or other applicable departments should be consulted to help answer the following questions.⁶

- **Protection:** What is required to protect the packaged product from physical, biological, and chemical harm? The design process should take into account the integrity, quality, and safety of the package throughout its life cycle. For example, the mode of shipping used to transport the package should be considered when determining the structural characteristics of the package. Additionally, the package should be designed to hinder tampering and pilferage. The environmentally-responsible packaging professional will design packaging that meets these goals while minimizing the environmental impact associated with the package. For example, optimizing a package's protective qualities so that a minimum amount of material is needed is a benefit to the environment as well as a cost savings.
- **Economics:** Is the environmentally-responsible packaging program economically viable? The costs and benefits of the environmentally-responsible packaging program should be quantified and compared with traditional packaging before the program is implemented. This will also provide an opportunity to reformat the program to optimize benefits based on recognized factors for cost savings found in the analysis. For example, damage reduction, reduced labor costs, reduced warehousing/storage costs, extended package life cycle, and other economic benefits may be pursued and accounted for.

Chapter 2: Environmental Packaging Procedure

- **Performance:** Is the environmentally-responsible packaging design compatible with other relevant processes? Failure to account for all processes relevant to the package will hinder its effectiveness. For example, the package should fit well on existing or new machinery lines. The package should be designed for efficient performance throughout its life cycle.
- **Marketing:** Does the package enhance the product's image and acceptability? The environmentally-responsible packaging design can add physical attractiveness to the product to support product differentiation and marketing techniques. Is there an opportunity for these characteristics to be part of a broader green-marketing effort?
- **Environmental Impact:** Does the packaging program meet current regulations for environmental impacts? Does it go beyond compliance? The program should use source reduction, recycling, and reuse throughout the package's life cycle to reduce environmental impacts such as consumption of energy and natural resources and pollution of air, land, and water.
- **Consumer Information:** Does the environmentally-responsible packaging program provide adequate and accurate environmental labels and declarations regarding the environmental impact of the package? All labels and declarations should meet the ISO standards and company specific regulations discussed in more detail in Chapter 11: Labels and Declarations (pg 100).

The following are examples of more specific questions that should be answered regarding internal packaging requirements.

- Are there any easy opportunities for making the product more robust, rather than requiring extensive packaging?
- What are the product's shock requirements?
- What are the product's vibration resistance requirements?
- What protection does it need from the elements?
- What are the handling requirements?
- How high are your pallets and are they going to be double/triple stacked?

Step 6: Select Raw Materials

The sixth step in designing environmentally-responsible packaging is raw material selection. There are many tradeoffs when choosing between raw materials (refer to chapters 3 through 9 for information on materials and their associated environmental impacts; chapter 10 includes information on how to make this decision). Choices should be made with the complete life cycle of the package in mind. For example, materials should not be chosen that may hinder the package later in the distribution system.⁷

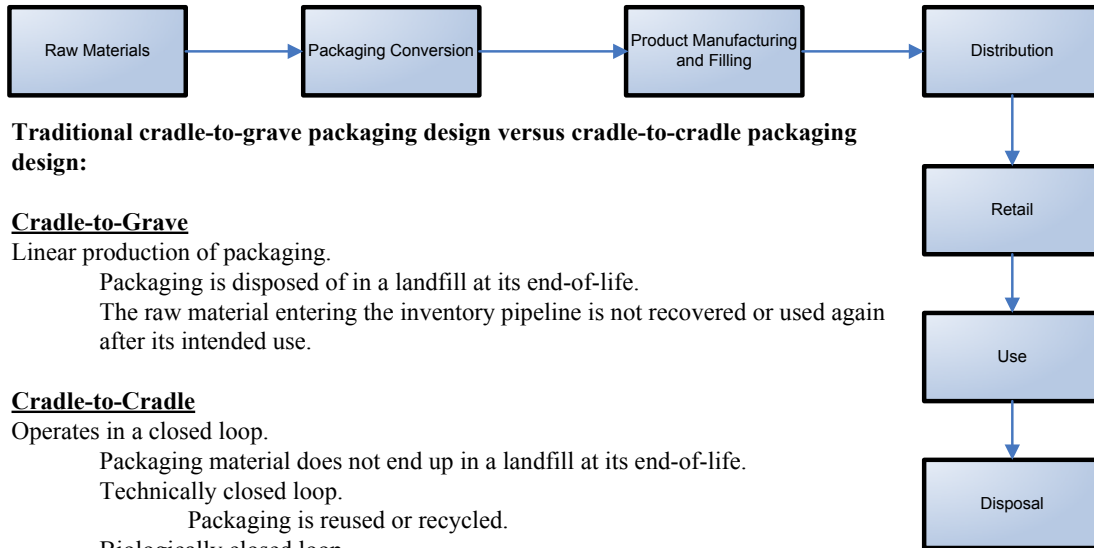
The following questions should be answered at this step:

- Have material options been clearly identified? Are there new materials or improvements on old materials that should be considered?
- Are the materials being considered renewable? If not, are there renewable alternatives that should be included in the options?
- Are the materials recycled? If not, are there recycled alternatives that should be considered?
- Can the packing materials be reduced, reused, or recycled? What are the end-of-life options for the materials?
- What are the environmental impacts of the material options?
- Do the material options meet the company-specific requirements? Do the material options meet applicable regulatory requirements?
- How will the combination of materials affect the package's end-of-life treatment?
- Are there any materials being used that may be toxic (i.e., inks and adhesives) or contain heavy metals? If so, how will they affect end-of-life treatment?

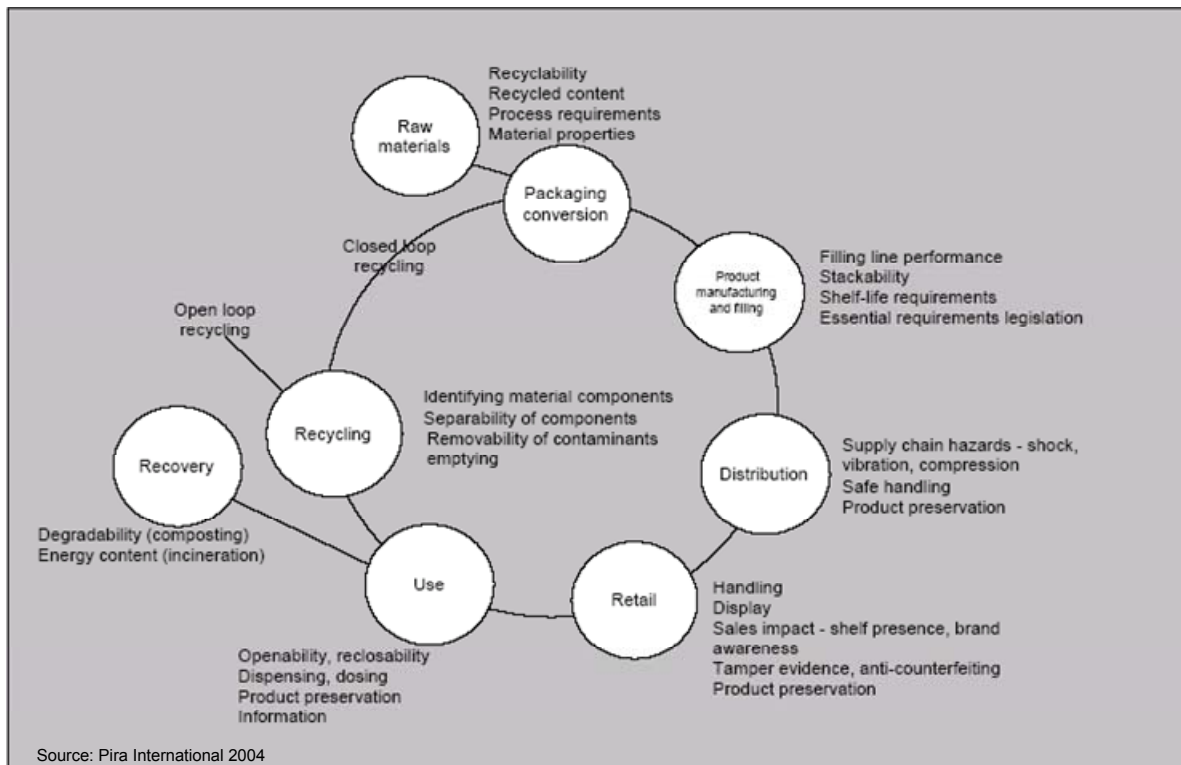
Raw material selection should be made to facilitate movement towards a cradle-to-cradle design. Traditional design, termed “cradle-to-grave,” assumes a package will end up as unwanted waste that must be dealt with at some cost to the end user, and often pits environmental concerns against profitability. However, cradle-to-cradle design allows the package to travel in a technical and/or biological closed loop, meaning materials used in the package will be reused, recycled, or will biodegrade and be returned to the environment.

Comparing Cradle-to-Grave and Cradle-to-Cradle Packaging Design

Cradle-to-Grave



Cradle-to-Cradle Design



Step 7: Design the Package

The seventh step in environmentally-responsible packaging is to design the package. By now you should be able to identify your company's goals and initiatives, the destination of the package, specific business requirements, marketing goals, applicable regulations, shipping options, and raw material options and their environmental impacts. It is at this point that the package should be refined to minimize environmental impact. For example, the following questions should be answered at this step:

- Is the package designed to use a minimum of each raw material?
- Is the product over-packaged? Is it packaged to resist situations it will never encounter?
- Is the package easy to disassemble into its recyclable component parts (i.e., does the design avoid commingling of materials?)
- What is the package's weight and dimensional weight?

Step 8: Environmental Characterization

The eighth step in designing environmentally-responsible packaging is communication of what the environmentally-responsible packaging program hopes to accomplish, what has been done, and why it is important. The following questions should be answered at this step:

- What are the environmental impact characteristics of the package that make it notable?
- How can these characteristics be accurately portrayed?
- What are the required labels for your package?
- Do the labeling and marketing needs lead to a larger package than is necessary to protect the product?
- If so, is there a creative way to reduce package size while still satisfying labeling and marketing needs?
- Are there any environmental issues relating to the package that consumers may need to be educated about?

Education is fundamental to an effective environmentally-responsible packaging program. The public may not know what the most environmentally-preferable option is, and since public awareness of environmental issues may impact their purchasing decisions, effective communication is essential. By accurately portraying efforts to reduce the environmental impact of the package design and materials being used, public awareness will improve and the product's market share may also increase.

Where applicable, comprehensive awareness programs focused on consumer and influence groups should be developed either individually, through local and industry associations, or in conjunction with packaging material suppliers, so the public may become better informed about the function of packaging and its proper disposal. It is strongly recommended that divisions and individuals participate with local, regional, national, and international organizations concerned

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with waste management in order to deal with environmental issues in the most effective manner. See Environmental Performance Characterization (pg 100) for a more detailed explanation of environmental labeling and declarations.

References

¹ “Environmental Design Guideline for IBM Packaging Engineers.” The IBM Competence Center for Packaging Engineering, 1990.

² Product Stewardship. 2001. Western Electronic Product Stewardship Initiative. 12 March 2005 <<http://www.recyclingadvocates.org/wepsi/ps.htm>>.

³ “Environmental Design Guideline for IBM Packaging Engineers.” The IBM Competence Center for Packaging Engineering, 1990.

⁴ Third-Party Take-back Organizations. 9 October 2003. Environmental Packaging International. <<http://www.enviro-pac.com/links.htm>>.

⁵ Product Stewardship. 2001. Western Electronic Product Stewardship Initiative. 12 March 2005 <<http://www.recyclingadvocates.org/wepsi/ps.htm>>.

⁶ “Environmental Design Guideline for IBM Packaging Engineers.” The IBM Competence Center for Packaging Engineering, 1990.

⁷ IBM 1990.

Ch 3: Environmental Impacts and Reduction Strategies

This Chapter covers:

- Categories of environmental impact related to electronics packaging.
- General strategies for reducing the environmental impact of packaging materials and processes.

This chapter is divided into two sections:

First, *Environmental Impact Overview* provides a general view of environmental impacts that can result from electronics packaging.

Second, *Impact Reduction Strategies* provides broad strategies for reducing this environmental impact based on the three key methods of environmental impact reduction (reduce, reuse and recycle) as well as other methods, such as use of alternative materials. This chapter is not material-specific. Subsequent chapters focus on the impact and specific impact reduction strategies for each material commonly used in electronics packaging: corrugated fiberboard, paperboard, wood, solid plastic, expanded plastic, and inks.

Environmental Impact Overview

To successfully reduce the environmental impact of a package, one must first understand how the packaging materials affect the environment.

To clearly understand these impacts, it is important to analyze them in an organized way. The categories that are commonly used to characterize the environmental impact of industrial materials and processes are natural resource use, energy use, impacts to water, impacts to air, disposal, and toxic substance release. It should be noted that this guideline does not cover all varieties of environmental impact, but it does cover the categories that are most relevant and deserve the most attention from industry.

What is an “environmental impact?”

For purposes of this chapter, an environmental impact is harm to the environment caused by the raw material extraction, production, use, or disposal of a material.

The quantitative data presented for each material, referred to as life cycle inventory (LCI) data, is provided as a means to get packaging professionals thinking about how the materials and processes they use impact the environment. Because data come from different sources, it is not appropriate to make comparisons across different material categories (e.g., comparing a plastic to corrugated fiberboard). General comparisons can be made within a product category (e.g., comparing polyethylene to polypropylene), however it is not accurate to base a material choice on LCI data alone. For example, while one material’s LCI data may appear preferable to another’s, if recycling is not possible for this material, it may not be the most environmentally preferable choice. Unfortunately, assessing and interpreting environmental impacts is a complex

task; chapter 10 “Balancing Issues,” (pg 90) covers this topic in more depth. In addition, see “Life Cycle Assessment” below for more information on methods used for decision making.

Life Cycle Assessment

Much of the information provided in the following chapters on specific materials is taken from existing life cycle assessment (LCA) studies. Since the early 1990s, methods for analyzing the environmental impact of a product have become more refined. A formal life cycle assessment attempts to qualify and quantify the environmental impacts of all stages of the life of the product. These stages commonly include sourcing of raw materials, manufacturing, transportation, use, and disposal (or recycling). The goal of most life cycle assessments is to create an inventory of the environmental impacts associated with a product and to interpret this inventory in such a way that comparisons can be made between products or designs.

The data provided in the next few chapters represent examples of life cycle inventory (LCI) data. It is important to highlight the difference between life cycle inventory data and a life cycle assessment (LCA). LCI data is simply quantitative information about the specific environmentally-related outputs of a product or process. An LCA takes LCI data, translates it into certain impact categories and interprets the results. Commonly used impact categories include acidification, human toxicity and climate change potential (among many others). These categories attempt to represent environmental factors that humans are concerned about.

Several standard methodologies for life cycle assessment exist today. One of the most widely accepted standards is ISO 14040. As part of the International Organization for Standardization (ISO)’s 14000 group of environmental management standards, ISO 14040 provides a methodology for conducting and interpreting an LCA. Learn more at the ISO’s web site: <http://www.iso.org/>

Other LCA Resources:

- Alliance for Environmental Innovation – <http://www.environmentaldefense.org/alliance/>
- Franklin Associates – <http://www.fal.com>
- Society of Environmental Toxicology and Chemistry – <http://www.setac.org>

General Example of Life Cycle Impacts

This section takes a brief, qualitative look at the environmental impacts associated with expanded polystyrene (EPS) throughout its life cycle in order to provide some context for this chapter. It is intended as an example only. In addition, the impacts described are not unique to EPS – all materials cause some level of impact to the environment. See the following chapters for more information.

EPS is derived from petroleum, a non-renewable resource. The extraction of petroleum from the ground is associated with the risk of impacts to air, water, and land from land degradation, oil spills, and release of harmful gases. Manufacturing of plastic resin from petroleum and the expansion of resin into an EPS product (cushioning for a computer monitor, for example) can result in release of harmful gases to the atmosphere. Once an EPS product is used and disposed of, impacts to the environment can vary. EPS does not readily degrade in the natural environment. Therefore, if EPS is irresponsibly disposed of as litter, it persists in the environment for a very long time and can harm wildlife and the natural environment. If EPS is disposed of in a landfill, the impact is primarily from the volume of solid waste as this material does not tend to degrade or leach harmful materials over time.

For a more thorough perspective on the environmental impacts of EPS, see Chapter 8 (pg 80).

Categories of Impact

Following is an introduction to the six main categories of environmental impacts covered in this guideline. Chapters 4 through 9 use these categories to discuss the impacts of each type of packaging material.

Impacts to Natural Resources

This category describes impacts resulting from extraction of raw materials and is largely qualitative because detailed quantitative data vary from site to site. For example, harvesting timber for paper production often has a large negative impact on the surrounding forest ecology. For plastics, as described above, extraction of crude oil, can significantly harm the surrounding natural environment. In addition, these two examples demonstrate the difference between a renewable and a non-renewable resource. Forests, if appropriately managed, can provide a sustainable supply of timber for production of forest products over the long term. Crude oil, on the other hand, is in finite supply; once the world's supply is used for human purposes, there will be none left.

Energy Use

This category seeks to quantify the energy that is expended during each stage of a material's life cycle. Energy use includes the energy expended at each stage of the life cycle. For example, energy is used to harvest and transport raw materials, to manufacture products, and to distribute the manufactured goods. Impacts from energy use depend on how energy is generated and are largely accounted for in the category "Impacts to Air." If the energy used to manufacture a product is generated from burning coal, for example (as is common in many parts of the world), then it is logical to include air emissions that result from this process as part of the environmental impact of product manufacturing. Therefore, reducing energy requirements can often lead to a reduction in the overall environmental impact of a product.

Impacts to Water

Impacts to water result mainly from production processes that involve release of waste water into a nearby lake or river. There are three types of water impact covered in this guideline:

- **Biological Oxygen Demand (BOD)** – BOD is an indicator of the concentration of organic pollutants in a sample of water. Organic pollutants are consumed by bacteria in water, a process which uses oxygen. If BOD is significantly high, these bacteria can proliferate until they use too much of the available oxygen, effectively choking other species which need oxygen in the water, such as fish. Effects of high BOD range from limiting biodiversity to total die-offs of oxygen-consuming species. This negative effect of BOD, called eutrophication, can have a serious detrimental effect on the ecology of a body of water.
- **Total Suspended Solids (TSS)** – TSS is a measure of the undissolved suspended material in wastewater. High TSS causes a reduction in water clarity, sometimes to the extent that water plants and algae do not get enough sunlight. This effect can limit biological activity in a body of water and, therefore, degrade the overall ecological health of the system. It can also reduce the water's recreational capacity.
- **Adsorbable Organic Halides (AOX)** – AOX is a measure of substances that can cause the formation of organochlorides – dioxin, furans and other chemicals that are known to be toxic to wildlife and humans. This type of impact is caused primarily during paper production and incineration of some packaging materials. Dioxin and furans tend to accumulate in the tissues of animals living in the water near pulp and paper mills. Dioxins and furans are toxic to humans.

Impacts to Air

There are a number of ways to characterize impacts associated with air emissions. Air emissions are harmful gaseous byproducts that are emitted during the life cycle of a material. The following are the categories used in this guideline:

- **Acidification** – Acidification is the release into the atmosphere of sulfur oxides (SO_x) and nitrogen Oxides (NO_x). These substances often result from the combustion of fossil fuels (especially coal) to generate energy. SO_x and NO_x are the primary causes of acid rain. When released into the atmosphere, SO_x (which converts to sulfuric acid) and NO_x (which converts to nitric acid) can be rained onto the landscape, causing damage to ecosystems and buildings.
- **Greenhouse gases** – Greenhouse gases are those gaseous compounds that, while not harmful to human health directly, are accepted as contributing to global warming and, therefore, climate change. Carbon dioxide (CO_2) is the primary greenhouse gas and, as a result, the impacts of other greenhouse gases, such as methane, are often quantified in terms of their equivalent amount of CO_2 (termed CO_2 equivalents).

Greenhouse gases result from any stage in a product's life cycle where fossil fuels are burned, such as manufacture and transportation.

- **Volatile Organic Compounds (VOCs)** – VOCs are organic compounds that evaporate readily at normal pressures and temperatures. For packaging materials, VOCs emitted during the life cycle are most often released during the manufacturing process. In addition, VOCs can be released into the environment over time from the material itself. Some VOCs are known to be toxic to humans.¹ Also, VOCs and NO_x can combine to form ground level ozone, which contributes to health problems such as asthma and is corrosive to plastics and other materials.

- **Hazardous Air Pollutants (HAPs)** – HAPs include many compounds that, when released to the environment, are harmful to human health. In the United States, the Environmental Protection Agency identifies over 150 Hazardous Air Pollutants and has rules that attempt to limit their emission. Some, but not all, VOCs are toxic to humans and considered HAPs. The main concerns of the EPA are the harmful health effects that can result from HAPs, which include poisoning, increased risk of cancer, and damage to immune and reproductive systems. Release of hazardous air pollutants can occur at any stage of the life cycle; however manufacturing processes are the most common cause.²

To learn more about hazardous air pollutants, visit the United States Environmental Protection Agency at:
<http://www.epa.gov/ttn/atw/allabout.html>

- **Ozone Depleting Substances (ODSs)** – Ozone depleting substances are chemicals that react in the upper atmosphere and break down the ozone layer. The ozone layer blocks harmful ultraviolet rays from the sun from penetrating to the earth's surface. Ultraviolet rays can cause skin cancer and other diseases in humans. Chlorofluorocarbons (CFCs) and a variety of other man-made industrial compounds are known ODSs.

To combat the depletion of the ozone layer by these compounds, the Montreal Protocol, an international treaty signed in 1987, called for a phaseout of CFCs and related compounds. While the most potent ODSs have been phased out in developed countries, some chemicals still in use have lesser impacts on the ozone layer.

Learn more at the United Nations Development Programme Unit on the Montreal Protocol:
<http://www.undp.org/seed/eap/montreal/>

Disposal

Ideally, packaging products are reused or recycled once they have performed their primary function. If reuse or recycling is not possible, disposal is commonly handled in one of two ways: landfilling or incineration.

- **Landfilling** – Packaging tends to take up a very large portion of landfill space – in some places more than one-third of landfill space is filled by packaging.³ Landfills consume open land space and new landfills are often difficult to site due to resistance

from local populations. The main impacts of landfilled packaging materials are the volume of space required and the greenhouse gases that may result from limited biodegradation of organic materials into methane and CO₂. However, research shows that little of the material placed in landfills actually biodegrades.⁴ In addition, some packaging materials may contribute to leachate that seeps from landfills into groundwater. Leachate is defined as the accumulation and leaking of liquids and other substances (possibly contaminated or toxic) through the ground. This can be very harmful to the environment and human health, especially if the leachate contaminates groundwater used as a source of freshwater by the surrounding public.

- **Incineration** – Incineration, the controlled burning of waste, drastically reduces the volume of material going into landfills. In addition, solid waste incineration is often used to generate electricity, a process commonly referred to as energy recovery. However, the resulting ash must still be landfilled. In addition, depending on the material incinerated, greenhouse and toxic gases can be released into the air during this process. Therefore, while landfill volume is reduced, the impact may be significantly transferred to air emissions.

Toxic Substance Release

Many of the materials and production processes associated with electronics packaging result in the release of toxic substances into the environment. For the most part, exposure to toxic materials is not a concern during the use of packaging. However, there are concerns over toxins being released into the air and waterways during the production and disposal of some materials. Following are three groups of toxic substances that are relevant to this discussion. The first two are also associated with other impact categories, but their toxicity merits that they be discussed in more direct terms. The following chapters discuss how toxic substances are associated with packaging materials.

- **Volatile Organic Compounds** – Some, but not all, VOCs can be very toxic to humans. Their impacts can include cancer, asthma, and poisoning. As mentioned previously, VOCs are often released during manufacturing processes. If emissions are not controlled properly, human exposure to VOCs can result.
- **Dioxins** – Dioxin is a man-made substance that, once dispersed in the environment, does not biodegrade quickly. It is a known carcinogen and highly toxic. Dioxin tends to bioaccumulate in animals. This means that organisms at the bottom of the food chain consume a toxin, like dioxin, which remains in their tissue. Animals higher up the food chain gain increased concentrations of the toxin in their bodies as they consume contaminated organisms. For example, bioaccumulation is the process behind mercury concentrations in some commercial fish, which can be dangerous to humans who eat those fish. Dioxin is a byproduct of the pulp bleaching processes used to make paperboard. It is also associated with the incineration of certain plastics.

- **Heavy Metals** – Lead, cadmium, cobalt, chromium, and nickel are all heavy metals that are toxic to humans in sufficient quantities. They are mainly found in printing inks used for packaging containers. Regulations over the last twenty years have succeeded in limiting toxic metal release stemming from ink usage. See Chapter 9 for more information (pg 87).

Impact Reduction Strategies

The goal of this section is to explain the strategies available to reduce the environmental impacts of packaging in the industrial and consumer electronics markets. The primary reduction techniques are:

- **Reduction:** Completing the same task using less material.
- **Reuse:** Using the material in its current form multiple times to do the same or different tasks.
- **Recycling:** Changing the form of the material (either by reforming it into the same product or converting it to something completely different) to use it again.

Key Strategies for Reducing Environmental Impact

The following are several important strategies for limiting environmental impact:

Avoid toxic substances – Toxic substances in packaging are mostly a thing of the past, thanks to industry and regulatory efforts. However, toxic substances do still result from the manufacturing processes as well as the disposal of some packaging materials. For example, incineration of PVC produces dioxin – a substance toxic to humans. Packaging professionals should learn about toxics related to packaging and take steps to limit or stop their release into the environment.

Enhance product ruggedness – Increasing the durability of the actual product provides an opportunity to reduce the amount of packaging for protection and cushioning. This results in the use of fewer materials.

Reduce weight and volume – A study conducted by Franklin Associates, a life cycle research firm, revealed that the most effective means of reducing the amount of solid waste going to landfills and of conserving resources and energy is to reduce the volume of material being used. For example, the study revealed that shipping bags, paper or plastic, were found to consume less fossil fuel, produce less solid waste, and produce fewer emissions compared to heavier corrugated boxes. This is an important concept to remember when designing packaging. By reducing the amount of a material used in a package, the material and shipping costs of that package will be reduced, along with the environmental impacts of that material. This environmental impact reduction strategy is called “lightweighting” and will be addressed more specifically in later chapters.⁵

Employ smart supply chain design – When developing a product supply chain, minimize the steps required to deliver the product to the end user. Each additional step in the supply chain, in most cases, requires additional material and energy to package and re-package a product. Efforts to construct supply chains that limit the steps, and the resulting material and energy requirements, will serve to reduce the product’s overall environmental impact.

These techniques can effectively reduce environmental impacts by decreasing the amount of material consumed for packaging. In addition to reducing the environmental impacts of production and solid waste problems, material reduction, reuse, and recycling can result in significant savings in material and energy costs. The following points should be taken into consideration when designing packaging:

- The required packaging characteristics, such as product protection, must be achieved. Improper packaging can lead to product damage, which results in increased costs and environmental impact.
- If the materials that are being used cannot be recycled or reused, make sure that they will have minimal environmental impacts when they are disposed of in either landfills or incinerators. For example, they should not contain any toxic or hazardous materials that could potentially leach into the soil or otherwise be dispersed into the environment.

- Packaging professionals should consider alternative packaging options that use minimal natural resources and do not require the use of toxic materials in the manufacturing process.

Ideally, a packaging design will have a minimum negative impact on the environment and will perform properly, be cost effective, and fully preserve the integrity of the product. The remainder of this section describes general techniques that can be used to reduce environmental impacts. These techniques fall into the following categories:

- Material Reduction
- Design for Reuse
- Design for Recyclability
- Using Recycled Content
- Using Lower Impact (Alternative) Materials

Material Reduction

Of the three coined environmental R's, Reduce, Reuse, and Recycle, material reduction is the most effective method of reducing environmental impacts. This section will give an overview of how to reduce the amount of materials that are used in packaging, thereby reducing the environmental impacts of the packaging product.

Material Reduction Objectives

- Reduce the amount of packaging entering the waste stream.
- Reduce the amount of packaging material being used without compromising quality and/or performance (the concept of lightweighting or minimal packaging.)
- Reduce the amount of waste material and byproducts of packaging manufacturing processes.
- Identify unnecessary packaging and attempt to reduce waste in all stages of packaging — primary, secondary, tertiary and transport packaging.
- Ship in bulk when possible and ensure high product density in bulk form.

Common Causes of Overpackaging

Often, more than the necessary amount of packaging is used to protect a product. This is referred to as “overpackaging.” This issue has been placed in the spotlight by recent waste disposal concerns. Now that it has been recognized as a problem, efforts are being made to reduce overpackaging. Some common causes of overpackaging include:

- An overly-cautious assessment of the transport hazards that an expensive product such as a laptop computer may encounter.
- An unclear specification of the destination and shipping method, resulting in packaging for a worst case scenario that the package will never encounter.

- Environmental test specifications that provide more protection than the product requires.
- Decorative or marketing packaging that is larger than the product requires (e.g., the compact disk long box).

Material Reduction Strategies

The primary way to reduce excess packaging material is to be aware of the causes of overpackaging and choose packaging that matches the product's size, weight, shape, fragility, filling requirement, pallet pattern, warehousing needs, and mode of shipment as accurately as possible. Some opportunities to reduce packaging include:

- **Reduced Product Protection:** Packaging materials can be reduced and sometimes eliminated when the product requires minimal protection. Minimal protection may be the result of:
- **Increased product ruggedness:** By increasing a product's durability or strength, less protection or cushioning is needed to adequately protect the product.
- **Use of material handling equipment:** Using equipment and strategies such as carts and/or well-controlled or minimal handling, shipping, and storing environments (e.g., close or nearby vendors) may reduce the protection the product requires for shipping and handling.
- **Communication:** Communication with suppliers and shippers can also help to reduce material use. For example, requiring shippers to use padded vehicles could effectively reduce the amount of packaging needed to protect the product.⁶
- **Eliminate materials:** Eliminating multiple packaging (e.g., avoiding use of both strapping and shrink wrap where only one is actually required) not only reduces the materials used, but may also reduce costs and energy used in production. It also simplifies the waste management of the distribution centers that often must deal with many different waste streams of hard-to-recycle materials.
- **Material Lightweighting:** Material lightweighting is a simple concept that involves using less or lighter material in a design. The objective is to use only enough material to provide the required level of performance (e.g., shock protection, stacking strength, durability, etc.).
- **Material Selection:** Sometimes the use of an alternate material and design can result in an overall reduction in materials used.
- **Bulk versus Unit Packages:** A material reduction technique often used with supplier and inter-plant packaging programs is bulk packaging. This includes both replacing a number of smaller packages with a single, larger more efficient package size and buying products in bulk and/or in a concentrated or refillable form. The use of bulk packaging consolidates outgoing materials and requires less packaging material, per part, than individually packaged parts.

Source Reduction Calculations

To quantify a material reduction, take the volume or weight of the original design divided by the number of uses, subtract the volume or weight used for the revised design divided by its number of uses, and divide by the original value of volume or weight divided by number of uses.

$$\% \text{ Reduction} = \frac{(X_o/R_o - X_n/R_n)}{X_o/R_o} \times 100$$

where:

X_o = Volume or Weight of the original design

R_o = Number of reuse cycles of the original design

X_n = Volume or Weight of the new design

R_n = Number of reuse cycles of the new design

Note: To obtain the volume of an irregular component, divide its weight by its density, or submerge the part in a known volume of water and measure the quantity of water displaced.

For disposal systems, R_o & $R_n = 1$, resulting in a very simple calculation.

Design for Reuse

It is always preferable to first achieve a reduction in packaging material; however the next alternative is to reuse the packaging. Reusable designs avoid the creation of additional packaging materials by reusing those already in existence. Reusable packaging systems should be considered within the context of the user's needs, specifications and packaging goals. It is important to remember that if the goal of a package is to be reused, not only does the packaging need to be designed for reuse, but there must also be a system in place to actually reuse it. If administered poorly, these systems can consume more material than other packaging alternatives. Designing a stronger, more material-intensive package that is then either thrown away or recycled is a waste of both money and resources.

The following are some suggestions on how to design packaging that can be reused.

Design Factors

- **Design Style:** Select container and packaging styles that lend themselves to high reuse. Use closures that do not damage the container; avoid permanent closures such as tape, hot-melt glue, staples, etc.
- **Easy Use:** Design reusable containers and packaging to allow easy packing, unpacking and repacking. Minimize complexity so the package can be easily reassembled and reused without a high degree of expertise. Where possible, the packing process should be no more than three steps – open, place (the part), and close/seal.

- **Component Replacement:** Design reusable containers such that worn or damaged components can be easily replaced, without having to throw away the entire container. Also, keep component designs simple to facilitate easy and fast replacement and procurement. Complex designs, sophisticated materials, and special tooling may cause high replacement cost and long replacement times.
- **Cleaning:** For reusable items that need to be cleaned, be sure to include adequate liquid flow and drain holes. Also, use materials that do not require special solvents for cleaning.
- **Other Uses:** When possible, design containers and packaging to be used for other programs (both current and future). With slight design changes, a reusable item designed and cost-justified for one program may be applied to other programs. Also, very durable designs, with minor modifications, may be cost-effectively applied to future programs, thus extending a reusable item's life beyond the life of one program.
- **Shipping:** Consider shipping weight and size in order to minimize shipping costs. In addition to size and weight, the container style may affect shipping costs.

Reuse Programs

The following issues should be considered when evaluating, developing, or implementing programs that make use of reusable packaging:

- **Transportation Distance:** Shipping distance and transit time greatly affect the total number of reusable containers needed for a program. When shipping distances are short, pipelines are usually small, and thus the total number of reusable containers needed is small. In addition, if the reusable items require additional vehicle trips, short distances result in lower transportation costs. Pipeline and return costs are often the largest costs in a reusable container program.
- **Distribution channels:** Some distribution channels branch out and diffuse the concentration of shipping destinations. This may reduce the manageability and cost-effectiveness of reusable packaging systems.
- **Part Size:** Large production parts are often better candidates for reusable packaging programs than smaller parts for several reasons:
 - There are fewer parts per container, so the containers make more round trips. This is a cost benefit if the container is well-designed, durable, and has a high reuse life. A higher number of reuses makes a reuse program more cost effective.
 - The cost difference between disposable and reusable containers is often smaller with large parts than with small parts. Combined with a high number of reuses, the total materials cost becomes very low.

- Large parts are often good candidates for warehouse-on-wheels (WOW) or kanban-on-wheels (KOW) inventory management programs. When parts suppliers are not close, just-in-time (JIT) delivery programs are more easily justified with larger parts. The larger parts often are more expensive and require more storage space, so eliminating these parts from warehouse storage usually results in significant inventory

savings. Frequent delivery and no warehouse storage also reduce the number of reusable containers needed and result in low or free return shipping costs, especially when the trucks are already returning empty.

- **Inventory Management:** Be sure to consider inventory management practices when evaluating and designing reusable containers. Be sure your inventory control process can handle a return system. Aspects such as response time and variability must also be considered.
- **Bulk Packs:** Bulk packaging applications are often good candidates for reusable containers.
- **Unit Packs:** For unit packages, look for ones that currently use several different materials in the package design. For example, electrostatic discharge (ESD)-sensitive and fragile components and assemblies (e.g., small disk drive, cards and boards) shipped by suppliers and component plants are often individually packed with conductive bags, foam cushioning, and fiberboard cartons. These individual and disposable packages can sometimes be redesigned with bulk containers which provide the required ESD protection. Bulk containers and unit loads control orientation and reduce both the handling risk and level of protection required.

Reuse Cost Analysis

The following are the cost elements in reusable packaging material and container programs. The cost comparison between reusable and disposable packaging should be made across the entire life of the product or part program. It should be structured as an out-of-pocket cost comparison and should include net present value and internal rate of return analyses. Any local business case requirements should also be included in the analysis and comparison.

Chapter 3: Environmental Impacts and Reduction Strategies

$$\begin{aligned} \text{Disposable Packaging Cost} \\ = (C \times V) / Q \end{aligned}$$

$$\begin{aligned} \text{Reusable Packaging Cost} \\ = (C \times V) / (Q \times P \times N) \end{aligned}$$

C = Unit Material Costs: Estimate unit costs or the per piece purchase cost of the proposed designs. Several supplier quotes may be appropriate.

V = Product Volumes: Obtain plans or estimates of manufacturing or shipping volumes (i.e., quantity vs. time, or manufacturing/shipping schedules) for the part or product to be packaged.

Q = Container Quantity: Determine the quantity of products the container will hold. This should take handling and assembly work areas into account.

P = Pipeline Quantity: Estimate the number of reusable items in the pipeline (including frequency of deliveries, transit times, process times, inventory buffers, kanban sizes, return shipping times, return shipping frequency, and any contingency buffers). The number of reusable items in the pipeline will change if the product volumes change. A more complex cost calculation is needed if product volumes and pipeline quantities change significantly over time.

N = Reuse Life (integer value): From design or prototype testing information, estimate the reuse life of the reusable item. How many reuses will the item have? This is rounded up to the next whole number to reflect total units purchased and the effect of using some units less than their total expected life.

The following comprise the total costs for a package program lifetime:

- **Total Packaging Costs:** Derived from the calculations above. Include any cost to repair or refurbish the reusable package.
- **Labor Costs:** Estimate the labor to use the disposable and reusable design. Often there will be no difference if the package designs are similar. Estimate administrative as well as any repair or cleaning costs associated with the reusable package.
- **Equipment/Tooling Costs:** Identify and estimate any other costs associated with the disposable or reusable design. These may include things such as implementation costs, inventory carrying costs, part or product quality-related costs (e.g., scrap & rework), and tax impacts or benefits.
- **Shipping Costs:** Estimate the cost to ship packaged items in reusable and disposable packages. If there is no weight or size difference between the reusable and disposable designs, shipping costs will be the same.
- **Disposal Costs:** Estimate disposal costs associated with both the reusable and disposable containers or packaging items. Include sorting costs, equipment use for compaction/baling, and the actual pick-up/disposal costs.
- **Return Costs:** For return programs, estimate handling and shipping costs to return reusable items.

Design for Recyclability

Recycling materials used in packaging, shipping, and receiving is a viable, and often profitable, means of reducing waste and returning materials to productive use. Unfortunately, not all products can be recycled. The Design for Recyclability sections of this document will provide strategies that can increase the recyclability of a packaging product. Boxes, plastic shrink wrap, pallets, and paper packaging material are all examples of packaging products that can be recycled if designed properly.

The following are broad strategies that can increase the recyclability of the product:

- Avoid commingling of materials whenever possible. For example, if corrugated fiberboard is attached to polystyrene foam using a permanent adhesive, the materials are commingled. The permanent adhesive will likely prevent the two materials from being completely separated, which will in turn prevent recycling. Select materials that can be recycled and design packages to make recycling easy (e.g., all one material or several materials that are easy to separate and sort).
- Be aware of the accessible recycling infrastructure in the location to which you are shipping. If the material you are using cannot be recycled there, try to find a comparable alternative material that can be recycled.
- Require suppliers to use packaging with recycled content.
- Recycle your own packaging waste. An effective in-house recycling system can be established within your operation to efficiently collect all recyclable materials.
- Ensure packaging is properly labeled to enable appropriate recycling and/or disposal.

Internal Recycling

Developing an internal recycling program is an important component to reducing the amount of solid waste your company is directly producing. In the following six material-specific chapters there will be an Internal Recycling section at the end of the Design for Recyclability section. This section will clarify the form that each specific material will need to be in for collection and recycling.

The following four steps can be used to start an internal recycling program within your company:

- Determine how much waste your company generates.
- Evaluate internal business practices to determine if used packaging materials can be reused in place of other materials that are purchased for shipping products.
- Arrange on-site pick-up of recyclables with a recycling vendor or your current waste hauler, or create a system for taking recyclables to the proper recycling depot.
- Ensure that all employees are informed of recycling collection protocol.

Using Recycled Content

Purchasing products that contain recycled content can reduce solid waste generation, conserve energy, and support markets for materials collected for recycling. When used in proper quantities and/or strategic applications, recycled materials may offer the manufacturer several benefits over virgin materials. These include:

- Lower material cost
- Little or no compromise in performance.
- Compliance with legislation⁷
- Reduction in the unnecessary depletion of natural resources

When purchasing materials for packaging, select products with the highest recycled content available. Look for the EPA's recommendations on purchasing recycled products. They can be found within the Using Recycled Content section in Chapters 4 through 8.

Products that can be made with recycled content include:

- Corrugated fiber boxes
- Plastic pallets
- Strapping
- Bubble wrap
- Foam cushioning material
- Shredded paper
- Protective paper

For more products that contain recycled content please refer to the Environmentally Preferable Products Recycled Content Guide found at:

<http://www.epa.gov/purch/recycling/contguide.pdf>

Finding information on the availability and cost of these recycled products can be a challenge. Fortunately, many states within the US provide resources on their website that can direct viewers to information on where to buy products that contain recycled content. The State of California website is very informative and provides buying information for many products including plastics. For an example of the type of information included on these state websites refer to the State of California Buy Recycled home page at <http://www.ciwmb.ca.gov/BuyRecycled/>. In addition there are a number of international guides for buying recycled products. One example is the Recycled Products Guide, the UK's directory of recycled products. This resource can be found at www.recycledproducts.org.uk/buy-recycled/.

Post-consumer and Pre-consumer Materials

Post-consumer materials are products that have served their intended end use and would otherwise be thrown away, whereas *pre-consumer* materials are manufacturing scrap. The use of post-consumer recycled content is important because it supports markets for material collection and recycling.

Alternative Materials

A method of reducing impacts that can be as effective as material reduction is using alternative materials that can serve the same function with fewer environmental impacts. The following sections will provide more specific applications of alternative materials.

Impact Reduction Strategies

As explained in Chapter 2 (pg 14), there are various ways a material can affect the environment as it moves through its life cycle. These impacts include energy use, water and air pollution, and consumption of valuable natural resources. Mitigating these impacts through alternative materials serves as an additional method of reducing the impacts of a packaging product. Unfortunately, there isn't a single clear method that can be used to reduce these environmental impacts. However, there are a few general concepts that can be applied to most of the materials used in packaging.

- Use materials made with recycled content, as these products reduce the need for natural resources and often require less energy in the manufacturing stage of the life cycle.
- Purchase or use materials that are certified as being extracted or harvested in a sustainable manner.

Using Recycled Paper

Using recycled paper brings many environmental benefits. Compared to virgin paper, producing recycled paper consumes less energy and natural resources, generates less air and water pollution, and decreases the amount of trash sent to incinerators and landfills – thus reducing solid waste and greenhouse gas emissions. By buying recycled paper, companies can take a significant step toward reducing their overall environmental impacts.

http://www.environmentaldefense.org/documents/517_coatedfreesheet.pdf

Purchase Certified Wood Products

The use of wood has a significant impact on the environment because it requires the removal of natural resources. If forests are harvested excessively and irresponsibly, future supplies of forest products will diminish. Purchasing wood from sustainable, well-managed forests can reduce the overall environmental impacts of using wood, as such forestry practices maintain and restore the health of forests. Forest certifications provide assurance that the forestry practices meet standards for sustainability. Two prominent forestry certifications are listed below:

- Forest Stewardship Council (FSC) – This is a multi-stakeholder supported forest certification program. It is international in scope. <http://www.fsc.org>
- Sustainable Forestry Initiative – This is a program run by the American Forest and Paper Association. It focuses on U.S. forests. <http://www.abouthfi.org>

When purchasing wood products or working with vendors, you can require that the pallets, crates, and wood packaging products you purchase are made using wood from certified forests.

In addition to purchasing certified wood, efforts can be made to purchase paper and paper-based packaging materials that are procured from sustainably-managed forests. Look for reclaimed, salvaged, and FSC-certified wood products.

For more information, visit the Forest Ethics web site:
<http://www.forestethics.org/purchasing/alternatives.html>

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Packaging Scenario: Options



Randy at XYZ Electronics – Package Options

[Continued from page 13]

Original Design

Randy considers the original design for the inkjet cartridge package and makes note of the materials used and its size. It is a PVC clamshell with two paperboard cartons made from virgin fiber using solid bleached sulfate production. Its dimensions are 13.3" x 10.7" x 1.8" (256 in³) and it weighs 127g.

Impact Reduction Strategies

After checking for applicable packaging regulations, Randy thinks about different strategies for reducing environmental impacts and tries to determine which can be applied to this package to meet his packaging goals.

- **Material Reduction:** Since one of the customer complaints was “excess” packaging, this is a good strategy to start with. The printer cartridge is only 2.4" x 1.8" x 0.7", so he believes the package can easily be reduced in size and still perform its needed function. He will also look for opportunities to eliminate steps in the supply chain to reduce packaging waste and transportation impacts.
- **Design for Reuse:** Since this is for a consumer package and Randy doesn't think consumers will be willing to bring a package back to the store for reuse, he decides not to use this strategy for this application.
- **Using Lower Impact (Alternative) Materials:** Randy has heard that there may be some environmental issues with PVC, so he considers using paperboard and different plastics like polypropylene (PP), which is durable in light weights, and polyethylene terephthalate (PET).
- **Design for Recyclability:** PVC and PP are technically recyclable, but recycling infrastructure in North America is more common for PET and paperboard. Therefore, he will give preference to PET and paperboard in his decision.
- **Using Recycled Content:** He checks with his material supplier and finds that he can get PET and paperboard with recycled contents up to 100%.

Randy then looks at the packaging goals and requirements for his inkjet cartridge package. He is an experienced packaging engineer, but is new to determining environmental impact, so he creates three options that will meet the packaging needs:

Package Option 1

Based on the old package, he decides to reduce the size of the PVC clamshell (Material Reduction) and change the paperboard cartons to 100% recycled content paperboard (Using Recycled Content). This new design's dimensions are 6.6" x 7.6" x 1.6" (80 in³).

Package Option 2

Considering paperboard's recyclability (Design for Recyclability) and its potential to be made with recycled content, he decides to design the main packaging using a more robust paperboard box (Alternative Material). He specifies a paperboard container made from 100% recycled content (Using Recycled Content). In order to get suitable protection for the cartridge, he needs to add a material for internal support, so he chooses an expanded polystyrene cushion. To facilitate recycling, the expanded polystyrene will not be glued to the paperboard. He is still able to reduce the size of the carton (Material Reduction), but not as much as Option 1 due to the volume of the expanded polystyrene, so this design's dimensions are 8.4" x 8.2" x 1.8" (124 in³).

Package Option 3

To achieve some of the same protective qualities as PVC, Randy considers other plastics. Polypropylene is durable with thin walls, so he tries an external package made with it. He needs some shock protection for the cartridge and wants to try to use recycled-content PET (which is also recyclable), so he designs a holding tray made from 100% recycled PET (Using Recycled Content, Design for Recyclability). This is also a small package (Material Reduction) with dimensions of 6.6" x 7.6" x 1.6" (80 in³) and weighs 43g.

Now, with three different designs he starts looking at the environmental impacts of the materials he has chosen.

Ch 4: Corrugated Fiberboard

This Chapter Covers:

- The environmental impacts of corrugated fiberboard
- Strategies for reducing the impacts of corrugated fiberboard

Corrugated fiberboard is the primary material used in electronics package designs. Corrugated containers are normally bought by a converter from a local sheet plant supplier or from an integrated supplier of corrugated products. The sheet plant obtains its corrugated sheets from a corrugation plant, which gets its liners from a paper mill. The integrated suppliers typically control the process from the forest to the finished package. The entire life cycle of corrugated fiberboard has significant effects on the environment – from impacts to forests due to timber extraction, to emissions from manufacturing, to the volume of solid waste produced during production and disposal.

Fortunately, corrugated fiberboard has tremendous potential to be reused and recycled. The corrugated recycling industry is well developed around the world. In the United States, nearly 75% of all corrugated containers are recovered for recycling.¹

The following chapter will address the various environmental impacts that result from the use of corrugated fiberboard in packaging. It will then examine the various strategies that can be used to reduce those impacts.

Environmental Impact

The life cycle of corrugated fiberboard depends on whether the fiber used comes from virgin resources (trees) or recycled content (recycled corrugated and paper).

There are a number of different processes used to make the pulp used in the production of corrugated containers. Each process results in different impacts on the environment. See Appendix B (pg. 123) for more details on the different processes used to make corrugated fiberboard.

Impact Summary – Corrugated Fiberboard*

	Virgin	Recycled
Solid Waste (kg/metric ton)	967	268
Wood Use (metric tons of trees)	2.8	0
Energy Use (MJ/metric ton)	31,999	22,492
Impacts to Water (kg/metric ton)		
BOD	1.9	1.8
TSS	3.0	0.8
AOX	0.4	n/a
Impacts to Air (kg/metric ton)		
NOx	7.8	6.6
SOx	11.5	11.8
Greenhouse Gas (CO2 equivalents)	1731	2775
HAPs	2.1	<0.01
VOCs	3.4	0.3

Table 1. Characterization of environmental impacts per metric ton of virgin vs. recycled fiber content corrugated containers.² Data represent the sum of impacts across the entire life cycle of corrugated fiberboard. See Chapter 3 for descriptions of the various impacts.

Impacts to Natural Resources

Corrugated containers begin their life cycle in one of two ways: either as harvested trees or old corrugated containers that are recycled into new ones.

The impacts to natural resources associated with using virgin fiber are relatively well-understood. Timber can be considered a renewable resource because, if appropriately managed, forests can provide a sustainable supply of timber. However, what constitutes “appropriate management” is highly controversial. Timber harvesting can have a lasting negative impact on the ecology of the surrounding area. Clear-cutting of forests, historically a common harvesting

* The study from which these data are taken provides analysis of two scenarios: Virgin, in which virgin materials are used to manufacture containers that are then disposed of after use; and Recycled, in which containers are manufactured using 100% recycled content and then 100% of these are recycled into new containers. In reality, a container would be made of a blend of virgin and recycled content. Actual quantities of impacts for blended virgin/recycled content must be inferred from this data.

method, has the most severe impact, causing loss of habitat, high levels of erosion, and degraded water quality in adjacent streams and rivers, among other issues. Currently, some forest products companies are attempting to address these impacts through variations in forest management techniques as well as certification programs to promote these sustainable techniques. See “Purchasing Certified Wood Products” on page 42 for more information.

In addition, privately-owned and managed forests are now common among forest products companies. A privately owned forest managed for lumber or pulp production is normally an area populated by trees all of the same type and of the same age. Soft pines and firs are often grown on managed forests in the southeastern U.S., for example, and provide a relatively fast-growing source of fiber. These managed forests do not represent a diverse natural forest and healthy ecosystem, due to the homogeneity of the trees grown – a phenomenon that does not often occur in natural forests. However, this method of production is preferable to clear-cutting natural forests.

The impact to natural resources resulting from recycled fiber corrugated containers is much less than those from virgin fiber. These impacts are mainly associated with the energy required to collect and transport old containers.

Energy Use

Production of corrugated containers is an energy-intensive process. For both containers made from virgin and those from recycled fiber sources, the manufacturing stage of the life cycle requires the most energy. In addition, processes using virgin fiber require energy expenditures to harvest and transport timber, reduce the trees to pulp, and transport waste containers to a landfill site. Using recycled-fiber containers requires energy expenditures to collect and sort old containers. Finally, both processes require energy to distribute newly made containers to markets.

Comparisons of the energy expenditures for a virgin fiber process and a recycled fiber process show that, overall, recycling old corrugated containers to make new ones uses less energy. These comparisons indicate that the total energy required to recycle old containers into new ones is 22,492 mega joules per metric ton of new containers. This compares to 31,999 mega joules per metric ton of virgin-fiber containers made and then dealt with using traditional waste management processes (landfilling and incineration).³ The table above illustrates this comparison.

Impacts to Water

Water is a key ingredient in the production of corrugated fiberboard. In fact, the pulp and paper industry is the largest user of industrial process water in the United States.⁴ For virgin fiber manufacturing processes it is common to use as much as 12,200 gallons of water per ton of paper product produced.⁵ Studies indicate that recycled fiber processes for corrugated containers result in close to 2,000 gallons per ton.⁶

Impacts to water resulting from corrugated containers occur mainly during the production stage of the life cycle. As with energy use, the use of virgin or recycled fiber results in different impacts.

Because of the need for water, paper mills are often situated next to lakes and rivers, and wastewater is often discharged back into the same body of water. Treatment of the wastewater prior to discharge varies considerably from facility to facility and from country to country.

The manufacturing process for corrugated containers commonly results in polluted wastewater. For example, chemicals used in the pulping process for corrugated products result in a wastewater that contains moderate to high levels of biological oxygen demand. See Table 1 for data on impacts to water resulting from corrugated fiberboard.

Impacts to Air

The life cycles of corrugated fiberboard and other paper products result in a number of emissions that are harmful to the atmosphere. The manufacturing stage is responsible for the largest share of emissions to the atmosphere. These include hazardous air pollutants, including some VOCs. Many of the air emissions that stem from manufacturing come from electrical energy derived from fossil-fuels.

Disposal

If corrugated containers are disposed of in a landfill, the most significant impact is generally the volume of space they take up. Corrugated that is placed in a landfill generally does not contribute to the harmful leachate that some landfills suffer from. Corrugated containers can degrade over time via biological and photochemical processes; however, degradation in landfills is generally low. The biodegradation that does result from corrugated contributes to greenhouse gas emissions (CO₂ and methane) – greenhouse gas emissions from landfills are included in the data provided in the Impacts to Air section in Table 1.

Toxic Substance Release

In the United States, the pulp and paper sector is the third largest contributor of toxic emissions to the air among those included in the U.S. Environmental Protection Agency's Toxic Release Inventory.⁷ Corrugated manufacturing does not commonly include a bleaching process (as do other paper and paperboard manufacturing processes), which can result in release of dioxin. While dioxin emission is not as big of a risk with corrugated, other toxic emissions, such as methanol, do still result from corrugated manufacturing.⁸

The U.S. EPA's Toxic Release Inventory (TRI) forces polluters to disclose the type and amount of pollutants that business processes emit to the atmosphere. The EU Pollutant Emission Register is Europe's equivalent to the TRI.

For more information see:

<http://www.epa.gov/tri>

<http://www.eper.cec.eu.int>

Impact Reduction Strategies

There are significant opportunities to reduce the environmental impacts associated with using corrugated fiberboard as a packaging material. This section discusses impact reduction strategies in six categories:

- Reduction of Toxic Substances
- Material Reduction
- Design for Reuse
- Design for Recyclability
- Using Recycled Content
- Alternative Materials.

Reduction of Toxic Substances

While the use of a corrugated container does not release any toxic substances, the manufacturing process can. Studies have found that that far fewer hazardous air pollutants and VOCs result from production methods that use recovered corrugated as the raw material.⁹ Therefore, using old corrugated containers as a raw material is seen, from a manufacturing standpoint as environmentally preferable to using virgin fiber. Packaging professionals should work with their suppliers to encourage production methods that minimize the release of toxic substances into the environment.

Material Reduction

Minimizing waste at the source is the most cost-effective way to reduce waste management costs and improve environmental performance. The following are some of the many ways a facility can reduce the amount of corrugated fiber it uses and generates as waste:

- Eliminate corrugated fiber boxes where they are not needed; for example, completely eliminate a packaging component or substitute rubber, plastic, or metal bands where appropriate.
- Review corrugated fiber package sizing to determine if small boxes could be eliminated in favor of large boxes or bulk handling. Replacing small boxes used for individual product packaging with large boxes that contain more than one product can eliminate the need for individual product packaging, resulting in an overall reduction of packing materials.
- Reduce the thickness or burst strength on corrugated fiberboard products. For example, when stacking strength, durability for repeated uses, or puncture resistance is not needed in a container, lower-strength boards may be selected. This may mean reducing triple-wall boards to high-performance double-wall materials, for instance.

- Purchase products in bulk. Bulk purchasing often eliminates the need for individual product protection or packaging, and can significantly reduce the amount of materials needed for packaging.
- Work with vendors and customers to reduce corrugated fiber consumption and implement reusable systems.¹⁰

Design for Reuse

- Select more durable corrugated fiber boxes for extended life and reusability.
- Substitute other types of containers that are reusable, such as durable plastic crates, wood or metal containers. These products cost more initially, but if the product is reused numerous times, environmental and economic advantages are apparent.
- Design returnable containers that can protect supplies and parts without added spacers, reinforcements, or protective covers.
- Request that suppliers ship products in boxes of a specific size that can be used in future outgoing shipments.
- Reuse corrugated moving boxes internally.¹¹

Benefits of Reusable Containers

- They use less materials and lower costs over time.
- They can reduce product damage if designed well.
- They can result in better use of vehicles and warehouse space because reusable containers can often stack more reliably.
- They reduce waste handling, storage, and disposal costs.

Design for Recyclability

When designing packaging that can be recycled, avoid adding contaminants (such as wax). Most corrugated fiber recyclers restrict the levels of contamination that they will allow in the product and will pay significantly less for contaminated loads of corrugated fiber.¹² Contaminants interfere with the remanufacturing process and must be removed from the corrugated fiber by the generator, the hauler, the broker, or the mill. Observe the following considerations when designing for recycling:

- Polystyrene foam, wood, plastic, metal, and other non-soluble materials are significant contaminants that can inhibit corrugated fiber recycling.
- Waxed corrugated *cannot* be recycled and must be separated from non-waxed corrugated fiber.
- Old newspapers and office paper wastes are considered contaminants if present in large quantities.

Chapter 4: Corrugated Fiberboard

- Corrugated recyclers will generally only allow *small* volumes of certain types of materials such as plastic packaging tape, carton staples, adhesive labels, glue bindings, and kraft paper tape.¹³

Internal Recycling

Corrugated packaging will have to be in the following forms to be collected for recycling:

- Corrugated boxes, partitions, slip sheets, pads, sleeves, tubes, etc.
- Loose, bundled or baled
- Free of contaminants (depending on available recycling technology, contaminants include: staples, waxes, non-slip treatments, waterproofing, laminations, bonded plastics)

Using Recycled Content

Corrugated packaging materials are increasingly available with high recycled-fiber content. In general, high performance corrugated board can be produced with a high content of recycled fiber. Recycled materials are best placed in the corrugated mediums and the inside liners of multi-wall board (e.g., double-wall or triple-wall). These non-critical components may be manufactured from up to 100% recycled fiber without seriously affecting performance. The EPA's recommended recycled fiber content for corrugated packaging products are contained in the chart below.¹⁴

Item	Post-consumer Fiber (%):	Recovered Fiber (%):
Corrugated containers		
(<300 psi)	25-50	25-50
(300 psi)	25-30	25-30

Table 2. The recovered fiber and post-consumer fiber content is calculated from the content of each component relative to the weight each contributes to the total weight of the box. The content levels should be read "X% recovered fiber, including Y% post-consumer fiber."

The post-consumer percentages included in the chart above are the EPA's recommendations, the purpose of including them is to serve as a reference and as a goal that can be achieved when purchasing recycled corrugated fiber.

Designing with Recycled Corrugated

When using paper with recycled content to produce corrugated, the following formula can be used to determine the recycled content of the resulting corrugated:

Recycled Fiber Content (by weight)

$$w(L1) + x(L2) + xx(M1)d1$$

SINGLE-WALL

$$L1 + L2 + (M1)d1$$

$$w(L1) + x(L2) + y(L3) + xx(M1)d1 + yy(M2)d2$$

DOUBLE-WALL

$$L1 + L2 + L3 + (M1)d1 + (M2)d2$$

$$w(L1) + x(L2) + y(L3) + z(L4) + xx(M1)d1 + yy(M2)d2 + zz(M3)d3$$

TRIPLE-WALL

$$L1 + L2 + L3 + L4 + (M1)d1 + (M2)d2 + (M3)d3$$

Where:

w = % recycled fiber in liner L1	xx = % recycled fiber in medium M1
x = % recycled fiber in liner L2	yy = % recycled fiber in medium M2
y = % recycled fiber in liner L3	zz = % recycled fiber in medium M3
z = % recycled fiber in liner L4	

	fluting take-up factor
d1 = take-up factor for medium 1 fluting	A flute = 1.50
d2 = take-up factor for medium 2 fluting	B flute = 1.30
d3 = take-up factor for medium 3 fluting	C flute = 1.42

L1 = weight of liner 1	M1 = weight of medium 1
L2 = weight of liner 2	M2 = weight of medium 2
L3 = weight of liner 3	M3 = weight of medium 3
L4 = weight of liner 4	

Alternative Materials

The following materials can be used in place of corrugated fiberboard:

- Durable plastic, wood, or metal containers.
- Rubber, plastic, or metal bands can replace the need for boxes where appropriate. These will hold the product in place without requiring an additional box or container.

References

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⁹ Paper Task Force 1995.

¹⁰ Commercial and Industrial Waste Reduction Old Corrugated Cardboard. May 1997. North Carolina Division of Pollution Prevention and Environmental Assistance. 11 March 2005 <<http://www.p2pays.org/ref/01/00353.pdf>>.

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¹⁴ Comprehensive Procurement Guidelines: Paperboard and Packaging. 17 March 2004. US Environmental Protection Agency. 5 March 2005 <http://www.epa.gov/epaoswer/non-hw/procure/products/paperbrd.htm>.

Ch 5: Paperboard

This Chapter Covers:

- The environmental impacts of paperboard
- Strategies for reducing the impacts of paperboard

Paperboard is used to manufacture folding cartons and is often used in computer electronics packaging. It was estimated that in 2004 alone there was over 9 billion dollars worth of folding carton sales within the packaging industry. There are approximately 300 companies with 490 plants whose primary business is manufacturing folding cartons.¹ The production of paperboard is a huge business and with it comes a number of environmental impacts.

The following chapter will first address the various environmental impacts that result from the manufacturing and use of paperboard in packaging. Once the impacts have been explained, the chapter will examine the various strategies that can be used to reduce those impacts.

Environmental Impact

The environmental impacts during resource extraction and disposal for paperboard are very similar to those for corrugated fiberboard. As such, much of what is discussed in the previous section also applies to paperboard. For more information, see Chapter 4 (pg 45).

However, the environmental impacts of the manufacturing processes for paperboard can differ from corrugated in a number of ways. The following processes are used to make the majority of paperboard used in packaging²:

- **Solid Bleached Sulfate (SBS)** – This grade is made from bleached kraft pulp. Today, this process uses mainly chlorine dioxide to bleach the pulp.
- **Coated Unbleached Kraft (CUK)** – CUK is made from unbleached kraft pulp.
- **Recycled Paperboard** – Recycled paperboard comes from recovered (recycled) fiber that has not been de-inked. In most cases, waste paper is mixed with water, mechanical energy and steam to re-pulp the paper.

The main difference in environmental impact between SBS and CUK is the lack of a bleaching process in CUK³. Historically, elemental chlorine was used as the bleaching agent. Using elemental chlorine in this process can result in a release of dioxin to local water supplies (dioxin is toxic to humans and wildlife, as mentioned previously). However, due to regulations in the United States (known informally as the “Cluster Rule”), most pulping plants have switched from using elemental chlorine to primarily using chlorine dioxide for the bleaching process.⁴ Chlorine dioxide does not result in the same level of toxic emissions associated with elemental chlorine.

Tables 2 and 3 below summarize the categorical impacts for SBS and CUK paperboard. Each type is compared with 100% recycled paperboard (that is, the “Recycled” column contains the same data in each table). In many cases, recycled paperboard pulp can be blended with either SBS or CUK to achieve certain cost or performance requirements.

Impact Summary: Bleached (SBS) and Recycled Paperboard*

	Virgin	Recycled
Solid Waste (kg/metric ton)	1118	289
Wood Use (metric tons of trees)	3.4	0.0
Energy Use (MJ/metric ton)	46,608	20,174
Impacts to Water (kg/metric ton)		
BOD	3.4	1.0
TSS	5.5	0.8
AOX	0.9	0.0
Impacts to Air (kg/metric ton)		
NOx	9.5	6.2
SOx	3.4	11.0
Greenhouse Gas (CO2 equivalents)	2,868	1,618
HAPs	1.1	0.0
VOCs	2.7	0.3

Table 3. Characterization of environmental impacts per metric ton of virgin SBS vs. recycled fiber paperboard.⁵ Data represent the sum of impacts across the entire life cycle – raw materials to disposal or recycling. See Chapter 3 for descriptions of the various impacts.

* The study from which these data are taken provides analysis of two scenarios: Virgin, in which virgin materials are used to manufacture containers that are then disposed of after use; and Recycled, in which containers are manufactured using 100% recycled content and then 100% of these are recycled into new containers. In reality, a container would be made of a blend of virgin and recycled content. Actual quantities of impacts for blended virgin/recycled content must be inferred from this data.

Impact Summary: Unbleached (CUK) and Recycled Paperboard*

	Virgin	Recycled
Solid Waste (kg/metric ton)	947	289
Wood Use (tons of trees)	2.7	0.0
Energy Use (MJ/metric ton)	32,695	20,173
Impacts to Water (kg/metric ton)		
BOD	1.7	1.0
TSS	2.7	0.8
AOX	n/a	n/a
Impacts to Air (kg/metric ton)		
NOx	7.0	6.0
SOx	9.5	11.0
Greenhouse Gas (CO2 equivalents)	2,545	1618
HAPs	1.5	0.01
VOCs	2.5	0.3

Table 4. Characterization of environmental impacts per metric ton of virgin SBS vs. recycled fiber paperboard.⁶ Data represent the sum of impacts across the entire life cycle – raw materials to disposal or recycling. See Chapter 3 for descriptions of the various impacts.

Impact Reduction Strategies

The following sections specify design techniques that can be used to reduce, reuse, and recycle paperboard. In addition, the following sections will provide suggestions on alternative materials that can be used, guidance on how to use recycled content in packaging products, and strategies to reduce the overall environmental impacts of paperboard.

Material Reduction

Overall reduction of paper use can achieve clear and measurable environmental and economic benefits. This type of source reduction reduces the amount of paper that must be produced in the first place, and therefore extends the fiber supply and avoids the use of natural resources and the release of pollutants associated with acquiring raw materials and manufacturing.⁷

The following strategies will help to reduce the amount of paper needed in packaging:

- Purchasers should work with suppliers to develop alternative packaging designs that minimize the use of paper materials.

- Package designers should consider lightweighting (downsizing packaging and/or optimizing volume contained in packages).⁸

Design for Reuse

Reuse of paper products is often difficult because of their lack of strength and durability relative to corrugated fiber or plastic products. However, here are a few ways to incorporate used paper products in packaging:

- Use incoming paper packaging materials to stuff outgoing shipments.
- Use shredded waste paper for cushioning material as an alternative to purchasing new cushioning material.⁹

Design for Recyclability

Incorporation of the following factors will assist in developing recyclable products:

- Use paper tape and starch based glues; minimize staples, hot melt adhesives, plastic tapes, and envelopes.
- Design using components that may be removed or separated in order to facilitate recycling.
- Apply the "Recyclable" and "Recycled-Content" symbols appropriately to all fiber package materials.
- Use paper-based packaging materials that are easily recycled, such as molded pulp.¹⁰
- Minimize ink coverage and use water- and soy-based inks or inks which are USDA approved.¹¹

Internal Recycling

Paperboard used in packages will have to be in the following forms to be collected and recycled:

- Loose, bundled or baled
- Slipsheets can be bundled with paperboard for recycling
- Free of contaminants (depending on available recycling technology, contaminants may include: staples, waxes, non-slip treatments, waterproofing, laminations, bonded plastics)

Using Recycled Content

It is a misconception that the inclusion of recycled fiber is undesirable for any fiber-based product. While it is true that recycling can reduce the performance of some paper products, that reduction is generally small and can be minimized when:

- The source of recycled fiber is of premium-grade (long fiber length).
- The source of recycled fiber is free of contaminants.

All fiber-based products can be manufactured with some contribution of recycled fiber. However, the performance requirements of the second (or next) generation product will dictate the quantity of recycled fiber used as an ingredient. If done properly, well-engineered applications for recycled fiber can produce both tangible and intangible advantages for its user. In some circumstances recycled fibers may increase the smoothness and dimensional stability of the paper. In addition, compared to 100% virgin board, paperboard that contains recycled content uses less wood, energy, and water, reduces emissions of greenhouse gases and air and water pollutants, and cuts the amount of trash sent to incinerators and landfills. The EPA's recommendations for purchasing paperboard that contains recycled content are included in the chart below.¹² These values indicate what is possible in the industry. Packaging professionals should strive to purchase the products that contain the highest post-consumer recycled content possible, given material performance requirements. In addition, it is important to stay up to date on new technologies and new products that are available with higher recycled content.

Recommended Paperboard Recycled-Content Ranges

Item	Recovered Fiber (%):	Post-consumer Fiber (%):
Solid Fiber Boxes	40	40
Folding Cartons	100	40-80
Industrial paperboard (e.g., tubes & cores)	100	45-100

Table 5. The recommended content ranges are not applicable to all types of paperboard used in folding cartons. Cartons made from solid bleached sulfate or solid unbleached sulfate contain no or small percentages of post-consumer fiber, depending on the paperboard.¹³ The content levels should be read "X% recovered fiber, including Y% post-consumer fiber."

Products manufactured from recycled fiber include:

- Paper, including newsprint, office paper, tissue, and corrugated
- Paperboard, such as semi-chemical, bleached paperboard
- Other materials, including building products (e.g., insulation), molded products (e.g., molded pulp trays, like egg cartons), or cushioning
- Coated recycled board (CRB), made from 100% recovered paper and usually contains a minimum of 35% post-consumer materials

Alternative Materials

Paper products are often used for specific purposes in electronic packaging and there aren't many materials that can be substituted for them. With this in mind, the best approach to finding alternative materials that have fewer environmental impacts is to:

- Replace virgin paper products with paper made with higher post-consumer recycled content (at least 30%).

- Look for non-wood paper alternatives made from kenaf, cotton, or other fibers. Many “agrifibers” yield more pulp-per-acre than forests and require fewer pesticides and herbicides.¹⁴
- Instead of using new paper products, reuse incoming shipping and receiving materials, such as packing peanuts, bubble wrap, and boxes, to pack items in outgoing shipments.¹⁵
- Make efforts to consistently purchase non-chlorine bleached fiber products.

Avoid using chlorine-bleached fiber products

The regulations in the United States (known informally as the “Cluster Rule”), have eliminated the use of elemental chlorine in most US pulping plants. Although these US plants have switched from using elemental chlorine to primarily using chlorine dioxide for the bleaching process, it is important to remember that paper mills in other countries may still be using elemental chlorine in their bleaching processes.¹⁶ It is therefore important to continue to make efforts to eliminate or reduce the requirement for bleached fiber products. The organochlorines used in the bleaching process have been shown to cause harmful effects in humans and various other species. It follows that reducing the demand for chlorine-bleached fiber products will help to reduce the potential ecological contamination that these compounds can cause. Both recycled and non-recycled paper products can be whitened without chlorine. Alternatives to chlorine bleaching include whitening with oxygen and hydrogen peroxide. The best environmental options are unbleached and hydrogen peroxide bleached products.¹⁷ This recommendation also applies to the corrugated fiber section mentioned above.

The following are general recommendations that can help eliminate or reduce the requirement for bleached corrugated liner or paperboard.

- Specify unbleached “natural” material.
- Specify white coated unbleached material.
- Specify mottled white liner. This achieves an 80% reduction in bleached fiber.
- Specify bleached materials having reduced “whiteness” requirement.
- Specify white coated mottled white or semi-bleached material.

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Packaging Scenario: Paperboard



Randy at XYZ Electronics – Considering Paperboard

[Continued from page 42]

As part of the redesign process Randy must research the environmental impacts of the three design alternatives he has come up with. Two of the design alternatives, as well as the original design, include the use of paperboard. The original uses virgin fiber SBS paperboard, while Randy would like to use 100% recycled-content paperboard for the new design options.

Environmental Impacts

The following chart qualitatively illustrates the environmental impacts of virgin and 100% recycled versions of solid bleached sulfate paperboard as well as clay-coated unbleached kraft paperboard.

	Virgin SBS	Recycled SBS	Virgin CUK	Recycled CUK
Solid Waste	High	Low	Medium	Low
Wood Use	High	Low	Medium	Low
Energy Use	High	Low	Medium	Low
Impacts to Water	High	Low	Medium	Low
Impacts to Air	Highest	Medium	High	Low

Table 6. The rankings *Low*, *Medium*, *High*, and *Highest* are attributed to each type of paperboard. *Low* indicates the least amount of negative environmental impacts and *Highest* indicated the largest amount of negative environmental impacts.

Impact Reduction Strategies

The ability of a material to be made using recycled content and the end-of-life options of a material should be included when evaluating the environmental impacts of a material. The following chart shows the strengths and weaknesses of using paperboard in a package design.

Characteristic	Paperboard's Capabilities
Ability to contain recycled content	very good
Reducibility	fair
Reusability	poor
Recyclability	very good

Table 7. Common characteristics of paperboard

Overall Assessment

If the correct type of paperboard is selected, paperboard has the potential to reduce the overall environmental impacts of the new printer cartridge package. If the package design Randy selects includes a paperboard component, he would do well to select paperboard that contains recycled content and that is unbleached, as these factors significantly reduce the environmental impacts of the manufacturing process. In addition, all paperboard is very recyclable, which further reduces its environmental impacts at end-of-life. Though it is unbleached, the clay coating of CUK enables quality printing to meet the marketing requirements for the package.

It is important to remember that the design alternative that consists of a paperboard box and expanded polystyrene cushioning has the largest dimensions. This indicates that the amount of material required to make the box will be greater than that needed for the other two designs. If you remember the general reduction strategies described in Ch 3 (pg 31), using the least amount of material, lightweighting, is an important and effective method of impact reduction. Randy must consider this when making the final material selection.

Ch 6: Wood

This Chapter Covers:

- The environmental impacts of wood
- Strategies for reducing the impacts of wood

The most common uses of wood in packaging are pallets, appliance bases, crates, boxes, pallet bins, top caps, dunnage, blocking and bracing. In the electronics industry, wood is most often used to build pallets for the transport of products. In the United States, wood pallets use 12% of the annual lumber production. In addition, 90-95% of pallets in the United States are made of wood.¹

This chapter will address the various environmental impacts that result from the use of wood in packaging. It will then examine the various strategies that can be used to reduce those impacts.

Environmental Impact

Most of the environmental impacts associated with solid wood packaging are consistent with those associated with the sourcing of material for corrugated and paperboard containers (since they all come from trees). Specifically, the relevant impacts include damage to ecosystems from harvesting wood, energy used to convert trees into usable lumber, additional cost for wood treatment before shipping, and the impacts associated with transporting the wood package. Please refer to Chapter 4 “Corrugated Fiberboard” (pg 45) for more information.

The key differences between wood packaging and corrugated and paperboard packaging are in the air emissions that result from treatments required for international shipping of wood products.

Impacts to Air

A major concern in the use of wood packaging is the overseas transport of and subsequent damage done by invasive species that can survive in wood. For example, the Asian longhorned beetle, a species that survived in wooden shipping containers from China, has killed entire forests of trees and caused millions of dollars of damage in the Northeastern United States.² International agreements (such as the UN’s “International Standard for Phytosanitary Measures (ISPM) 15”³) are now in place to prevent the harmful effects of transporting invasive species in this manner.

There are two methods used to kill species living in wood containers: heat treatment and fumigation. Beyond the energy required to produce heat, heat treatment is relatively benign in its environmental impact. Fumigation methods, however, cause impacts to the atmosphere and, potentially, to human health.

For information on ISPM 15 and countries that have adopted it, see the U.S. National Wooden Pallet & Container Association:
<http://www.nwpca.com/INTLRegulations/ISPM15CountryUpdate.htm>

Methyl bromide (MeBr) is the only substance that is currently approved worldwide to fumigate wood packaging. If exposed to this substance in the appropriate quantity, pests, like the Asian longhorned beetle, will not survive. The main concern over Methyl bromide is that it is an ozone depleting substance. That is, when it escapes to the atmosphere during the fumigation process, it will deplete the ozone layer in the same way that CFCs do. Methyl bromide is currently undergoing an international phase-out under the terms of the Montreal Protocol. However, the use of MeBr in fumigation of wood packaging has been granted an exemption and it will continue to be used for phytosanitary measures internationally. This is of concern because, in addition to its ozone depleting effects, methyl bromide is fatal to humans in high concentrations. As a result, fumigation using methyl bromide is highly regulated in the U.S. by state and local agencies.

Impact Reduction Strategies

The following sections specify design techniques that can be used to reduce, reuse, and recycle wood materials that are used in packaging. In addition, the following sections will provide suggestions on alternative materials that can be used, guidance on how to use recycled content in packaging products, and strategies to reduce the overall impacts of wood.

Packing crates, drums, pallets, box pallets, or other load boards and spacers are all wood products that are used in packaging. The following recommendations and guidelines will be focused on how to reduce, reuse, and recycle pallets and crates.

Material Reduction

Wood is a very economical and durable material that plays a large roll in the packaging industry. The purpose of this section is to provide guidelines that will help to minimize the need for virgin wood products.

Cooperation between the supplier and the manufacturer has the potential to reduce costs as well as reduce the creation of virgin wood pallets and wood pallet waste. The following ideas may help reduce pallet requirements.⁴

- Work with suppliers to redesign packaging and cargo to eliminate the need for pallets.
- Ask suppliers or purchasers if they can work with:
 - Returnable boxes and crates instead of pallets.
 - Corrugated fiber pallets, which can be recycled with other corrugated fiber packaging.
- Eliminate poor pallet quality that drives unnecessary repalletization.
- Use pallet designs that will allow for reuse in downstream and upstream processes.
- When feasible, use refurbished pallets to reduce the need for new components.
- Use plastic or corrugated slipsheets in place of pallets.

- Design packages to fit more densely on a pallet or in a crate so that fewer are needed.
- Allow for taller stacks of packages on pallets.
- When possible, use returnable pallets or crates.

Design for Reuse

Reusing wood pallets has the potential to reduce the strain on natural wood resources as well as reducing costs involved in manufacturing, purchasing, and disposing of pallets. Opportunity for reuse begins in the design process. If a pallet is consciously designed for reuse, it has the potential to be used numerous times. An example of this is the Europallet, whose manufacturing process conforms to the Swedish Standard SS .842007. In a comparative durability analysis based on the number of handlings, the Europallet lasted for an average of 109 handlings. The pallet it was compared to was a single use pallet, that only lasted for 21 handlings.⁵ This study indicates that the original design of a pallet is important, and can significantly influence its capacity for reuse. The Pallet Design System (PDS™) is an excellent tool that can be used to design efficient reusable wood pallets as well as to reduce the wood requirement for one way or expendable pallets. This tool is used throughout the world and can be accessed through the Pallet Central website, www.palletcentral.com.⁶

Another strategy that can be used to increase pallet reuse is to create requirements for pallet management procedures. Under certain circumstances, where pallets are captive to a manufacturing facility, companies can manage their own pallet pooling system. To capture the benefits of reuse, a control system must be in place to capture and return, and reuse. There are third party management programs available, such as CHEP USA, PECO, and The Nelson Company that can be used to assist pallet management programs.⁷

Repairing pallets and salvaging material from used pallets can also provide environmental and economic benefits.⁸ In addition, reusing pallets is a way to reduce product handling costs for pallet users. If the pallet arrives in good condition, it should always be reused. Here are some suggestions on how to extend the lifetime of a pallet.

- Return unneeded pallets, boxes, and packaging materials to suppliers for reuse.
- Repair wood pallets. Publications on pallet repair and recycling procedures can be found at <http://www.unitload.vt.edu/pubs2.htm#pr>. These articles address reinforcement techniques, performance of recovered pallets parts, and the use of metal connector plates to repair wood pallet stringers.

Design for Recyclability

In terms of recycleability, approximately 400 to 450 million new wood pallets are manufactured in the United States every year. Over 200 million used wood pallets are recycled and re-enter the market every year, indicating the existence of a significant infrastructure to collect wood pallets and recycle the materials, primarily back into pallets. Wood pallets are also very recyclable because of the existence of the collection infrastructure of independent businesses throughout the

country.⁹ In addition to recycling pallet wood back into pallets, untreated, damaged, and unusable solid wood pallets can be recycled by using them for mulch or building materials. The following are design ideas that can increase the recyclability of pallets.¹⁰

- Avoid treating wood with toxic substances, such as fumigating wood with methyl bromide.
- Avoid petroleum-based inks, staples, waxes, non-slip treatments, waterproofing, laminations, bonded plastics, and nails/fasteners.

For more information on pallet reduction and reuse please see the Pallet Reduction and Reuse Technical Appendices at:

<http://www.ciwmb.ca.gov/Packaging/Wood/pallets.doc>

Using Recycled Content

Use of any wood that has already served a purpose is considered recycling. For example, reusing a pallet, repairing a broken pallet, or converting a pallet into another wood product are recommended forms of recycling. However, if you are going to use pallet wood for another purpose, check to see if the wood has been treated in any way. There is generally a mark placed directly onto the pallet stating if it has been treated. If so, make sure the treatment added to the wood is compatible with its future use. Some countries require wood to be treated and some have bans on certain treatments, such as those included in ISPM 15. If treated wood has been recycled, re-manufactured, or repaired, all components must be treated and the wood should be re-certified and re-marked.

Recycled composite pallets or crates are another recommended option. These products contain both recycled wood and recycled plastic. They are very durable and can provide the same function as a wood pallet or crate. The following chart includes the EPA's recommended recycled materials content levels for pallets made from wood, plastic or paperboard.¹¹

Product	Material	Post-consumer Content (%)
Wooden pallets	Wood	95-100
Plastic lumber	Plastic	100
Thermoformed (Plastic pallets)	Plastic	25-50
Paperboard pallets	Paperboard	50

Table 8. Recycled Content recommendations for wood and alternative material pallets.

The post-consumer recycled content shown above for each type of pallet should be used as a guide when purchasing pallets. Assuming packaging performance requirements are met, it is environmentally preferable to use as much recycled content as possible.

Alternative Materials

Research has indicted that wood has a number of positive environmental attributes.¹² Therefore, the goal of this section is not to provide ways to avoid the use of wood in packaging generally. Instead, it is included to provide the packaging professional with material options that can be used in place of wood in specific situations where the use of alternative materials could reduce overall environmental impacts. Here are a number of other materials that can be used in certain instances instead of wood pallets:

- Corrugated fiberboard pallets can be used in place of wood pallets. Corrugated pallets provide the greatest flexibility at the lowest cost and can be easily customized to meet special needs.¹³ Corrugated paperboard pallets are the most recyclable because of the extensive and available infrastructure.¹⁴ For more information on corrugated pallets please refer to the Chaille Brindley paper in the references.
- Durable, reusable, and collapsible pallets made from plastic aluminum, plastic, or wire mesh are sometimes preferable to wood. Unfortunately plastic and metal pallets are not as recyclable as wood or corrugated fiberboard pallets. Their after market value is relatively low because the recycling infrastructure is not readily available or well established. Therefore, if these materials are going to be used in place of wood, it is important to ensure that there is a management and reuse program in place for plastic and metal pallets.¹⁵
- Slipsheets, which are generally made of either corrugated, plastic, or fiberboard, can be used in place of pallets for applications that involve push-pull devices or to move or store products.¹⁶
- Plastic pallets are the most common alternative. There is a greater initial investment, but the cost may be recovered in money deferred from purchasing, repairing, disposing or recycling wood pallets and crates.

See the following web site for more information on how to use pallets effectively in electronics packaging:

www.palletcentral.com

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Ch 7: Solid Plastics

This Chapter Covers:

- The environmental impacts of solid plastics
- Strategies for reducing the impacts of solid plastics

The electronics industry uses a number of plastic packaging materials. Many of these plastic polymers can be manufactured in either a solid state (blister packs, packaging tubes, etc.) or an expanded (foamed) state often used as cushioning for fragile products. Therefore, for the purposes of discussing the environmental impacts of each, this guideline breaks them down into *solid* plastics and *expanded* plastics. Foamed or expanded plastics will be discussed thoroughly in Chapter 8: Expanded Plastics (pg 80). This chapter focuses on the most commonly used non-foamed plastic packaging materials, which include:

- Polyethylene (PE) – Films and bags
- Includes high density PE (HDPE), low density PE (LDPE) and linear low density PE (LLDPE).
- Polypropylene (PP) – Films, trays, and bags
- Polyvinyl Chloride (PVC) – Packaging tubes, blister packs, and bags
- Poly (ethylene) Terephthalate (PET) – Blister packs and trays

The following Chapter addresses the various environmental impacts that result from the use of non-foamed plastics in packaging. It will then examine the various strategies that can be used to reduce those impacts.

Environmental Impact

Analysis of the environmental impacts of plastic packaging materials is an extremely difficult task due to the large number of materials and the diverse ingredients used to produce them. The vast majority of packaging plastics are derived from crude oil, meaning they can be characterized as the product of a non-renewable resource. Estimates indicate that in 2003 the fraction of global crude oil production used by the plastics industry was 4%.¹ Environmental impacts of oil and gas drilling include degradation of sensitive habitats and general depletion of the non-renewable fossil fuel base. Alternative plastic materials that are based on renewable materials, such as corn starch, do exist. These products, though not widely used today, present an opportunity to use a renewable material in plastic packaging.

In addition to fossil fuels, packaging plastics require a variety of additives that provide the material with a number of desired characteristics

such as flexibility and static resistance. These additives can have negative impacts on human health and the environment and may also prevent bags being recycled due to commingling of materials (for more on commingling, see Chapter 3, pg 39).

To learn more about how plastic packaging is manufactured from crude oil, see Appendix B (pg 123).

Plastic Categories

Impacts in this chapter are characterized in a manner similar to paper and corrugated fiberboard. However, it is important to note that the life cycle inventory studies used here to provide data on plastics encompass only part of the life cycle – raw material extraction and manufacturing – whereas the data on paper and corrugated encompassed not only extraction and manufacturing but also use and end-of-life treatment.* Therefore, it is not possible to compare life cycle inventories between corrugated fiberboard and polyethylene, for example. However, it is still possible to derive rough environmental impact comparisons between the different types of plastic resin.

In addition, while most plastic products are technically recyclable, there is limited data on how virgin plastic compares to recycled plastic with regard to environmental impact. As a result, this section does not present an impact comparison of virgin and recycled plastic, as was done for corrugated fiber board and paperboard. That being said, most plastics are recycled by separating them by resin type, grinding them down to pellet size, and remolding them using the same processes as virgin plastic. With this knowledge we can make a rough judgment as to the impacts of using recycled plastic relative to virgin plastic. For more information on recycled plastics, see (pg 77).

Thermoplastic vs. Thermoset Plastics

Solid and expanded plastics both have two subcategories: thermoplastic and thermoset. Thermoplastics can be repeatedly softened by heating and hardened by cooling in order to reprocess the plastic through molding or extrusion. Conversely, thermosets, which have been formed and cured by heat, remain substantially infusible and insoluble. Thus, thermoplastics can, theoretically, be readily recycled back into the original form, while thermosets cannot (though infrastructure for thermoplastic recycling varies from region to region). Although thermoset plastics cannot be recycled, they often can be used for other applications. For example, flexible polyurethane foams are commonly shredded into a small particle size before being compressed into re-bonded polyurethane foam for carpet underlayment. Refer to the adjacent table for examples of Thermoplastic and Thermoset materials. If you have questions about the end of life options for specific plastic materials, contact your plastics supplier to find out if they have an existing recycling and/or reuse programs in place.

* This is unfortunate. However, data availability during development of this guideline was limited. Though often difficult to obtain, life cycle inventory data do exist for all plastics used in packaging. See Chapter 10 for a summary of leading lifecycle assessment databases and software packages.

Thermoplastic (Recyclable)	Thermoset (Not Recyclable)
Polyethylene	Polyurethane
Polystyrene	Foam-in-place urethane
Polypropylene	
Poly (ethylene) Terephthalate	

Table 9. Thermoplastic and Thermoset plastics used in electronics packaging.

Impact Summary – Common Plastics

	HDPE	LDPE	LLDPE	PP
Energy Use (MJ/metric ton)	76,560	77,800	73,980	72,690
Impacts to Water (kg/metric ton)				
BOD	0.02	0.03	0.07	0.03
TSS	0.18	0.11	0.15	0.07
AOX	0.0	0.0	0.0	0.0
Impacts to Air (kg/metric ton)				
NOx	2.86	3.41	2.76	2.78
SOx	4.03	4.96	3.90	3.60
Greenhouse Gas (CO2 equivalents)	2,158	2,233	1,724	2,137
VOCs	0.16	0.49	0.07	0.02
	PS	PVC	PET	
Energy Use (MJ/metric ton)	84,000	93,460	109,210	
Impacts to Water (kg/metric ton)				
BOD	0.14	0.30	0.78	
TSS	0.74	2.45	0.54	
AOX	0.0	0.0	0.0	
Impacts to Air (kg/metric ton)				
NOx	0.02	13.18	29.39	
SOx	0.02	15.65	35.15	
Greenhouse Gas (CO2 equivalents)	n/a	2,581	6,173	
VOCs	0.0	0.0	1.0	

Table 10. Characterization of environmental impacts, per metric ton, of plastic resins commonly used in packaging.² Data do NOT represent entire life cycle – only raw materials to “pelletized” resin beads. See Chapter 3 for descriptions of the various impacts.

Energy Use

The energy required to produce a given amount of a plastic product depends on the resin type. The majority of the energy required is used in the actual manufacturing of the resin and the package the resin is converted into, often due to the high temperatures involved in manufacturing. Polystyrene resin, for example, must be heated to almost 600 degrees Celsius. Some of this energy expenditure is offset by the recovery of steam and other process byproducts, which are reconverted to energy to drive the process. However, some resins, such as polyurethane, do not require a large amount of heat in the manufacturing process. Therefore, energy impacts due to manufacture differ for varying types of plastic. Other energy expenditures come from raw material extraction and transportation.

Impacts to Water

Water is used primarily for flushing and cooling purposes during the manufacture of plastic resins and products. Many manufacturing processes allow the water to be captured and reused, thereby limiting water use and wastewater discharge. Wastewater from plastic production has been found to possess suspended solids, oil and grease, and heavy metals including lead, mercury, iron, and aluminum³ (see Tables 3-6 for more information.). Some of these materials, especially mercury, cause wastewater effluent to be toxic to humans and the surrounding ecosystem.

Impacts to Air

Air emissions are often the source of the greatest environmental impact during the life cycle of plastics. Often these can be described as “fugitive emissions,” or chemicals that escape into the air during the manufacturing process. These include a diverse list of VOCs and particulates that have proven or suspected toxic effects on human health. In high enough doses, these chemicals can have an adverse effect on the central nervous system as well as other human health impacts.⁴ Often, fugitive emissions result from the solvents that are used in the resin manufacturing process (see the section below on Toxic Substances).

In some cases the monomer itself, the precursor to a resin polymer, is a harmful emission. For example, styrene, which is “polymerized” into polystyrene, is a known carcinogen,⁵ as is vinyl chloride, the monomer form of polyvinyl chloride.

The plastics life cycle includes the release of some quantity of greenhouse gases. These result primarily from the transportation stage of the life cycle and the generation of energy used in the manufacturing process. In addition, the energy generated to run manufacturing processes results in emissions that contribute to acidification (NO_x and SO_x). See Table 10 for more information.

Disposal

If not recycled, plastic packaging normally ends up in a landfill or is incinerated for energy recovery.

Most plastics used in packaging are relatively inert and usually will not contribute any toxic substances to the leachate that is associated with landfills. One exception to this generalization is PVC (refer to the section on Toxic Substances below). The largest environmental impact of this phase of the life cycle is the volume of space required to accommodate plastics in a landfill. Many plastics are not biodegradable and will not degrade in a landfill.

Incineration of plastic packaging does succeed in reducing the volume of refuse going into landfills, however incineration of some plastics can produce harmful emissions into the air. Incineration of plastics can result in emission of greenhouse gases, NO_x, SO_x, hydrochloric acid, mercury, and other pollutants. PVC incineration is of particular concern because it can result in the production of airborne dioxins.

Because the amount of solid waste is increasing in nearly every part of the world and space for landfiling is limited in certain regions, incineration as a method of solid waste management will likely increase. Researchers continue to look for ways to reduce the environmental impacts of plastics incineration.⁶

Litter

Finally, it is important to recognize the problems associated with plastic litter. The same properties that make plastic acceptable in landfills make it a difficult problem if it is irresponsibly disposed of as litter. Because plastic does not degrade in the environment, it will persist as litter for a very long time. Expanded plastics (discussed in the next section), can become a more widespread problem due to their often brittle nature, which allows them to break apart and disperse in the environment. This causes difficulty in cleanup in addition to having negative ecological effects.

Toxic Substance Release

Toxic substances associated with plastics used in packaging arise mainly during the manufacture and disposal phases of the life cycle. During the manufacture of plastic packaging, toxic substances often result from the solvents, resins, and lubricants that are used. These substances are considered hazardous waste in some regions and must be disposed of according to regulatory standards. In addition, disposal of plastic packaging can release toxic substances into the air. Incineration of plastics is a controversial subject. Some plastics are thought to incinerate without releasing toxics; however others can pose a hazard. Polyurethane releases hydrogen cyanide when incinerated, for example. PVC can also disperse toxic substances when incinerated; furthermore, it is suspected that PVC packaging has the potential to release toxins during the use of a product (see below).⁷ The potential for use-phase toxic release is not thought to be a risk for other types of plastic used in packaging, however.

Polyvinyl Chloride

Polyvinyl Chloride, or PVC, has received much attention for its negative impact on the environment. This attention results from two aspects of PVC:

- **Plasticizers:** Most PVC contains plasticizer compounds that give it a desired flexibility. Plasticizers are not chemically bonded to the PVC and will migrate to the surface of the product over time and be released into the atmosphere. It is suspected that plasticizers (including phthalates) may cause harmful health affects in humans.
- **Dioxin:** Dioxins are suspected carcinogens and can act as endocrine disrupters as well as causing immune system damage. Dioxins are not produced during the production of PVC. However, incineration of PVC (either for disposal or by accident) does result in the formation and release into the atmosphere of dioxin compounds.

Impact Reduction Strategies

The following sections specify design techniques that can be used to reduce, reuse, and recycle plastics that are commonly used in packaging. In addition, this chapter will provide suggestions on alternative materials that can be used, guidance on how to use recycled content in packaging products, and strategies to reduce the overall impacts of plastics.

Material Reduction

Reduction of plastic packaging is an effective way to reduce environmental impacts. There have been many successful packaging reduction innovations in the plastics industry in recent years. Here are a few suggestions on how to reduce the use of solid plastics.

- Reduce wall thickness of plastic containers. When impact strength, precise dimensions, and durability are not significant, wall thickness of plastic containers can be reduced. Designing plastic packaging using less material results in lighter products that can achieve the same strength.
- Replace Low Density Polyethylene (LDPE) films with thinner Linear Low-Density Polyethylene (LLDPE) films.⁸

Design for Reuse

Switching from one-use package designs to reusable designs can also decrease the environmental impacts of plastic packaging. Because of its durability, plastic is often well-suited for reusable applications.

- Design rigid plastic products that can be used multiple times for the same function, such as durable, reusable plastic bins, crates or boxes.
- Use plastic instead of wood or paperboard for shipping. Plastic products are more durable and more likely to withstand multiple uses.⁹

Design for Recyclability

The process of recycling post-consumer plastics is challenging because of the large number of resin types in use and their incompatibility with one another. Plastics recycling began during the oil crisis in the early 1970s. The price of a barrel of oil increased dramatically, which sparked efforts to reuse the energy and material content of plastics instead of purchasing oil from other countries to create virgin plastics. This began a number of industry and government initiatives that focused on recovery and recycling of scrap plastics. Since then, the plastics recycling industry has continued to grow and improve.¹⁰ By giving proper attention to package design, it is possible to create plastic products that can be recycled. Here are some recommendations:

- The plastics used in packaging should be easily separable from other materials.
- If different types of plastics must be used together, choose plastics with significantly different densities, making it easier to separate them for recycling.
- Avoid mixing polymers. Most polymers do not mix, bond or adhere well to one another. Mixing of resin types can result in a product that has inferior physical properties in addition to being hard to recycle.
- Many solid plastics can be recycled locally and used to make plastic lumber. HDPE is commonly the material used to make recycled plastic lumber.
- Include the proper plastic recycling code on the product to ensure easy recycling.
- Use only water-dispersible adhesives and non-bleeding inks on labels to ensure that pigments from the labels will not bleed during the recycling process.¹¹
- Find an alternative to designs using PVC. Most PVC products contain plasticizer compounds. Additionally, when PVC products are disposed of or incinerated they release dioxins. Both the plasticizer compounds and dioxins have been suspected to cause harmful effects to human health. For more information refer to the Polyvinyl Chloride section found earlier in this section (pg 75).¹²
- Avoid additives such as fire retardants which can create an acidic chemical reaction and corrode the inside of an extruder.
- Ensure that plastics being used are always identified with the proper Society of Plastics Industry (SPI) code. For more specific information on SPI codes and labeling refer to Appendix F: Standardized Packaging Symbols (pg 164).

Internal Recycling

Plastics used in packages will have to be in the following forms to be collected and recycled:

Polyethylene

- Free of contaminants (including foreign objects: items such as wood, metal, glass, etc. which could damage an extruder)
- Cushions, bags, trays
- Contained via baling, compacting, bagging or boxed

- Materials should not be melted down or densified by applying heat. Uncontrolled heating or melting of PE materials can render them useless for primary recycling applications.
- For best quality and highest value, materials should be separated by types such as:
 - Natural white
 - Colors (blue, black, etc.)
 - Anti-static
- Whenever possible, material should be separated by manufacturer, due to the various resin types used by different manufacturers which yield different performance values.

Polypropylene

- Molded cushions/shapes and molded plank used for fabrication
- Injection molded and thermoformed cushioning
- Block and brace packaging
- Sheet form for folding cartons
- Free from contaminants
- Other polymer types not compatible with PP, i.e. polyurethane, polystyrene, polyethylene, etc.
- Foreign objects: Items such as wood, metal, glass, etc.

Polyvinyl Chloride

- Tubes (e.g., semiconductor tubes), trays, miscellaneous sheet stock
- Baled, compacted, bagged
- Free from contaminants
- Other plastics resins not compatible with PVC
- Foreign objects: Items such as wood, metal, glass, etc.

Using Recycled Content

Manufacturing plastic packaging materials containing recycled resins is a relatively new development. Packaging decisions should maximize the use of materials containing the highest possible recycled content that can still meet the packaging requirements. Several states are in the process of establishing laws which govern the disposal of solid waste including packaging materials. Most of these laws are similar in that they provide for exemptions from proposed taxes or restrictions when materials used in products (or packages) are made from recycled materials in whole or in part (typically 30-50%), or are reused a certain number of times (typically 5). The following chart contains specific recycled content recommendations provided by the U.S. EPA for purchasing solid plastics.¹³ These values indicate what is possible in the industry. Strive to purchase the products that contain the highest post-consumer recycled content whenever possible. However, it should be understood that certain material performance

requirements may not be currently obtainable when recycled content is used. (Examples include ESD protection, corrosion control, shock and vibration performance, etc.) In addition, it is important to stay up-to-date on new technologies and new products that are available with higher recycled content.

Item	Post-consumer (%):	Total Recycled Content (%):
Solid Plastics		
High Density Polyethylene (HDPE)	90%	90%
Polyethylene (PE)	30-50%	30-50%
Poly (ethylene) Terephthalate (PET)	100%	100%
Polypropylene (PP)	--	10-40%

Table 11. The United States EPA recommended recycled content goals for plastics.

For contact information of buyers and sellers of recycled plastics please refer to the www.plasticsresource.com web site.

Alternative Materials

The following materials can be used in place of solid plastic packaging:

- **Recycled Plastic Composite:** Recycled plastic composite is made from a combination of recycled wood and recycled plastic or from 100% recycled plastic.
- **Polylactic Acid (PLA):** Polylactic acid is a biodegradable synthetic polymer made from corn waste that can be molded, vacuum formed, blown, or extruded to yield products typically made from conventional petroleum-based plastics.¹⁴
- **Corrugated/Paperboard fiber:** Corrugated/Paperboard fiber boxes can often be used in place of plastic containers.
- **Molded Pulp:** Molded pulp materials (MP) have the potential to conserve natural resources because the pulp may be obtained from waste newspaper. However, molded pulp may have low shock absorbing principles.
- **Microsphere Plastic Composite:** An improvement on traditional molded pulp, this product is made from molded pulp and includes a modified starch binder. It is applicable to the packaging of electronic equipment because the composite contains 10% expanded plastic microspheres. This provides additional shock absorbing properties. Shredded pulp and microspheres separate in water after 10 minutes. Approximately 98% of the microspheres can be separated, and the remainder may be used as raw material for newsprint. Because the shredded pulp/microsphere composite does not have a synthetic polymer binder, it is recyclable.¹⁵

Biodegradable Materials

Refer to the section titled Degradable Materials in the Expanded Plastic Chapter (pg 84).

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- ² EcoProfile. PlasticsEurope. 11 March 2005 <<http://www.apme.org>>.
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- ¹³ Environmentally Preferable Products Recycled Content Guide. 2001. State of Missouri DPMM - Mo. State Recycling Program. 5 March 2005 <<http://www.oa.mo.gov/purch/recycling/contguide.pdf>>
- ¹⁴ Polylactic Acid Research. Industrial Agricultural Products Center. 5 March 2005 <<http://agproducts.unl.edu/pla.htm>>.
- ¹⁵ Noguchi, Tsutomu, Mayumi Miyashita, Jun 'etsu Seto, Masaru Tan, and Mitoshi Kawano. "Development of moulded pulp materials for the packaging of electronic equipment." Packging Technology and Science 10 (1997): 161–168.

Ch 8: Expanded Plastics

This Chapter Covers:

- The environmental impacts of expanded plastics
- Strategies for reducing the impacts of expanded plastics

Expanded plastics are plastics that have been blown, or expanded in volume, to perform their function. This process dramatically reduces the density of the plastic. Plastics that are manufactured into an expanded form are:

- Expanded Polystyrene (EPS)
- Expanded Polyethylene (EPE)
- Expanded Polypropylene (EPP)
- Expanded Polyurethane (EPU)

This chapter will address the various environmental impacts that result from the use of expanded plastics in packaging. It will then examine the various strategies that can be used to reduce those impacts.

Environmental Impact

The key difference between the environmental impact of normal plastic and that of expanded plastic is in the blowing agent that is used to foam the resin into its expanded form. Otherwise, many of the environmental impacts, for the purposes of this guideline, are similar to those of solid plastics. Therefore, this section deals mainly with the additional impacts to air caused by expanded plastic.

Impacts to Air – Blowing Agents

Expanded plastics are produced by incorporating a blowing agent into the manufacturing process. The blowing agent is either incorporated into the raw material during manufacture of the resin beads or introduced during expansion of the resin into a packaging product (this second process is referred to as extruded foam plastic). Steam or hot air is often used to expand the blowing agent and the resin beads into expanded form.

Expanded plastics have historically been associated with depletion of the ozone layer. This is because CFCs, and later HCFCs, were used as the blowing agent during expansion of some extruded plastics. However, as discussed earlier in this guideline (pg 28), the Montreal Protocol in 1986 phased out the use of CFCs. Since then, industry has, for the most part, complied with this agreement. More recently, HCFCs, which were used as a CFC substitute but still have ozone depleting properties, are being removed from foam packaging manufacturing processes. In the place of CFCs and HCFCs, manufacturers are turning to pentane, butane (both

hydrocarbons) or carbon dioxide. Expanded polystyrene, for example, uses pentane as the blowing agent. While these substances do not contribute to ozone depletion, pentane can contribute to ground level ozone, which is associated with many health problems, including asthma.

The extrusion and expansion processes may release the blowing agent into the atmosphere. Many manufacturers capture and reuse the blowing agent in a closed system. Installation of recapture systems should be encouraged to reduce harmful air emissions and preserve natural resources.

Impact Reduction Strategies

The following sections specify design techniques that can be used to reduce, reuse, and recycle expanded plastics commonly used in packaging. In addition, the following sections will provide suggestions on alternative materials that can be used, guidance on how to use recycled content in packaging products, and strategies to reduce the overall impacts of expanded plastic.

Expanded plastics are often used in the electronic packaging industry. Studies have shown that recycling and reuse strategies for plastic-based products can yield significant environmental benefits in terms of fossil fuel consumption and greenhouse gas emissions. In addition, reducing and reusing plastic products will decrease the amount of plastic in our solid waste stream.

Material Reduction

Material reduction is the preferred impact reduction technique for all types of electronics packaging, but it is especially effective for plastics. The following strategies can be used to reduce the amount of expanded plastics needed for electronics packaging:

- Proper selection of the type of foam can allow you to reduce wall thickness, density and maintain required cushioning performance. Reduced wall thickness can also be used on molded cushions (e.g., molded expanded polystyrene, EPS end caps and cushioned trays).
- Reduce foam density. This can be done easily by using EPP vs EPE. Prior to making efforts to reduce foam density, it is important to keep in mind that the performance properties and recyclability of EPS, EPP, EPE, and Urethane differ greatly and need to be evaluated individually when deciding on a cushioning material.

Design for Reuse

Given the proper operating environment and the proper design, most foamed plastics are reusable.

- Certain foam products, for example EPE and EPP, can be reused several times when designed properly.

- Some foam cushions made with low-density materials may break apart and/or compress after repeated use, making them unsuitable for reuse. For example, EPE and EPP have the potential to be both low density and very durable compared to EPS which has a very low tear strength. Cushioning materials selected should be able to provide adequate shock protection after many drops and reuses. As a general guide, a cushion should be able to pass the test requirements for each reuse.

Design for Recyclability

An important consideration for designs using expanded plastic packaging is the end use options for the material. Some manufacturers have arrangements with their fabricators to return the scrap materials when the truck delivers the next order of a new product. More often though, the materials may be too bulky or light to be cost-effectively shipped for reuse or recycling, or the infrastructure may not exist to recycle or collect materials for reuse. Material selection decisions based on recyclability should consider the ultimate recovery possibilities of the material. There are numerous plastics recycling sites around the country and many of them are identified on the www.plasticsresource.com website. The following suggestions can increase the recycling potential of expanded plastics.

- Label the plastic effectively so the various resin types can be identified for recycling. This will enable the recycler to efficiently separate plastic materials by resin type. (e.g., High Density Polyethylene, Polystyrene, Polypropylene...)
- Use commingled plastics as little as possible. Commingled plastics are not easily identifiable for separation, making them more difficult to recycle.
- Avoid using materials that contain carbon or metal fiber. If these contaminants get in the material, they often cannot be removed without excessive cost. Recycling carbon or metal-loaded material will eventually increase the conductivity of the material, which can be extremely dangerous.
- Avoid adding other contaminants such as staples, glue, labels, and fire-retardant chemicals.

Internal Recycling

Expanded plastics used in packages will have to be in the following forms to be collected and recycled. Before setting up/using any recovery system, determine the specific plastic you are using as well any other materials that were added to the product.

Polystyrene, Polypropylene, and Polyethylene

- Free of contaminants (Staples, glue, labels, addition of fire-retardant chemicals)
- Custom molded parts, Loose-fill (peanuts), Thermoformed trays
- Contained via baling, compacting, or bagging

Polyurethane

- Polyurethane actually comes in 2 forms, both flexible and rigid.
- Free of contaminants (Any material which is not either polyester or polyether is considered a contaminant. The list includes but is not limited to: Foam-in-Place, rigid urethane, corrugated, nails, wood scraps, and other plastics.)

Using Recycled Content

Although the availability recycled foam and technological considerations can limit the ability of packaging manufacturers to incorporate significant amounts of recycled content, many expanded plastics can contain post-industrial and post-consumer recycled content. With proper quality controls, recycled post-consumer plastics perform as well as virgin plastics. There are two main ways that protective packaging manufacturers can incorporate recycled content into EPS protective packaging; blend in used EPS particles from bead foams that have been ground down to the bead level, or purchase beads that already contain recycled content.¹ The former of these two options is the more common way for manufacturers to incorporate recycled content. Unfortunately, the beads that have been ground and reused as recycled content basically serve as filler material and generally do not make up more than 10-15% of the new protective packaging. The latter process is a relatively new option that has been available for since 2001. Using recycled beads in the manufacturing process can produce protective packaging that contains a higher percentage of recycled content.² The EPS recycled content recommendations contained in the following chart provided by the U.S. EPA for purchasing expanded plastics is most likely a reflection of the later option that uses recycled beads in the manufacturing process.³ The values included in the chart indicate the purchasing possibilities within the industry. All effort should be made to obtain these goals, but they should not be considered an absolute. However, it should be understood that certain material performance requirements may not be currently obtainable when recycled content is used. (Examples include ESD protection, corrosion control, shock and vibration performance, etc.) In addition, it is important to stay up-to-date on new technologies and new products that are available with higher recycled content.

Item	Post-consumer (%):	Total Recycled Content (%):
Expanded Plastics		
Expanded Polystyrene	50%	50%
Expanded Polyethylene	25-30%	25-30%

Table 12. The United States EPA recommended recycled content goals for expanded plastics.

For contact information of buyers and sellers of recycled plastics please refer to the www.plasticsresource.com web site.

Alternative Materials

Sometimes the use of an alternate material and design can result in the reduction of material used. Shock protection requirements for a design can be met by using:

- Different types of foam (EPS, EPE, EPP, or Urethane)
- Corrugated or paperboard fiber cushioning material
- Molded pulp cushioning material
- Cushioning products made using a combination of starch and paper fibers

Because of differences in chemical composition and physical structure, the volume and mass of foam needed will vary depending on the material selected. When choosing a cushioning material to use in packaging, the general goal is to use as little as possible without compromising the protection of the product. However, it is important to remember that although a material may be require less volume and mass, that does not necessarily mean that it is better for the environment. Be sure to research the overall environmental impacts of your material options. In certain situations, biodegradable cushioning materials can also be used as an alternative to expanded plastics.

Degradable Materials

Some plastics manufacturers are attempting to comply with legislation by offering materials that are degradable. Degradable materials are ones that break down by natural causes, usually through one of two mechanisms: microorganisms or bacteria in the case of biodegradable materials, or the sun's ultraviolet rays in the case of photodegradable materials. Carbonyl additives are commonly encountered in photodegradable materials. Cornstarch or vegetable oil is sometimes added to materials to enhance their biodegradability. However, unless used in conjunction with the proper disposal methodology (some landfills do not afford the opportunity for degradation) both additive types represent a misuse of resources. The use of biodegradable or photodegradable materials can inhibit recycling. It complicates resin separation by adding additional materials to the waste stream, and if these materials are introduced to a recycling operation they may compromise the quality of future products manufactured from the resin. For example, PE foam is biostable and will not decompose effectively. Any attempt to enhance its degradability by adding cornstarch or photodegrading agents only discourages its reuse and recycling. Therefore, biodegradability of a plastic is not considered preferable unless the material is bound for composting. This does not completely rule out the use of biodegradable materials, however. Some may still have other benefits, such as Polylactic Acid, which is made from corn waste, a renewable resource.

Recommendation: Do not use degradable plastics unless the package will be composted once it has served its useful purpose.

References

¹ “Recycled Content in Expandable Polystyrene Foam Protective Packaging.” Alliance of Foam Packaging Recyclers, 2001.

² Alliance of Foam Packaging Recyclers, 2001.

³ Environmentally Preferable Products Recycled Content Guide. 2001. State of Missouri DPMM - Mo. State Recycling Program. 5 March 2005
<<http://www.oa.mo.gov/purch/recycling/contguide.pdf>>.

Packaging Scenario: Plastics



Randy at XYZ Electronics – Considering Plastics

[Continued from page 60]

Now that Randy knows which paperboard material is environmentally preferable, he must assess the plastic materials that are part of his three design alternatives (PVC, PP, PET, and EPS).

Environmental Impacts

The following chart provides a qualitative comparison of the life cycle environmental impacts associated with the plastic materials that Randy is considering. The information for PET is for virgin PET resin (recycled-content life cycle inventories were not available). Overall impacts for recycled-content PET are generally lower, so this must be taken into account.

	PVC	EPS	PP	PET
Energy Use	Highest	High	Low	Medium
Impacts to Water	Highest	Medium	Low	High
Impacts to Air	Medium	High	Low	Highest
Toxicity Risk	Highest	High	Low	Medium

Table 13. The rankings *Low*, *Medium*, *High*, and *Highest* are attributed to each type of plastic. *Low* indicates the least amount of negative environmental impacts and *Highest* indicated the largest amount of negative environmental impacts.

Impact Reduction Strategies

Even with the above rankings, Randy has a difficult job deciding which material is the most environmentally preferable. It appears that polypropylene is the preferable material, but it cannot be recycled in most regions. PET is recyclable, but has some high impacts. Randy is fairly certain, however, that PVC is not environmentally preferable. It appears to be the worst performer in this qualitative exercise.

Now that Randy has assessed the individual materials in his design alternatives, he can evaluate the overall environmental performance of each Package Option.

Ch 9: Printing Inks

This Chapter Covers:

- The environmental impacts of inks
- Strategies for reducing the impacts of inks

Printing inks are relevant to this discussion due to their widespread use on all kinds of packaging products. Consumer packaging, for example, often contains elaborate and colorful marketing messages that are created using printing inks. The following chapter will explain the environmental impacts of inks and provide guidance on how to reduce these impacts.

Flexographic printing is the most commonly used method to print onto packaging. Inks are either solvent-based, water-based or UV-based.

Flexographic printing inks contain several components, including pigment, resin, solvent and additives.¹ Pigment is the color that is associated with the ink. Resin, often derived from petroleum, causes the ink to adhere to the printing medium, or substrate. Solvent makes the ink fluid and is often designed to evaporate once the ink adheres to the substrate. Additives give the ink other properties, such as flexibility and texture.

Environmental Impact

The manufacture and use of printing inks result in two main categories of environmental impact: emission of VOCs and heavy metal content. Emission of VOCs continues to be a concern and is also discussed below. The heavy metal problem has, for the most part, been drastically reduced in scale – see “Inks and Heavy Metals” below.

Impacts to Air

Several of the ingredients used in flexographic printing inks result in harmful emissions to the atmosphere. These emissions, mainly VOCs, occur both during manufacture of the ink and during the application of the ink to the package. Emission of VOCs is affected by many factors, such as the kind of ink (whether solvent-, water- or UV-based), the pigment used, ambient temperature, speed of the press system, and equipment operating time.

Research shows that all three varieties of flexographic ink pose environmental risks from VOC emissions. In most cases, water- and UV-based inks result in fewer VOC emissions than do solvent-based inks. This is because solvent-based inks tend to contain more VOC-producing chemicals. However, because users of solvent-based inks are required to install an oxidizer (a piece of equipment designed to consolidate and filter air emissions), there may be some cases in which VOC emission is lower for solvent-based ink facilities.²

For a detailed comparison of flexographic printing inks, see the U.S. EPA's study titled “Flexographic Printing Ink Options: A Cleaner Technologies Assessment.”
<http://www.epa.gov/dfe/>

Inks and Heavy Metals

Prior to the 1990s, printing inks commonly contained mercury, lead, cadmium, and other heavy metals, which are all toxic to humans. Legislation during the 1990s in the U.S. and European Union called for reduction of heavy metal content in inks due to health concerns. While there was no threat of exposure during the use of packaging, accidental spills or releases during manufacture were a concern. In addition, packaging disposed of in landfills or through incineration often resulted in a release of heavy metals to the environment. In 1989, the Coalition of Northeastern Governors in the United States drafted legislation that limited heavy metal content packaging. This limitation soon became law in the entire United States. In 1994, the European Union's Directive on Packaging and Packaging Waste required a similar limitation on heavy metals in packaging. Due to these regulations, heavy metals in packaging (mainly from printing inks) have been greatly reduced.

In 2005, in both the United States and the EU, heavy metals must be limited to 100 parts-per-million in packaging and packaging waste.

Impact Reduction Strategies

There are no standard solutions to reducing the environmental impacts of inks. Due to the complex nature of this topic, this section will not present specific directions on how to reduce the environmental impacts of inks. Instead, it will provide resources and knowledge about the various types of inks that can then be applied to reduce the impacts of inks in a variety of different situations. The following are the key points that should be remembered when using inks:

- Do not use inks that contain heavy metals. For more information refer to the Inks and Heavy Metals section above.
- The manufacture of inks as well as the application of inks to packaging results in the emission of VOC's into the atmosphere. Packaging professionals should ensure that ink suppliers are complying with all regulations relating to air emissions.
- Generally, water-based inks have the fewest environmental impacts. There are exceptions to this generalization, though. In certain situations, solvent-based inks can have fewer environmental impacts than water-based inks, and would be the preferred option. Hence, it is important to learn about the materials and processes used to make the ink to determine the best option for each situation.
- For a detailed comparison of flexographic printing inks, see the U.S. EPA's study titled "Flexographic Printing Ink Options: A Cleaner Technologies Assessment." This article can be found at: <http://www.epa.gov/dfe/>.
- Recent advances in technology have reduced the risk of ink-related problems during recycling processes. However, packaging professionals should learn about the recycling infrastructure in relevant regions to know if ink use can inhibit recycling.

References

¹ Flexographic Ink Options: A Cleaner Technologies Substitute Assessment, February 2002. Design For Environment Program, Office of Pollution Prevention, United States Environmental Protection Agency. 11 March 2005 <<http://www.epa.gov/dfe/pubs/flexo/ctsa/index.html>>.

² United States Environmental Protection Agency <<http://www.epa.gov/dfe/pubs/flexo/ctsa/index.html>>.

Ch 10: Balancing Issues

This Chapter will cover:

- Trade-offs between environmental issues
- The effect of environmental issues on other packaging considerations

This chapter will examine how to balance the various environmental issues that arise from different packaging choices. While there is sometimes a clear environmental preference for one packaging choice over others, in other cases there is a trade-off between different kinds of environmental impacts. On top of the many types of environmental concerns, there can also be a conflict between environmental impact and other packaging considerations.

This chapter opens with a discussion of evaluating trade-offs between environmental issues. Then we consider environmental issues in relation to other packaging considerations.

Tradeoffs between Environmental Issues

In some cases there are clearly preferred options that reduce the environmental impact of packaging. However, sometimes the options produce mixed results. For example, selecting recycled corrugated fiberboard reduces the impact to energy and solid waste, but selecting virgin corrugated results in fewer greenhouse gases. If we have two alternatives, one that will reduce landfilled waste by 300 lbs and one that will reduce mercury by 300 mg, which is the better option?

The first step in evaluating this scenario is to consider the changes in terms of percentages. If one option will reduce landfilled waste from 1500 to 1200 lbs (20% reduction or 300 lbs) and another option will reduce mercury release from 500 mg to 200 mg (60% reduction or 300 mg), then the reduction in mercury is a greater percentage change (even though the landfilled waste reduction is greater in absolute weight). Of course, the percentage change is only one aspect among many to consider.

As to whether a 20% reduction of landfill waste is better than a 20% reduction in greenhouse gases, there is no definitive way to make this decision. However, there are some methodologies that offer guidance. The most rigorous examination of these issues involves Life Cycle Assessments (for more information, see pg 26). A methodology sometimes used in Life Cycle Assessment (LCA) is called “weighting” or “valuation.” This method is used at the end of the LCA when the totals for each category of impact have been calculated (for example, all of the greenhouse gases generated in resource extraction, refinement, production, and end-of-life handling are added together). These totals are then compared to levels known to be harmful, requirements of regulations, or total world output. Next, each category is subjectively assigned a weight indicating its importance in relation to other impacts (for example, human toxicity might receive a higher weight than greenhouse gas potential if it is determined to be more important). Then, the total impact for each category is multiplied by the category’s weight and the products are summed to give an aggregated (single) value of the total impact of the product. Some LCA software packages, like TEAM (see “Evaluation Software” below), use this method to aggregate all environmental impacts into a single score. This allows for easy comparison between package

designs, but it also obscures what the precise impacts are and makes hidden assumptions about the importance of different impacts. These subjective weighting systems can be influenced by many factors such as cultural values from a particular region, a country's regulations, or a company's environmental goals.

The most critical step in valuation is determining the specific weights of the categories. There is no consensus on how weights should be assigned. Often a company's environmental policies determine the weight given to each type of environmental impact. Has the company set a goal to phase out toxic materials? Is there a zero-landfill target? Is the company trying to reduce its greenhouse gas emissions? The answers to these questions will guide the ultimately subjective selection of the weights necessary to quantitatively evaluate the trade-offs between impacts.

Evaluation software

Here are some sophisticated pieces of software that aim to quantitatively weigh and compare many different environmental impacts.

The following are the three leading full life cycle assessment tools. They are capable of taking all of the materials and processes for a package and its delivery and generating a list of its environmental impacts. They also have an option to combine the various environmental impacts into a single score, which can be helpful in comparison.

- **GaBi** (from the University of Stuttgart, Institute of Polymer Testing and Polymer Science): high-quality Life Cycle Assessment software (for all materials, not just plastic) <http://www.gabi-software.com/>
- **Sima Pro** (from PRé Consultants): another leading Life Cycle Assessment software <http://www.pre.nl/simapro/default.htm>
- **Tool for Environmental Analysis and Management** (TEAM, from Ecobilan/Price Waterhouse Coopers): another leading Life Cycle Assessment software http://www.ecobalance.com/uk_lcatool.php

Here are three methods for combining known environmental impacts into a single score or rating.

- **EcoIndicator99** (from PRé Consultants): Evaluation method used in many LCA programs. Topics evaluated include carcinogenic, eco-toxicity, resource depletion, fossil fuel use, land-use changes, damage to ecosystem quality, and ethical values http://www.pre.nl/eco-indicator99/eco-indicator_99_introduction.htm
- **Environmental Design for Industrial Products** (EDIP, from the Danish EPA): Available for purchase as a book. European-centered method includes global warming, ozone depletion, smog formation, acidification, nutrient enrichment, eco-toxicity, and human toxicity through environmental exposure. <http://www.mst.dk/activi/08020000.htm>

- **Tool for the Reduction and Assessment of Chemical Impacts (TRACI**, from the US EPA): Free U.S.-focused evaluation tool which evaluates topics including ecotoxicity, eutrophication, human health, ozone depletion, global warming, acidification, photochemical smog, fossil fuel depletion, land use, and water intake.
http://www.epa.gov/ORD/NRMRL/std/sab/iam_traci.htm

Packaging Considerations

There are times when the goals of environmental impact reduction and other packaging considerations (such as packaging cost or product protection) are in perfect agreement – improving one improves the other (for example, reducing the material used for packaging reduces both environmental impact and package costs). However, there are also times when these goals conflict – improving another packaging consideration increases the environmental impact (for example, increasing the size of the package to deter shoplifting also increases the material used and thus environmental impact), or vice versa.

Understanding how different packaging requirements can affect environmental performance will help the packaging professional manage the overall environmental impact of a package. This section examines these considerations in terms of their agreement or disagreement with environmental issues. The following considerations will be examined in this section:

- **Product Protection:** How much protection does the packaging need to provide to the product? What does it need to protect the product from?
- **Package Cost:** How much does it cost to create the packaging, including materials, assembly, design time, and tooling costs?
- **Shipping Cost:** How much does it cost to ship the package?
- **Security:** Does the packaging need to be tamper-proof or large enough to deter theft?
- **Marketability:** Does the package meet the company's requirements and expectations for marketability in stores?
- **Customer:** Who is the packaged product going to (factory, distribution center, retailer, consumer)? What are their expectations for the package?

Product Protection

What elements does the package need to protect against? What is the needed compression strength for the carton? What is the resonating frequency and how much work will the packaging need to do to avoid it? Protection is cited as the single most important consideration for packaging design.

Supports Environmental Considerations

- **Breakage Protection:** In the electronics industry, the environmental impact of the product being protected by the package is usually greater than that of the packaging itself. Therefore, packaging that inadequately protects the product creates greater environmental impact when the product breaks and must be repaired or disposed of.
- **New Materials:** New developments like plastic-stabilized pulp molds (pg 83) offer recycled content, are recyclable, and increase compression strength for added protection.

Conflicts with Environmental Considerations

- **Packaging Fragile Products:** For very fragile products, it can be more beneficial environmentally (as well as economically) to make the product more robust than it is to surround it with large amounts of packaging for protection. The more robust product also adds value for the customer.
- **Overpackaging:** Providing excess protection due to unclear protection needs or overcompensation increases the environmental impact of packaging (as well as product and shipping costs).

Package Cost

What are the material costs? What are the costs associated with package assembly and palletization? The cost of the package can be easily measured and is often of high visibility and concern.

Supports Environmental Considerations

- **Material Reduction:** Reducing the material in a package reduces both the cost and the environmental impact of the packaging. According to the Tellus Institute Packaging Study, with the exception of the presence of certain toxic materials (like heavy metals and PVC plastic), the most important indicator of environmental impact is the mass of the package¹.
- **Alternative Materials:** Some alternative materials, particularly ones with recycled content, can be less expensive than standard materials, reducing both the packaging cost and the environmental impact.

Conflicts with Environmental Considerations

- **Alternative Materials:** Some alternative materials, such as corn starch-based expanded foam in place of expanded plastics, increase the packaging cost while decreasing the environmental impact.

Shipping Cost

What is the cost of shipping the packaged product? The mass and volume of the package usually determine the cost of shipping. For volume, a key concern is the shipping density (number of units that can fit in a freight truck, intermodal container, etc.). For mass, a high gross weight can increase shipping costs.

Supports Environmental Considerations

- **Volume Reduction:** Reducing the volume of the package increases the number of units per shipment, which reduces fuel consumed and thus both environmental impact and the cost of shipping.
- **Weight Reduction:** Depending on the shipping method, reducing the weight of the packaging may reduce shipping costs as well as environmental impact.

Conflicts with Environmental Considerations

- **Bulky Alternative Materials:** Some packaging alternatives with lower environmental impact achieve their needed protection through greater volume. This will reduce the shipping density, thus increasing shipping costs and the environmental impact from fuel consumption.

Security

How easy is it for the packaged good to be stolen? How easy is it to open the package and remove a small part? Can a child easily gain access into the package? These considerations add an extra dimension to package design that often clashes with environmental and other considerations. These considerations are most often encountered in packaging for the consumer market.

Supports Environmental Considerations

- **Package Durability:** If easily opened packages result in a product being unsellable and then disposed of, it results in a waste of resources. Therefore, durable packaging supports both product security and environmental impact reduction.

Conflicts with Environmental Considerations

- **Theft Protection:** Small products are often placed in oversized packaging to make theft of the product more difficult, using significantly more packaging material than is strictly needed to protect the product in transit, which increases the package's environmental impact.

Marketability

Is the packaging large enough to meet the company's need for information display? Are there requirements for image and text size and placement?

Supports Environmental Considerations

- **Disposal Instructions:** Promoting responsible recycling or disposal of the packaging as part of green marketing (using the existing packaging display surface) can improve the end-of-life performance of the packaging, lowering its overall environmental impact.
- **Green Marketing:** Touting the environmental performance of the package (if above average) can assist in marketing efforts, especially if coordinated with the marketing department. This is where recyclability and recycled-content materials can be advertised.
- **Consumer Education:** Using some of the package display space to educate the consumer on the choices your company made to reduce the environmental impact of the packaging can encourage consumers to think beyond just recycling and disposal issues to the impacts from resource extraction, production, shipping, etc.

Conflicts with Environmental Considerations

- **Large Displays:** If marketing desires result in a package that is larger than is strictly needed for product protection, this will result in more material usage and therefore greater environmental impact.

Customer

Who is receiving the packaged product? Requirements will vary for manufacturer packaging, distribution packaging, retailer packaging, and consumer packaging. The destination of the product will also determine the appropriateness of bulk packaging.

Supports Environmental Considerations

- **Bulk Packaging:** In cases where bulk packaging is appropriate, avoiding individual packaging can greatly reduce the material used to protect the product.
- **Reusable Packaging:** For pre-consumer customers, durable and reusable packaging can be feasible to reduce both costs and environmental impacts.

Conflicts with Environmental Considerations

- **Individual Packaging:** If the receiver requires individual packaging above the normal need for product protection, it will increase the resources used in packaging.

Conclusion

The environmental issues surrounding packaging decisions can be complex and have many interactions with both other environmental issues and other packaging considerations. By knowing how to prioritize environmental impacts and understanding how environmental issues interact with other packaging considerations, a packaging professional is able to make an educated decision on which packaging option is the most environmentally preferable while best meeting business needs.

Now that we have learned how to reduce the environmental impacts of a package, in the next chapter we will examine how to properly describe the environmental performance of packages through accurate and effective labels and declarations.

References

¹ “CSG/Tellus Packaging Study: Assessing the impacts of production and disposal of packaging and public policy measures to alter its mix, Boston: Tellus Institute, 1992.” Tellus Institute Packaging Study, 1992.

Packaging Scenario: Conclusion



Randy at XYZ Electronics – Conclusion

[Continued from page 86]

Now that Randy has evaluated the individual materials of his packaging options, he can put them together.

Summary of Impacts

Since he has already analyzed the impacts of paperboard (pg 62) and plastics (pg 86), he drafts a quick qualitative table to help him visualize the different environmental impacts from his three options:

Environmental Impact	PVC & Paperboard	Paperboard & Expanded Polystyrene	PP & PET
Natural Resources	Low	Low	Low
Energy Use	High	High	Medium
Impacts to Water	Highest	Low	Medium
Impacts to Air	Medium	Medium	Medium
Disposal	High	Medium	Low
Toxic Substances	Highest	Medium	Medium

Table 14. The rankings *Low*, *Medium*, *High*, and *Highest* are attributed to each package design. *Low* indicates the least amount of negative environmental impacts and *Highest* indicates the largest amount of negative environmental impacts.

Comparing Environmental Issues

Now that he knows the impacts of each of these options, he must determine which package represents the preferred group of environmental impacts. This involves comparing some environmental issues, like recyclability, with others, like toxic pollution. This requires inherently subjective value decisions, so Randy begins by taking another look at the Environmental Policy and goals of XYZ Electronics (pg 12).

The environmental policy clearly guides Randy to give significant weight to energy use and disposal impacts. Also, six months ago, XYZ declared a long-term and publicly-stated goal to be a good corporate citizen by eliminating toxic materials from their products. While much of the attention is focused on the electronics, Randy sees this as an opportunity for his packaging decision to support the company's goal. This leads him to give toxicity issues more weight in his evaluation.

Evaluating Choices

With more weight given to eliminating toxic substances, the PVC package stands out as having a relatively high toxic impact. Combined with its other high impacts, Randy eliminates the PVC package as an option. This leaves him with the paperboard container and the polypropylene container, which are pretty close in overall impact. However, for the categories of environmental impact that XYZ is focusing on (energy use, disposal, and toxics), polypropylene becomes the slightly preferred material for the package (paperboard has a better performance for impacts to water, but that is not as high a priority for XYZ).

Packaging Considerations

Next, to see how the three options affect his other packaging considerations, he drafts another quick table:

Packaging Consideration	PVC & Paperboard	Paperboard & polystyrene foam	PP & PET
Product Protection	high	medium (no protection from environmental damage)	high
Packaging Cost	same	same	same
Shipping Volume	80 in ³	124 in ³	80 in ³
Security	high	low (too easily opened)	high
Marketability	high	high	high
Customer Needs	low (hard to open)	high	high

Table 15. The rankings *Low*, *Medium*, and *High* are attributed to each package design for each packaging consideration. *Low* indicates poor performance and *High* indicates good performance.

Since the PP/PET package results in the best package performance as well as slightly better environmental performance in his most important categories, Randy decides to select that package. He summarizes the benefits of his new package over the old one:

Environmental Benefits

- It does not contain toxic materials such as heavy metals, chlorines, vinyl chloride monomers or other halogens.
- It does not produce any ozone depleting chemicals.
- The main package can be recycled as a category 5 plastic (though the infrastructure for this recycling is limited in North America).
- The package materials can be incinerated with no toxic emissions.
- The thermoformed plastic inner tray is made from 100% post-consumer recycled PET material, which not only uses recycled materials, but is also recyclable as a category 1 plastic (for which recycling infrastructure is widely available).

Operational Benefits

- The PET tray holds the inkjet cartridge in place without any product damage.
- The design eliminates the need for two retail paperboard cartons in the clamshell .
- The design eliminates shipping to and from a 3rd party clamshelling operation (used in the old PVC package), which reduces steps in the supply chain, resulting in faster production and lower environmental impacts from transportation.
- The smaller package size increases pallet density, which reduces shipping costs and operational space requirements as well as environmental impacts from transportation.
- The smaller size reduces warehouse space requirements and storage requirements.
- The new materials reduce packaging weight by 66% (127g to 43g).
- An easy-open feature added to the back of the new package increases safety and ease of use for the customer.

Environmental Characterization

Randy looks over his list of benefits to see what he can add to the package to characterize the environmental features. The lack of heavy metals and ozone depleting substances is a given in North America, so he leaves those unspoken. To aid in recycling, he puts together two recycling labels, one for the outer package and one for the inner tray. He also wants to tout the recycled content of the PET, so he includes that as part of the label:



Conclusion

Randy has complied with all packaging regulations and met all of the goals for this package (fewer environmental impacts, less packaging, and improved ease of use and safety for the consumer). In addition, he has achieved some cost savings through reducing the weight and volume of packaging materials, thereby lowering material, shipping, and storage costs.

Ch 11: Environmental Labeling and Declarations

This Chapter Covers:

- How to avoid being deceptive and/or misleading when designing environmental labels and declarations
- Voluntary environmental certification programs and the associated Eco-Labels

Environmental labeling and declarations are an effective way to inform the consumer about what your company has accomplished through its environmental initiatives. The following chapter examines the criteria the International Organization for Standardization (ISO) and the U.S. Federal Trade Commission (FTC) have set for the appropriate use of environmental labeling. The chapter concludes with a brief look at three types of environmental certification programs as defined by ISO.

Additionally, Appendix F (pg 164) includes more detailed information on standardized symbols.

Environmental Labeling and Declarations Guidelines

The effective characterization of a package's environmental attributes can increase market share and reduce the environmental impact from that product category. Environmental labels provide potential purchasers with information about a product in terms of its overall environmental character, a specific environmental aspect, or any number of factors¹. Assuming a competitive marketplace, other providers may respond by improving the environmental aspects of their own products to enable them to use environmental labels or make environmental declarations, resulting in reduced environmental impact from that product category.

The assessment of environmental performance should be based on scientific methodology that is sufficiently thorough and comprehensive to support the claim with results that are accurate and reproducible.² Specifically, assessment of environmental performance is based on environmental policy, environmental objectives, and environmental targets.³

ISO 14020

The FTC and ISO have established voluntary guidelines for environmental performance characterization. ISO 14020 sets nine general principles on environmental labels and declarations. The following table lists the nine principles; however, it is useful to examine the first in a little more depth. The first principle states: "Environmental labels and declarations shall be accurate, verifiable, relevant and not misleading."⁴ Cause-related marketing is not a new concept, but it has become so prevalent in environmental performance characterization that there are concerns of misleading or inaccurate information being disseminated by some companies. The term "green-washing" refers to a provider trying to look more environmentally preferable than they are. Another complication is that the extent of green-washing is often subjective, due to the inherent uncertainty associated with scientific methods. In an attempt to discourage green-washing, ISO 14020 requires that information concerning the procedure, methodology, and any

criteria used to support environmental labels and declarations shall be available and provided upon request to all interested bodies. This information must include any underlying principles, assumptions, and boundary conditions.

Environmental Labeling Principles From ISO 14020

- Environmental labels and declarations shall be accurate, verifiable, relevant, and not misleading.
- Procedures and requirements for environmental labels and declarations shall not be prepared, adopted, or applied with a view to, or with the effect of, creating unnecessary obstacles to international trade.
- Environmental labels and declarations shall be based on scientific methodology that is sufficiently thorough and comprehensive to support the claim that produces results that are accurate and reproducible.
- Information concerning the procedure, methodology, and any criteria used to support environmental labels and declarations shall be available and provided upon request to all interested parties.
- The development of environmental labels and declarations shall take into consideration all relevant aspects of the life cycle of the product.
- Environmental labels and declarations shall not inhibit innovation which maintains or has the potential to improve environmental performance.
- Any administrative requirements or information demands related to environmental labels and declarations shall be limited to those necessary to establish conformance with applicable criteria and standards of the labels and declarations.
- The process of developing environmental labels and declarations should include open, participatory consultation with interested parties. Reasonable efforts should be made to achieve consensus throughout the process.
- Information on the environmental aspects of products and services relevant to an environmental label or declaration shall be available to purchasers and potential purchasers from the party making the environmental label or declaration.

FTC “Green Guides”

“Section 5 of the FTC Act prohibits unfair or deceptive acts or practices in or affecting commerce.”⁵ The “Green Guides” apply Section 5 of the FTC Act to environmental marketing claims. The following excerpts from the FTC “Green Guides” provide brief explanations and examples of how to avoid being deceptive or misleading in your company’s environmental claims.

Examples in *italics* come directly from the FTC “Green Guides.” To review more examples of appropriate and inappropriate environmental claims, see:

<http://www.ftc.gov/bcp/grnrule/guides980427.htm>

Impact Reduction Strategies

Characterization of impact reduction strategies is an opportunity to explain programs and methods used to reduce environmental impacts throughout the life cycle of the package to potential purchasers. It is useful to group impact reduction strategies into categories; we have grouped them into: material reduction, design for reuse, design for recyclability, using recycled content, and alternative materials. However, caution should be used to avoid overgeneralization leading to misrepresentation; unqualified general environmental claims are difficult to interpret and may express a wide-range of meanings to consumers. Every environmental claim about a quality, feature, or attribute of a product or package should be substantiated. Avoid generalized claims of environmental benefit, such as “environmentally friendly,” “green,” “earth friendly,” “environmentally safe,” and the like, unless they can be substantiated.

Example 1: A product wrapper is printed with the claim "Environmentally Friendly." Textual comments on the wrapper explain that the wrapper is "Environmentally Friendly because it was not chlorine bleached, a process that has been shown to create harmful substances." The wrapper was, in fact, not bleached with chlorine. However, the production of the wrapper now creates and releases to the environment significant quantities of other harmful substances. Since consumers are likely to interpret the "Environmentally Friendly" claim, in combination with the textual explanation, to mean that no significant harmful substances are currently released to the environment, the "Environmentally Friendly" claim would be deceptive.

Example 2: A product is advertised as "environmentally preferable." This claim is likely to convey to consumers that this product is environmentally superior to other products. If the manufacturer cannot substantiate this broad claim, the claim would be deceptive. The claim would not be deceptive if it were accompanied by clear and prominent qualifying language limiting the environmental superiority representation to the particular product attribute or

attributes for which it could be substantiated, provided that no other deceptive implications were created by the context.

Distinction between Product, Package, and Service

An environmental performance characterization should be clearly stated to apply to the product, package, or service. Minor or incidental parts do not need to be delineated unless they may significantly hinder the claim of environmental benefits.

Example 1: A box of aluminum foil is labeled with the claim "recyclable," without further elaboration. Unless the type of product, surrounding language, or other context of the phrase establishes whether the claim refers to the foil or the box, the claim is deceptive if any part of either the box or the foil, other than minor, incidental components, cannot be recycled.

Example 2: A soft drink bottle is labeled "recycled." The bottle is made entirely from recycled materials, but the bottle cap is not. Because reasonable consumers are likely to consider the bottle cap to be a minor, incidental component of the package, the claim is not deceptive. Similarly, it would not be deceptive to label a shopping bag "recycled" where the bag is made entirely of recycled material but the easily detachable handle, an incidental component, is not.

Biodegradability

Environmental performance characterization should not include unsubstantiated claims of biodegradable or degradable material. Any such claims should be substantiated with reliable and accurate scientific evidence that the package and all its constituent parts will completely biodegrade. Additionally, information should be provided on what conditions are required for the package to biodegrade (e.g., ambient) and whether these are consistent with common forms of disposal.

Example 1: A trash bag is marketed as "degradable," with no qualification or other disclosure. The marketer relies on soil burial tests to show that the product will decompose in the presence of water and oxygen. The trash bags are customarily disposed of in incineration facilities or at sanitary landfills that are managed in a way that inhibits degradation by minimizing moisture and oxygen. Degradation will be irrelevant for those trash bags that are incinerated and, for those disposed of in landfills, the marketer does not possess adequate substantiation that the bags will degrade in a reasonably short period of time in a landfill. The claim is therefore deceptive.

Example 2: A plastic six-pack ring carrier is marked with a small diamond. Many state laws require that plastic six-pack ring carriers degrade if littered, and several state laws also require that the carriers be marked with a small diamond symbol to indicate that they meet performance standards for degradability. The use of the diamond, by itself, does not constitute a claim of degradability.

Recycled Content

A recycled content claim should qualify the amount of recycled content, by weight, used in the package. Additionally, recycled content should only apply to material that has been recovered from the waste stream during the manufacturing process or after consumer use. If the entire package, except incidental parts, is made from recycled content, an unqualified claim of recycled content may be made.

Example 1: A product in a multi-component package, such as a paperboard box in a shrink-wrapped plastic cover, indicates that it has recycled packaging. The paperboard box is made entirely of recycled material, but the plastic cover is not. The claim is deceptive since, without qualification, it suggests that both components are recycled. A claim limited to the paperboard box would not be deceptive.

Example 2: A paperboard package with 20% recycled fiber by weight is labeled as containing "20% recycled fiber." Some of the recycled content was composed of material collected from consumers after use of the original product. The rest was composed of overrun newspaper stock never sold to customers. The claim is not deceptive.

Recyclability

Recyclability claims should qualify which components of the package are recyclable and which are not. Additionally, recyclability claims only apply to material that can be recycled with the available recycling infrastructure.

Example 1: A nationally marketed bottle bears the unqualified statement that it is "recyclable." Collection sites for recycling the material in question are not available to a substantial majority of consumers or communities, although collection sites are established in a significant percentage of communities or available to a significant percentage of the population. The unqualified claim is deceptive because, unless evidence shows otherwise, reasonable consumers living in communities not served by programs may conclude that recycling programs for the material are available in their area. To avoid deception, the claim should be qualified to indicate the limited availability of programs, for

example, by stating "This bottle may not be recyclable in your area," or "Recycling programs for this bottle may not exist in your area." Other examples of adequate qualifications of the claim include providing the approximate percentage of communities or the population to whom programs are available.

Example 2: A label claims that the package "includes some recyclable material." The package is composed of four layers of different materials, bonded together. One of the layers is made from the recyclable material, but the others are not. While programs for recycling this type of material are available to a substantial majority of consumers, only a few of those programs have the capability to separate the recyclable layer from the non-recyclable layers. Even though it is technologically possible to separate the layers, the claim is not adequately qualified to avoid consumer deception. An appropriately qualified claim would be, "includes material recyclable in the few communities that collect multi-layer products." Other examples of adequate qualification of the claim include providing the number of communities with programs, or the percentage of communities or the population to which programs are available.

Material Reduction

There are four basic approaches to material reduction or waste reduction: (1) Reuse products; (2) Increase product durability; (3) Reduce the amount of material per product; and (4) Decrease consumption. Claims of source reduction should be qualified for the amount of the source reduction and how comparisons were made.

Example 1: An ad claims that solid waste created by disposal of the advertiser's packaging is "now 10% less than our previous package." The claim is not deceptive if the advertiser has substantiation that shows that disposal of the current package contributes 10% less waste by weight or volume to the solid waste stream when compared with the immediately preceding version of the package.

Example 2: An advertiser notes that disposal of its product generates "10% less waste." The claim is ambiguous. Depending on contextual factors, it could be a comparison either to the immediately preceding product or to a competitor's product. The "10% less waste" reference is deceptive unless the seller clarifies which comparison is intended and substantiates that comparison, or substantiates both possible interpretations of the claim.

Describing Alternative Materials

Environmental performance characterization of alternative materials should follow all of the above criteria (i.e., not include unsubstantiated claims regarding the recyclability, material reduction, recycled content, biodegradability, or other claims of environmental benefit).

Certification Programs

Voluntary environmental certification programs provide a method for evaluation and endorsement of a package. If the package meets the environmental standards as set by the certifying body, it may display the appropriate ecolabel, according to program guidelines (see ISO 14020: Environmental labels and declarations – General principles, pg 100). The ecolabel identifies a package as environmentally preferable, provides third-party corroboration of environmental claims, and distinguishes a product from those of competitors that can't support their environmental assertions. Certification programs have been found to be particularly effective as marketing tools in Western European countries and in jurisdictions where environmental purchasing programs exist.

In most countries, voluntary environmental certification programs are either controlled or regulated by the government. In the US, however, voluntary environmental certification programs are privately operated and unregulated. There is generally a fee associated with the application and verification process, and the programs may require additional fees for use of the ecolabel.

ISO has divided certification programs into three basic forms, as follows:

ISO Type I

- ISO Type I certification programs correspond to ISO 14024: Environmental labels and declarations – Type I environmental labeling - Principles and procedures.
- This category includes what are known as “Seal-of-Approval” Programs. These programs offer certification for various categories of products as well as product-specific certification.
- Examples of “Seal-of-Approval” Programs:
- Green Seal: <http://www.greenseal.org/>
 - Based in the United States
 - *Criteria:* Green Seal uses a life cycle approach to ensure that all significant environmental impacts of a product are considered.
 - *To become certified:* Prepare an application for certification (available at the Green Seal website), pay product evaluation fee, submit the necessary data and product samples, and set up a site visit.



- EU Eco-Label Flower: <http://europa.eu.int/comm/environment/ecolabel/>
 - Based in the European Union
 - Criteria: The Eco-Label Flower uses a life cycle approach similar to Green Seal, with the major difference being that the criteria are developed by the European Union Eco-Labeling Board and must be passed by the Commission. Criteria are not passed until applicable member states are allowed to vote.
 - To become certified: Present an application with all required certification and necessary documents to the Competent Body in a member state that the product is sold in and pay the applicable fees.



ISO Type II

- ISO Type II certification programs correspond to ISO 14021: Environmental labels and declarations – Self-declared environmental claims (Type II environmental labeling).
- This category includes “Self-Declared Information” programs. These programs offer certification for manufacturers based on the environmental impact and performance of the manufacturing process and the product. They rely on independent third party certification.
- Example of a “Self-Declared Information” Program
- Scientific Certification Systems (SCS): <http://www.scscertified.com/>
 - Based in the United States
 - Criteria: SCS develops its criteria from life cycle studies. SCS offers single-attribute certification claims to manufacturers (e.g., material content, indoor air quality, etc.), environmentally preferable product certification, and life cycle assessment services.
 - To become certified: (1) Authorization: Applicant provides SCS with initial information to determine if certification is feasible and signs a work order and certification agreement. (2) Data review: Applicant submits requested data. (3) Claim verification: Could include an on-site audit by an SCS engineer; including up-stream suppliers as necessary. (4) Certification: If product claims are substantiated certification is granted with use of certification artwork as applicable. (5) Monitoring: The certified company submits annual data to SCS to ensure that it still meets the certifying criteria.



ISO Type III

- ISO Type III certification programs correspond to ISO 14025: Environmental labels and declarations – Type III environmental declarations.

Chapter 11: Environmental Labeling and Declarations

- Type III programs are known as “Eco-Profile” programs. They offer a more comprehensive form of certification which takes into account environmental impacts throughout the life cycle of the package (i.e., manufacture, use, and disposal).
- Example of an “Eco-Profile” Program:
 - Scientific Certification Systems (SCS): <http://www.scs-certified.com/>
 - See above for information on SCS.
- An Eco-Profile presents a chart displaying the results of a life cycle assessment.

References

¹ ISO Standards: ISO 14020. International Organization of Standardization.

² ISO 14020.

³ The Environment Sphere. 6 February 2005. The Global Development Research Center. 11 March 2005 <<http://www.gdrc.org>>.

⁴ ISO Standards: ISO 14020. International Organization of Standardization.

⁵ FTC Green Guides: Guides for the Use of Environmental Marketing Claims. Federal Trade Commission. 11 March 2005 <<http://www.ftc.gov/bcp/gmrule/guides980427.htm>>.

Ch 12: Staying Current

This Chapter Covers:

- How to stay up-to-date with regulations and standards
- How to stay up-to-date with new materials and technology
- How to stay up-to-date with regional recycling infrastructures

Staying up-to-date and in compliance with regulations and industry standards can increase market share and reduce environmental impact from products. Maintaining compliance will help avoid fines and delays due to injunctions or other penalties from non-compliance. Additionally, following the industry standard will increase the efficiency of manufacturing processes through standardization. This section will cover the European Committee for Standardization (CEN)'s Essential Requirements, packaging reduction, material restrictions, and minimum recycled content requirements. Additionally, the International Organization for Standardization's (ISO) 14000 series is included, as it provides standards for using everyday business practices to promote environmental programs and their effectiveness. Finally, information is provided on staying up-to-date with new technologies/materials and infrastructure changes.

Standardization

European Essential Requirements

The CEN standards are official standards enforceable throughout Europe. Countries are permitted to adopt their own more stringent standards in the areas of material recovery, energy recovery, and reuse. As of 2005, France and the United Kingdom are the only countries that have adopted their own implementing standards. The "Essential Requirements" include six individual standards plus one "umbrella" standard, as follows¹:

- **Source Reduction:** Companies must assess source reduction opportunities and certify that the packaging system constitutes the minimum adequate packaging to serve the necessary functions.
- **Reuse:** Reusable packaging must be capable of being refilled or reloaded a minimum amount of times within its life cycle, reused for its original purpose, and be part of a reuse system in each market in which it is introduced.
- **Recycling:** The design of the package must consider recyclability in each country in which it is marketed and must not interfere with those countries' recycling systems.
- **Packaging recoverable in the form of energy:** Packaging to be incinerated must demonstrate that it will make a positive contribution to the energy recovered in a waste incinerator.
- **Composting and Biodegradation:** Biodegradable packaging must demonstrate that no materials known to be harmful to the environment were deliberately introduced into packaging or packaging materials.

- **Heavy Metals:** Packaging must contain less than 100 ppm of the sum of the concentration levels of lead, cadmium, mercury, and hexavalent chromium.
- **Requirements for the use of European Standards in the field of packaging and packaging waste:** The standard establishes assessment, documentation requirements, and links all the elements from the other standards together.

For additional information on using the CEN Essential Requirements and staying current with changes made to them, a guide is available free of charge in pdf format from the EUROPEN website at: http://www.europen.be/issues/CEN/CEN%20STANDARDS%2012_01.pdf.

Or, contact:

- Essential Requirements for Packaging in Europe
Avenue de l'Armee 6 Legerlaa
1040 Brussels – Belgium Le Royal Terveuren
Tel: (+32) 2 736 36 00
Fax: (+32) 2 736 35 21
Email: Packaging@europen.be
Web: <http://www.europen.be/index.html>
- The European Organization for Packaging and the Environment
(same address as above)

ISO

The International Organization for Standardization was created in 1947 “to facilitate the international coordination and unification of industrial standards”². These standards are developed through consensus agreements between national delegations representing all economic stakeholder groups – suppliers, users, government regulators, and other interest groups, such as consumers and non-governmental organizations (NGOs). The stakeholders reach consensus on all relevant specifications and criteria to provide a reference framework (a common technological language) between suppliers and their customers. International standardization is market-driven and therefore based on voluntary involvement of all interests in the market-place³.

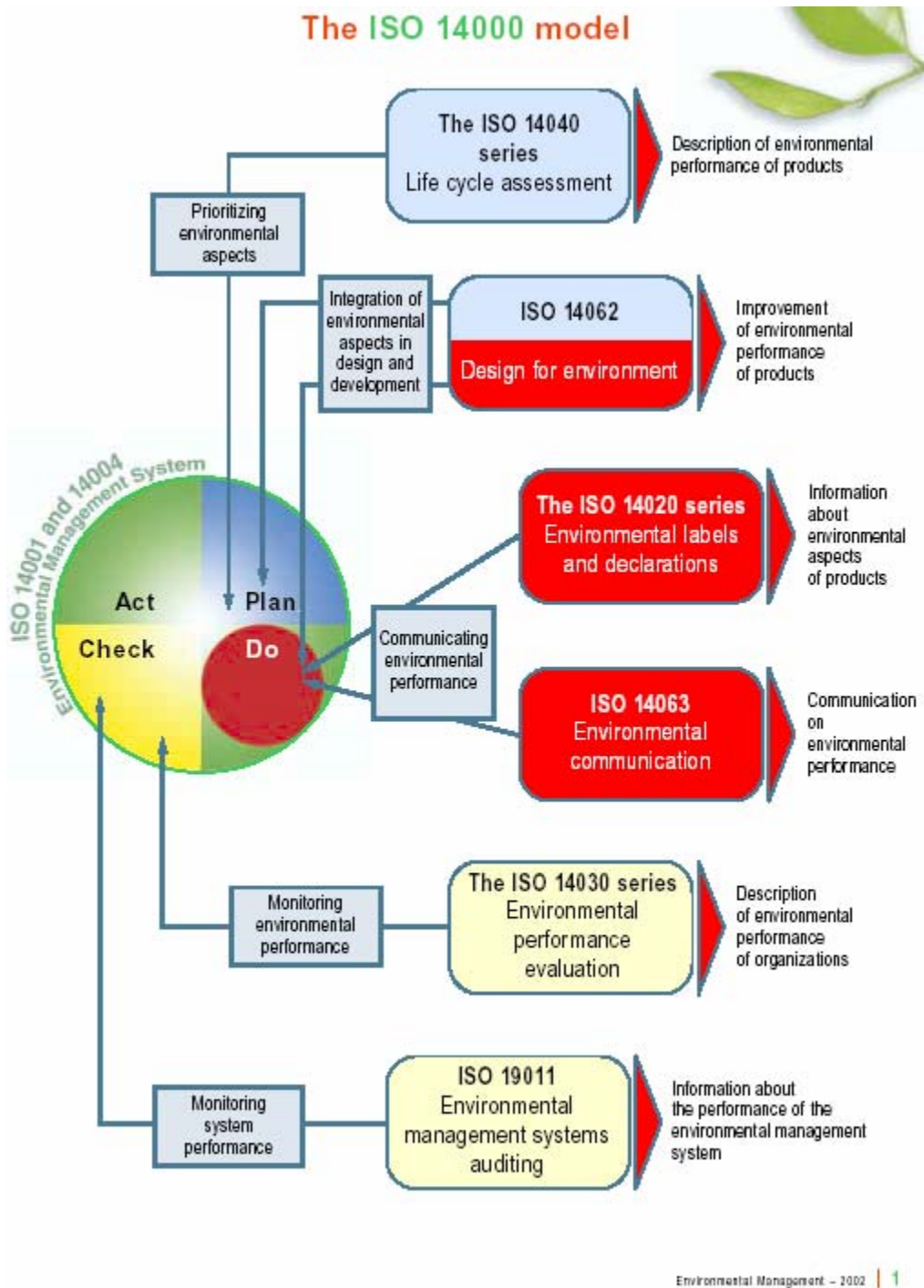
ISO 14000 Series

The ISO 14000 Series of standards is designed to help businesses improve production efficiency, hazardous material handling, pollution prevention, etc. by incorporating environmentally conscious considerations into traditional business practices. As an example, we will consider ISO 14001 to help you understand the purpose and technique of the standards.

ISO 14001

ISO 14001 – Environmental Management Systems Standard – provides businesses with a framework to identify, meet, and manage their environmental obligations. ISO 14001 is strictly voluntary and is based on a simple operating principle: Use traditional business practices to systematically manage environmental responsibilities, just as businesses systematically manage finance, inventory, or product quality. The core of the plan is compliance, pollution prevention, and continual improvement. It is applied by identifying environmental issues that are significant to the facility, development and implementation of programs to accomplish those objectives, and periodic review and monitoring of the objectives. Records are kept to prove there is a functioning system in place, and some companies choose to become registered to the standard by having an accredited independent auditor review their systems to be sure they satisfy ISO 14001.

Other ISO 14000 Standards and their Relationships



Source: <http://www.iso.org/iso/en/prods-services/otherpubs/iso14000/model.pdf>

For additional information on ISO 14000 and staying current with changes in the ISO series, please contact ISO:

- ISO Central Secretariat
International Organization for Standardization (ISO)
1, rue de Varembe, Case postale 56
CH-1211 Geneva 20, Switzerland
Tel: (+41) 22 749 01 11
Fax: (+41) 22 733 34 30
Email: <http://www.iso.org/iso/en/xsite/contact/01enquirysevice/nquirysevice.html>
(Provides a list of options so that your question may be directed to the right department)
Web: <http://www.iso.ch/>

Regulation

The following sections briefly provide examples of packaging-related regulatory requirements for some countries.

Packaging Reduction – Empty Space Requirements

Australia, New Zealand, and South Korea all have restrictions on the amount of headspace or concealed empty space in packaging as part of their environmental and fair-trade regulations. These regulations are designed to prevent packaging from deceiving costumers about the nature and size of the product.

Packaging Reduction – Packaging Plan Requirements

Australia, Belgium, the Netherlands, Slovakia, South Korea, and Spain all require companies to submit detailed plans that demonstrate how packaging will be reduced. Packaging reduction plans may become required throughout Europe in the future.

Material Restrictions

Many countries have bans or restrictions on the use of certain materials. Some materials are banned, while others are discouraged through taxes in an attempt to discontinue their use. The use of polyvinyl chloride (PVC) is restricted in some European and Asian countries; expanded polystyrene (EPS) is restricted in certain applications in South Korea; restrictions on wood packaging exist in many countries (specific to wood treatment and form); and the use of plastic bags are restricted in certain countries.

Minimum Recycled Content Requirements

Some U.S. states have established minimum recycled content standards for recycled material in packaging to increase the value of recycled materials. For example, there are minimum recycled content standards for plastic containers in California and Wisconsin, glass containers and trash bags in California, and newspapers in 27 states. Additionally, Denmark and France provide a fee reduction for paperboard materials containing over 50% recycled content.

Staying Current with Regulations

It is imperative that the packaging professional stay current with regulations in their target markets. EIATRACK is an excellent source of information:

EIATRACK is a subscription based web service, which delivers information on product-oriented environmental compliance for the electronics sector. The EIATRACK Team is made up of legal and technical partners that cut across the disciplines of law, environmental policy and science. Compliance issues are tracked through subject updates and reports across global jurisdictions.⁴

Please visit the EIA Track website for additional information: <http://www.eiatrack.com/>

Technology/New Materials

Journals, conferences, newsletters, magazines, and other sources of information on technological and material changes provide the resources for the packaging professional to stay ahead of the pack. The following sections provide some examples of sources for information on advances in technology and materials.

Corrugated

Corrugated Packaging Council – <http://www.corrugated.org/>

The Corrugated Packaging Alliance (CPA) is an industry initiative jointly sponsored by the American Forest & Paper Association (AF&PA) <<http://www.afandpa.org/>> and the Fibre Box Association (FBA) <<http://www.fibrebox.org/>>. The Corrugated Packaging Alliance was formed in 2002 to create and implement a comprehensive plan for corrugated and containerboard. The Corrugated Packaging Council (CPC) develops programs to promote the performance and environmental benefits of corrugated packaging. It promotes communication to support the industry's objectives.

Wood

APA – The Engineered Wood Association – <http://www.apawood.org/>

APA provides valuable information on engineered wood products.

National Wooden Pallet and Container Association (NWPCA) – <http://www.nwpca.com/>

NWPCA provides a search engine for pallet users to find manufacturers of pallets, boxes, bins, crates, and reels. NWPCA also provides a search engine that pallet and container manufacturers can use to find supplies, services, machinery, and equipment.

Plastic

The American Plastics Council (APC) - <http://www.americanplasticscouncil.org>

APC includes five business units and an affiliated trade association comprised of APC member companies, other industry stakeholders, and customers, whose purpose is to address issues specific to their products. APC's business units include: Alliance for the Polyurethanes Industry, Polycarbonate Business Unit, Polystyrene Packaging Council, Expandable Polystyrene Resin Suppliers Council, and Rigid Plastic Packaging Institute; The Vinyl Institute is the affiliated trade association.

APC develops and invests in programs to create industry data and solutions addressing plastics and the environment. The information is meant to improve the efficiency and cost-effectiveness of recycling programs and to maximize plastics recycling in a way that is economically and environmentally responsible and sustainable. APC currently provides the following informational resources:

- How to Collect Plastics for Recycling – A technical manual to assist recycling professionals in improving the efficiency of existing collection efforts.
- Technical Assistance Program – A program that conducts field research to test and evaluate innovative recycling equipment.
- Plastic Industry Statistics and Resin Review – Reports containing production and detailed sales information for major plastic resins. Monthly inventory, capacity and preliminary reports are available. More than 90% of the plastics industry participates in development of the statistics and resin review.

http://www.americanplasticscouncil.org/s_apc/sec.asp?CID=296&DID=895

Recycling Infrastructure

The recyclability of materials depends on the existence of infrastructure in the desired marketplace; the following two sources provide information on staying current with changes in recycling infrastructure in different locations. Consult with Appendix C for more detailed information on recycling infrastructure.

Recycling Today - <http://www.recyclingtoday.com>

The self proclaimed “portal to the recycling industry,” Recycling Today provides information on recycling-related conferences and events, legislation, recycling associations, industry links by sector, a marketplace listing of suppliers, recycling infrastructure directories, etc.

National Recycling Coalition - <http://www.nrc-recycle.org/>

The National Recycling Coalition, Inc. (NRC) is a nonprofit 501(c)(3) organization whose membership of 4,500 includes recycling and environmental organizations; large and small businesses; federal, state and local governments; and individuals. The Coalition, based in Washington, D.C., provides technical education, disseminates public information on selected recycling issues, shapes public and private policy on recycling, and operates programs that encourage recycling markets and economic development.⁵

References

¹ Packaging Basics. The European Organization for Packaging and the Environment. 11 March 2005 <<http://www.europen.be/index.html>>.

² Why Standards Matter. 26 January 2005. International Organization for Standardization. 11 March 2005 <<http://www.iso.org/iso/en/aboutiso/introduction/index.html>>.

³ How are ISO standards developed? 30 September 2003. International Organization for Standardization. 11 March 2005 <<http://www.iso.org/iso/en/stdsdevelopment/whowhenhow/how.html>>.

⁴ About Us. 2004. Electronics Industries Association. 11 March 2005 <<http://www.eiatrack.com/content/eiatrack/about/>>.

⁵ About Us. National Recycling Coalition. 11 March 2005 <<http://www.nrc-recycle.org/>>.

Appendix A: Glossary and Acronym Guide

Acidification: The process of making a substance acidic or converting it into an acid. In environmental terms, acidification generally refers to acid rain, which occurs when various industrial pollutants – primarily sulfur oxides and nitrogen oxides – combine in the atmosphere with naturally occurring oxygen and water vapor.

Additives (plastic): Substances added to a plastic to increase its impact strength, clarity, chemical resistance, heat resistance, weather resistance, color retention, melt strength or another quality that makes the plastic a more usable product. Additives may include antistatic agents, blowing agents, flame retardants, heat stabilizers, plasticizers, pigments, reinforcements, biostabilizers, and/or biodegradable plasticizers.

Adsorbable Organic Halides (AOX): AOXs are substances that can cause the formation of dioxin, furans, and other chemicals that are known to be harmful to wildlife and humans.

Aggregation: A technique in Life Cycle Assessment that combines several disparate impacts (such as effect on biodiversity, energy requirements, and air pollution) into a single score or rating. This process requires an ultimately subjective weighting of these different factors to determine their relative importance to total environmental impact. For instance, highly toxic heavy metals might be given considerably more weight per kg than relatively innocuous municipal solid waste.

Biodegradability: The capability of a substance to be broken down into simpler compounds or molecules through the action of microorganisms; for example the breakdown of food when composted. Biodegradability requires the presence of oxygen.

Biological Oxygen Demand (BOD): The amount of oxygen used by microorganisms in the process of breaking down organic matter in water. The more organic matter (e.g., sewage) a body of water contains, the greater the population of microbes it can support. The more microbes there are, the more oxygen they use, leaving less oxygen available for other organisms, such as fish.¹

Blowing agent: A gas or substance incorporated in a plastics mixture for the purpose of making foamed materials.

British Thermal Units (BTUs): A unit of measure for the amount of energy a given material contains (e.g., energy released as heat during combustion). One BTU is the quantity of heat required to raise the temperature of one pound of water one degree Fahrenheit.

Bulk Packaging: Including many units in a single package with minimal individual packaging. This often results in a reduction of the packaging material used.

Byproducts: Substances produced as result of industrial or biological processes, in addition to the principal product. For example, byproducts of processing wood into lumber include resins, cellulose (the main component of wood), chemicals, and other extractives. These byproducts can be used to make paper, corrugated fiber and a variety of other products.

Appendix A: Glossary and Acronym Guide

Carbon Dioxide (CO₂): An odorless, colorless gas that occurs naturally in the earth's atmosphere. It is produced by respiration and combustion of fossil fuels. While non-toxic, CO₂ is suspected to contribute to global warming.

Chlorine: A highly irritating, greenish-yellow gaseous halogen used as a bleach, oxidizing agent, and disinfectant in water purification. It is produced principally by electrolysis of sodium chloride and is capable of combining with nearly all other elements.

Clear cutting: A forest management practice in which loggers clear large areas of forest of all mature trees.

Commingled plastics: A mixture of multiple plastic resins, possibly with very different properties, in a single material. Commingling of materials, especially plastics, can inhibit recycling due to the difficulty of separating out the constituent materials.

Composite: Material made from a combination of recycled plastic and recycled wood.

Corrugated fiberboard: The structure formed by a corrugated inner medium glued between two or more flat fiberboard liners.

Cradle-to-Cradle: A design strategy in which all components of a product will be reused or recycled, or will biodegrade. This allows the product's materials to travel in a technical and/or biological closed loop, meaning that at end-of-life the materials come back to where they started. For example, a biodegradable package made from corrugated fiberboard would travel in a biological closed loop if it is composted after use, as it ends up degrading back into the earth from which the original natural resources were first extracted.

Cradle-to-Grave: Traditional package design, which assumes a package, will end up as unwanted waste that must be dealt with at some cost to the end user. This strategy often pits environmental concerns against profitability. The life cycle of a product with a cradle-to-grave design is not a closed loop and the materials will therefore not end up in the same place where they began.

Dimensional Weight: The density or weight per cubic foot of a shipment of cargo. The calculation of a shipment's weight based on the International Air Transport Association (IATA) volumetric standard, and not on its actual weight. Dimensional weight is calculated by multiplying length x height x width and dividing the sum by 166 lbs (if multiplied in inches) for international shipments or by 194 lbs (if multiplied in inches) for domestic shipments.²

Dioxin: A class of chemicals known to be toxic to human health. Dioxins are a byproduct of paper production and the incineration of some plastics.

Ecology: The science that deals with the relationships between organisms and their living and non-living surroundings.

Effluent: Any solid, liquid or gas which enters the environment as a byproduct of an industrial process. Effluent refers to substances that flow out of a designated source.

Appendix A: Glossary and Acronym Guide

Emissions: Material released into the air either by a discrete source (primary emission) or as a result of a photochemical reaction or chain of reactions (secondary emission).

End-of-Life (EOL): The stage in a product's life cycle when it is no longer used and must be reused, recycled, incinerated, or landfilled.

Environmental Impact: Any change to the natural environment, whether negative or positive, that is entirely or partially the result of an organization's activities, products, or services.

Fossil Fuel: Naturally occurring carbon or hydrocarbon fuel; for example coal, natural gas, and oil. Fossil fuels are formed over geologic time by the decomposition of prehistoric organisms.

Furan: A class of chemicals known to be toxic to human health. Furans are often a byproduct of paper production.

Greenhouse Gases (GHGs): Gases which trap heat in the atmosphere. These gases cause the "greenhouse effect," contributing to global warming. Carbon dioxide and methane are two of the most prominent greenhouse gases.

Hazardous Air Pollutants (HAPS): Airborne toxic chemicals that cause serious health and environmental effects. Such pollutants include asbestos, beryllium, mercury, benzene, coke oven emissions, and vinyl chloride. These air pollutants are not covered by ambient air quality standards, but according to the United States' Clean Air Act they may reasonably be expected to cause or contribute to irreversible illness or death.

Incineration: Combustion of waste products in the presence of excess oxygen, producing water, carbon dioxide and ash, as well as non-combustible residuals. If combustion is incomplete, other organic byproducts may occur.

ISO: International Organization for Standardization. ISO is an international non-governmental body that creates standards such as ISO 9000 (product quality standards), and ISO 14000 (environmental management standards).

Kanban: A Japanese word for 'sign', Kanbans are typically a re-order card or other method of triggering the pull system based on actual usage of material. Kanbans are attached to the actual product, at the point of use. Squares painted on the floor to indicate storage or incoming areas are frequently, but mistakenly, referred to as kanbans.

Kenaf (alternative paper): An annual agricultural plant, native of India, with long fibers in its bark suitable for papermaking.

Kraft Paper: A paper made predominantly from wood pulp produced by a modified sulfate pulping process. It is a comparatively coarse paper particularly noted for its strength, and in unbleached grades is used primarily as a wrapper or packaging material.

Landfill: A land disposal facility or site that is carefully lined and monitored, where nonhazardous solid wastes are placed.

Appendix A: Glossary and Acronym Guide

Leachate: Liquid that has percolated through solid waste or another medium and has extracted dissolved or suspended materials from it, some of which may be harmful and may contaminate nearby groundwater. Leachate prevention is of primary concern at municipal waste landfills.

Life Cycle Assessment (LCA): A method for analyzing a product's environmental impact throughout its life. The method examines everything that happens from the time the raw materials are taken from the earth to the time the product is disposed of.

Lightweighting: Reducing the thickness or weight of packaging material with the intention of reducing overall material use.³

Methane (CH₄): An odorless, colorless, asphyxiating, flammable, and explosive gas which can be formed by the anaerobic decomposition of organic waste matter. The major component of natural gas, it can be used as fuel. Found in landfill gases.

Multiwall corrugated fiberboard: The structure formed by two or more corrugated inner mediums, each glued between two flat facings.

Natural Resource: A naturally occurring material that has economic value, such as soil, wood, air, water, oil, or minerals.

Nitrogen Oxides (NO_x): Gaseous compounds of nitrogen and oxygen produced directly or indirectly from the combustion of fossil fuels and from processes used in chemical plants. There are three forms of nitrogen oxides: nitric acid (NO), nitrogen dioxide (NO₂) and nitrous oxide (N₂O). Nitrogen dioxide is one of six “criteria pollutants” in the Clean Air Act which are measured as a key indicator of air quality.⁴ Nitrogen oxides that are emitted into the air can contribute to acidification and ground-level ozone, a key component of smog.

ODM: Original Design Manufacturer

OEM: Original Equipment Manufacturer

Ozone: A gaseous molecule that consists of three oxygen atoms (O₃). Ozone can exist high in the atmosphere, where it serves as a barrier that protects Earth from the sun's ultraviolet rays, or close to the ground, where it is a primary component of smog.

Paperboard: As a general rule, paperboard is any paper with a thickness of 12 points (0.012 inch) or more. Paperboard has a heavier basic weight and is thicker and more rigid than paper.

Photodegradability: The ability for a material to be broken down in chemical reactions driven by the sun's ultraviolet rays. In packaging, photodegradability applies to some plastic materials.

Post-consumer Recycled Content: Product made with materials that have been used by consumers and then recycled into material feedstock.

Pre-consumer Recycled Content: Product made with materials that have been used in an industrial process, but have not entered the consumer waste stream. Pre-consumer recycled content is sometimes referred to simply as "recycled content."

Appendix A: Glossary and Acronym Guide

Primary Transport Packaging: The first layer of packaging that comes in direct contact with the product or part.

Pulp: A mixture of cellulose material that is ground up and moistened to make paper.

Recycled Content: Any product made with materials that have been used before. A product with a recycled content label can include pre-consumer content, post-consumer content, or both.

Recycling: Any process that converts a previously used material into a useable product. The new useable product may have the same form or a different form. An example of this is converting glass into asphalt or a soft drink can into aluminum feedstock.

Reducing: Any strategy that lowers the amount of waste generated as the result of a process (such as using a smaller package to ship an item).

Resin: Usually polymers which are of a high molecular weight. Resins can be solid or semi-solid and can be either natural or synthetic in origin. In ink, a resin is the main ingredient which binds the various other ingredients together and aids in adhesion to the printing surface. Resins are also the main component of plastic materials.

Resource Extraction: The process of harvesting or extracting natural resources for processing. Examples include logging, drilling for oil, and mining metals.

Reusing: Refers to any process that uses a material in its current state without reprocessing it first. Examples include refilling bottles or using Styrofoam peanuts in another package.

Secondary Transport Packaging: The second layer of packaging, which combines multiple individually-packed units.

Slipsheet: A flat platform that can be used in place of a pallet for applications that involve push-pull devices or to move or store products.

Solid Bleached Sulfate: A grade of paperboard that is made from bleached kraft pulp. This process often uses a blend of elemental chlorine and chlorine dioxide to bleach the pulp.

Sulfur Oxides (SO_x): Pungent, colorless compounds containing sulfur and oxygen that are formed primarily by the combustion of sulfur-containing fossil fuels such as coal and oil. Two sulfur oxides are sulfur dioxide (SO₂) and sulfur trioxide (SO₃). Sulfur oxides can combine with water vapor in the atmosphere to produce acid rain. Sulfur dioxide is also a criteria pollutant (see NO_x)

Tertiary Packaging: The outermost layer of packaging, which includes the shipping container and any loose packing material necessary to protect the product during transport.

Thermoformed plastic: Plastic that can be repeatedly softened by heating and hardened by cooling through a temperature range characteristic of the plastic, and that in the softened state can be shaped into articles through molding or extrusion.

Appendix A: Glossary and Acronym Guide

Thermoset plastic: Plastic that, after having been cured by heat or other means, is substantially infusible and insoluble.

Toxic Release Inventory: A program created by the United States Superfund Amendments and Reauthorization Act of 1984 that requires manufacturing facilities and waste handling and disposal sites to report annually on releases of more than 300 toxic materials.⁵

Tree Farm: A privately owned forest or woodland that has a primary management goal of producing timber crops. A tree farm is normally an area of managed forest comprised of trees of the same age and species throughout.

Unit Load: Packages loaded onto a pallet, into a crate, or into any other configuration of materials that enables the goods to be handled as a single unit.

Virgin material: Material that does not contain any recycled content

Volatile Organic Compounds (VOCs): Organic compounds that evaporate readily at normal pressures and temperatures into the air. Some, but not all, VOCs are toxic.

Wet-strength: Mechanical strength of paper when it is saturated with water.

References

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12 March 2005 <<http://www.britannica.com/eb/article?tocId=9079247>>

² Fedex Glossary. FedEx. 12 March 2005
<http://www.fedex.com/ca_english/shippingguide/glossary.html>.

³ Waste Prevention for Business. NYC WasteLess Business. 11 March 2005
<<http://www.nycwasteless.org/bus/prevention.html>>.

⁴ Glossary of Terms. 2004. Energy Use Investigation. 11 March 2005
<<http://www.uwsp.edu/cnr/wcee/keep/Audit/glossary-n.htm>>.

⁵ Glossary S-Z. 200Online Learning Center. 11 March 2005 <http://highered.mcgraw-hill.com/sites/0070294267/student_view0/glossary_s-z.html>.

Appendix B: Material Guides

This appendix provides additional information about the manufacturing of fiber-based (corrugated and paperboard) and plastics packaging products.

Fiber-based Products

The following pages contain information excerpted from the European Integrated Pollution Prevention and Control Bureau's document titled "Reference Document on Best Available Techniques in the Pulp and Paper Industry."¹ This reference document was created in response to the European Commission's Directive on integrated pollution prevention and control (Council Directive 96/61/EC). It provides comprehensive information regarding the best available technology for use in manufacturing of all pulp and paper products.

1.6 Overview of pulp and paper manufacturing*

Paper is essentially a sheet of cellulose fibres with a number of added constituents to affect the quality of the sheet and its fitness for intended end use. The two terms of paper and board (No. 6.1 b, Annex 1 of the IPPC-Directive) generally refer to the weight of the product sheet (grammage) with paper ranging up to about 150 g/m² and a heavier sheet regarded as board (paperboard).

The pulp for papermaking may be produced from virgin fibre by chemical or mechanical means or may be produced by the re-pulping of recovered paper (RCF). In the pulping process the raw cellulose-bearing material is broken down into its individual fibres. Wood is the main raw material but straw, hemp, grass, cotton and other cellulose-bearing material can be used. The precise composition of wood will vary according to the type and species but the most important constituents are cellulose, hemicelluloses and lignin.

Wood naturally contains around 50% water and the solid fraction is typically about 45% cellulose, 25 % hemicelluloses and 25% lignin and 5% other organic and inorganic materials. In chemical pulping, chemicals are used to dissolve the lignin and free the fibres. The lignin and many other organic substances are thus put into solution from which the chemicals and the energy content of the lignin and other organics may be recovered. The extent of this recovery is dependent upon the chemical base used and the process configuration. In mechanical pulping processes mechanical shear forces are used to pull the fibres apart and the majority of the lignin

* Excerpted from page 10 of "Reference Document on Best Available Techniques in the Pulp and Paper Industry" - See reference at the end of this Appendix.

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remains with the fibres although there is still dissolution of some organics. Pulps produced in different ways have different properties, which make them suited to particular products. Most pulp is produced for the purpose of subsequent manufacture of paper or paperboard. Some is destined for other uses such as thick fiberboard or products manufactured from dissolved cellulose.

Paper produced by the use of recovered paper as fibre source will involve some cleaning of contaminants prior to use and may involve de-inking depending upon the quality of material recycled and the requirements of the end product the recycling process. The fibres are reusable a number of times depending on the quality of the recycled material and the purpose of the end product. The paper product may also comprise up to 45% of its weight in fillers, coatings and other substances.

There are many different products produced by the papermaking industry and can be broadly categorized as follows:

- Newsprint
- Packaging paper boards*
- Uncoated printing and writing papers
- Liner and fluting
- Coated printing and writing papers
- Tissue
- Packaging papers
- Specialty papers

* From high quality finished cardboard to a range of qualities of cardboard packaging

Each of these categories demands specific properties of the product and the most appropriate manufacturing route to these products may differ substantially. For instance, newsprint is a product required in high volume on a regular basis but is only required to have moderate strength, opacity, printability and a relatively short life. Thus a manufacturing route which involves a high yield of pulp at the expense of maximum achievable strength, brightness and texture can contribute to the efficient use of raw materials.

In contrast, the critical quality of packaging papers is their strength if they are to be fit for their intended use. In this case it is necessary to accept a lower yield inherent to a different manufacturing route in order to achieve this strength. Printing and writing papers need a different balance of brightness, texture and strength, and some can be required to last for great many years. Tissue papers are made to have good dry and wet strength for their weight and typically will be used once and not re-enter the fibre cycle.

1.7 Classification of pulp and paper mills*

The high degree of process-integration in pulp and paper industry implies that the concept of BAT must be related not only to separate processes, systems or lines, but also to the whole integrated units. For instance, in order to reduce effluent volumes, water has to be recirculated typically from the paper mill to the pulp mill in addition to internal loops in both parts of a mill.

At the same time, a certain product may be manufactured through various different processes and systems and it may be equally relevant to compare such different options, although based on quite different processes, when considering BAT. For instance, newsprint may be manufactured from several different pulp sources such as stone groundwood (SGW), pressurized groundwood (PGW), thermomechanical pulp (TMP), refiner mechanical pulp (RMP), chemithermomechanical pulp (CTMP), sulphite pulp (Si), bleached softwood kraft pulp (BSKP), and/or deinked pulp (DIP). Different furnishes will of course give rise to different emissions.

As pulp and paper products are highly diverse and applied processes even for one and the same product may vary greatly, many factors of production technology must be taken into account to guarantee a high level of environmental protection. The best techniques for the pulp and paper industry cannot be defined solely by describing unit processes. Instead, the whole installations must be examined and dealt with as entities.

In a document supplied by Finland to the EIPPCB [J. Pöyry, 1998 b], a proposal was made how to classify the pulp and paper industry operating in the European Union by distinguishing the technical properties of the installations and their product range. Following this proposal, the technically diverse installations in the EU area are presented using a grouping of 9 main classes. This classification scheme is product-orientated i.e. distinguishes BAT for different pulp and paper products.

In Figure 1.1 the relationship between the amount of mills and capacities on a European level according to this classification is illustrated.

* Excerpted from page 11 of “Reference Document on Best Available Techniques in the Pulp and Paper Industry” - See reference at the end of this Appendix.

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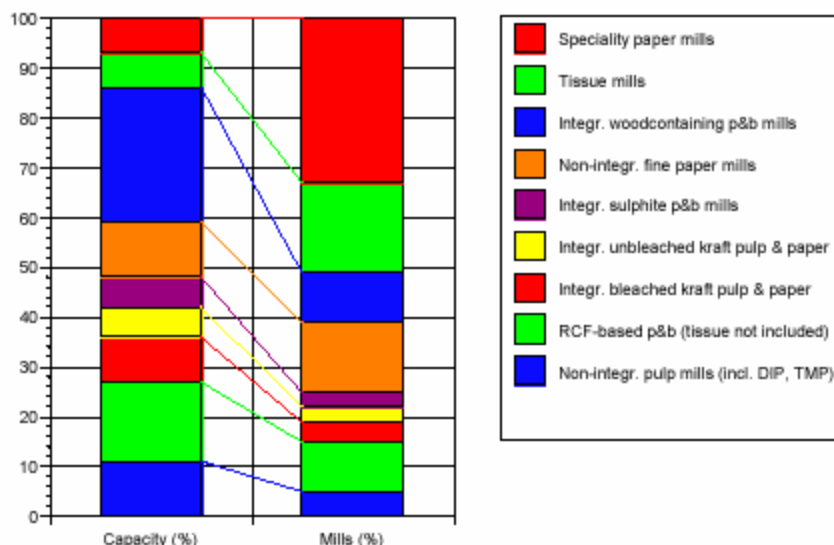


Figure 1.6: Capacities versus amount of mills in Europe

[According to J. Pöyry, 1998; changes made by EIPPCB]. In this study the 9 main classes of the classification scheme are further subdivided in 33 subclasses according to different end products

However, In the European paper industry there is a trend to use a mixture of raw materials as fibre furnishes (e.g. mixture of different types of virgin fibres and recovered fibres). There are also a lot of mills in Europe that are only partly integrated or use fibre mixtures, which are not covered by the proposal. For example there are tissue mills using 10%, 20%, 30% and so on till 90 or 100% of recovered fibres. These mills can not only be described on a product-orientated level. Furthermore, several of the mills are conglomerates giving problems in allocating the total discharges to the different pulp and/or paper types produced when they are not strictly described on a process level as proposed within the BREF.

The process of pulp and papermaking consists of quite many stages. Besides the fibrous material different chemicals and a great amount of water and energy in the form of steam, fuel oil or electric power is required in the process. The wide range of processes involved in the manufacture of pulp and paper can be broken down into a number of unit operations for the sake of discussion. A sequence of operations can be described from raw materials to product but individual processes will not involve all the operations and some are mutually exclusive alternatives.

Bearing in mind that there is no single right or wrong proposal but only reasonable and manageable proposals preference were given to classifying the European Paper industry as described below. To obtain clearer arrangements of the variety of processes involved, the most important pulp, paper and board manufacturing processes are described separately for five main classes that are described in separate chapters in this document. The main types of pulp and paper manufacturing are sub-divided in several sub-classes. The proposed structure of the European pulp and paper industry and the composition of the BREF are shown Figure 1.7. It strikes after a description of the major differences of pulp and paper production from an environmental-point-of-view:

Appendix B: Material Guides



Figure 1.7: Classification of pulp and paper mills proposed by this document including cross-references to the relevant chapters for those mills

The kraft pulping process is described in Chapter 2. Within kraft pulping emission levels associated with the use of BAT for bleached and unbleached grades are distinguished. The BAT emission levels for non-integrated and integrated kraft pulp mills are both given in this chapter. The impact of the paper mill can be regarded as included for water discharges within the uncertainties given. On the other hand, as paper drying is more energy consuming than pulp drying figures for energy consumption and air emissions will differ between integrated and non-integrated pulp mills. These aspects are discussed in this chapter. However, the corresponding sections of the papermaking chapter (Chapter 6) have to be considered when determining BAT for integrated kraft pulp and paper mills (available techniques for papermaking). Some process steps of kraft pulping are similar for all ways of pulp manufacturing (e.g. wood handling, drying) and are therefore described only once and references to other parts of the documents are given.

The sulphite pulping process is described in Chapter 3. The sulphite process is much less uniform (e.g. different bases and pH-values) than the kraft pulping process which makes it more difficult to select BAT. The description is concentrated on the major sulphite pulping process in Europe, the magnesium sulphite pulping. Some additional information on NSSC and dissolving pulp will also be given in this chapter.

Mechanical and chemi-mechanical pulping is described in Chapter 4. Groundwood pulping, TMP and chemi-mechanical pulping (CTMP) has been distinguished. Most mechanical pulping is integrated with paper manufacturing. Therefore, the emission levels associated with the use of BAT for both mechanical pulping and papermaking are given in the Chapter 4. However, the

corresponding chapter on papermaking (Chapter 6) has to be taken into account to identify the techniques to consider in the determination of BAT for integrated mechanical pulp and paper mills. Cross-references are given to other sections of the document to consider.

Recycled fibre processing is described in Chapter 5. BAT associated levels for processes with and without de-inking are distinguished thereby discussing some further differences in recovered fibre preparation as for e.g. tissue, LWC/SC, carton-board. The emission levels associated with the use of BAT presented are referring to integrated pulp and paper mills because most recovered fibres based mills are integrated mills. The corresponding chapter on papermaking (Chapter 6) has also to be taken into account. There, the techniques to consider in the determination of BAT as far as papermaking is concerned are described. Cross-references are given to the sections to consider.

Papermaking and related processes is described in Chapter 6 for the major paper grades being manufactured in European paper mills. Paper manufacturing at a site of its own (non-integrated paper mills) is dealt with in this separate chapter because, in numbers, most of paper mills in Europe are those mills. There is a certain overlapping to integrated pulp and paper mills that manufacture pulp and paper at the same site. Cross-references are given in those cases to the relevant sections.

No specific information on techniques to consider in the determination of BAT for board manufacturing was provided. Therefore, the document gives no separate description of the production of board. From environmental-point-of-view, the most important differences are between tissue and other paper grades and also between coated paper and board compared to uncoated paper and boards. Thus the following grades were distinguished within Chapter 6:

Coated printing and writing paper as for instance coated fine paper used for printing, writing and copying

Uncoated printing and writing paper, for example, uncoated fine paper.

Tissue paper mills

Speciality paper mills

This group (mainly wood free paper grades) is at the same time the major types of non-integrated paper mills in Europe. Of course, there are also integrated paper mills within that group.

Speciality paper mills is an extremely diverse grouping, which covers a high amount of different products. Speciality paper mills are often producing with more than one change of type per working day. Many speciality paper mills are also non-integrated paper mills. Because of its variety of products no emission levels associated with the use of BAT will be presented for speciality paper mills. The different products have their specific "environmental problems". The values and explanations presented in the BAT chapter should be taken as examples about emission levels to be expected from some types of speciality paper mills. They are not regarded as to cover the whole group of speciality papers completely.

Plastics

The manufacturing process for the vast majority of plastics used in packaging begins when petroleum is pumped from the ground. Petroleum then goes through a series of refining processes that separate it into its constituent parts. The refining processes produce monomer materials that are then transformed into polymer resins that are used to make plastic products. Resins are combined with additives which give the material certain desirable properties. Table 16 below provides a list of the common additives used in plastic resins.

Plastic Additives

Antiblocking agent	Prevents sticking of thin plastic sheets to each other, or “blocking”	Quartz or silica in polyethylene
Antioxidants	Reduces the rate of autoxidation of the plastic at service temperature	Metal deactivators, peroxide decomposers
Antistatic agent	Prevents charges on polymer surface leading to static discharge	Quaternary ammonium salts in rigid PVC
Biocide	Prevents growth of microorganisms on plastics	Phenols and chlorinated phenols in coatings
Blowing agent	Used to create polymeric foams [expanded plastics].	Inert gases and AIBN* that decompose to N ₂ on heating. *AIBN= 2,2' azobisisobutyronitrile
Inert filler	Reduces the cost of formulation and changes the color	Chalk used in plastic formulations
Reinforcing filler	Increases the modulus and other properties of a polymer	Carbon black used in plastic formulations
Coupling agent	Promotes better adhesion between phases in filled and glass-fiber-reinforced plastics	Organosilanes, titanates, and zirconates
Curing agent	Crosslinks the polymer	Sulfur or organic sulfur compound in rubber
Flame retardant	Reduces the flammability of plastics products	Borates, and organophosphorous compounds
UV stabilizers	Minimizes the solar UV-B induced degradation of plastics outdoors	Hindered amines and light absorbers

Appendix B: Material Guides

Impact modifier	Increases the impact resistance of plastics	Rubber and thermoplastics in epoxy resin
Lubricant	Minimizes internal and external friction leading to degradation	Ethylene(bis)stearamide used in rigid PVC
Pigments	Colors plastic products	Inorganic pigments, carbon black, and organic pigments
Plasticizer	Softens the plastic and makes it more processable	Pthalates in rigid PVC compounds

Table 16. Common plastics additives and their functions.
Excerpted from Plastics and the Environment by Andrady, et.al.²

Plastic Manufacturing Processes

The following pages contain excerpts of a document written by PlasticsEurope (formerly the Association of Plastics Manufacturers). They describe the processes used to transform resin into plastic products. See the entire document at <http://www.apme.org>.³

Transformation processes

An important property of plastics which makes them suitable for a wide range of low-cost packaging applications is their ability to be converted into an exceptionally wide range of shapes, large and small, simple and complex. Consider the following packages, all made from plastics:

- A mesh bag containing fruit
- A film wrapping over a meat package
- A foamed plastic tray the meat sits on
- A range of plastic bags, from thin disposable to thick reusable.
- A bottle for soft drinks
- A crate
- A pallet.

This remarkable range of package types is thanks in part to the fact that plastics are exactly that, plastic. In other words, at elevated temperatures they soften and are capable of being shaped into a wide variety of forms. Most of the plastics used for packaging are thermoplastic, and many processing techniques are available to convert them into the desired shape. In all of them, the plastic raw material, usually in the form of granules, is melted, and the resultant viscous fluid is then shaped by means of pressure.

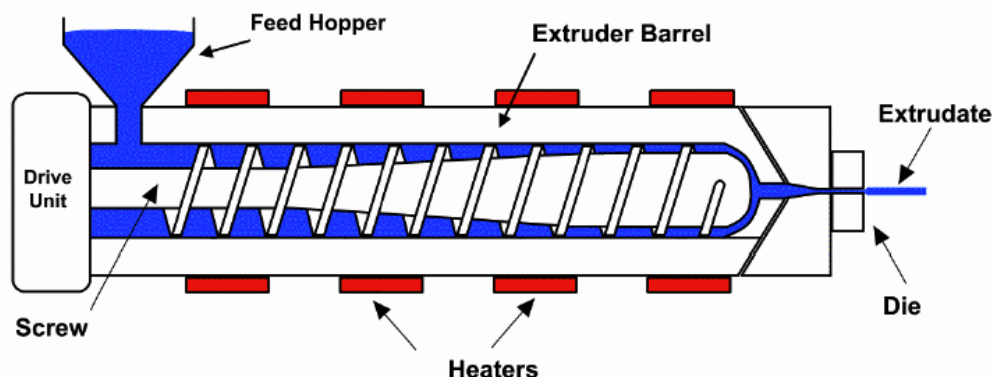
Extrusion

The first step of several of the shaping processes for plastics is often extrusion. Granules are fed from a hopper into the barrel of the extruder where they are melted by heat and the mechanical action of the screw.

The action of the screw forces the molten plastic through an orifice called a die.

The shape of the die determines the type

of product produced. For example, an extremely small orifice will spin a fine plastic thread which can subsequently be woven. An alternative die design will create thin flexible plastics films of the type used for packaging food. Sheets of plastic which will be shaped by thermoforming are also produced in this way.

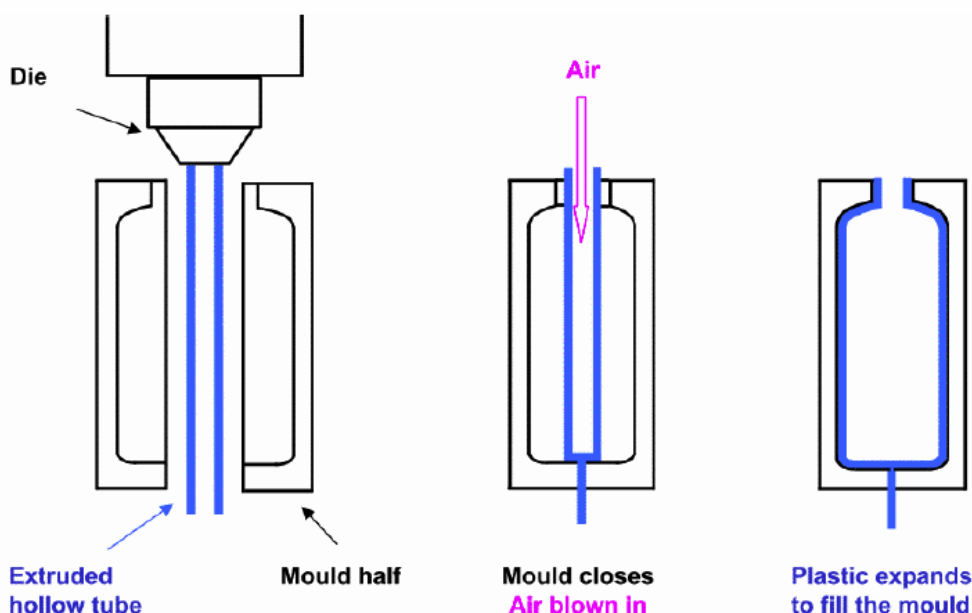


Extrusion blow moulding

Extrusion is also the first stage in the manufacture of many types of plastic container.

In extrusion blow moulding, a hollow tube, called a parison, is extruded, usually in a downward direction, and the two halves of the mould close on it. A seal is formed at the bottom as the parison is trapped between the mould halves, and at the top air is blown in,

polymers for the different layers are each melted in separate extruders, and then brought together in a complex die which extrudes them as a multilayer tube. The tube is then blow moulded in the normal way. Multilayer technology provides a wide range of benefits. For certain types of food container, special polymer layers can be incorporated which for example resist diffusion of oxygen. Another benefit is the



expanding the parison until it fills the mould. The mould is cooled and opened to release the solidified container. It is quite easy to see whether a hollow container, for example one used for a household detergent, has been made by this process. A telltale line across the bottom usually shows where the two halves of the mould have trapped and sealed the lower end of the parison. A variation of this process is used to produce multilayer containers. The

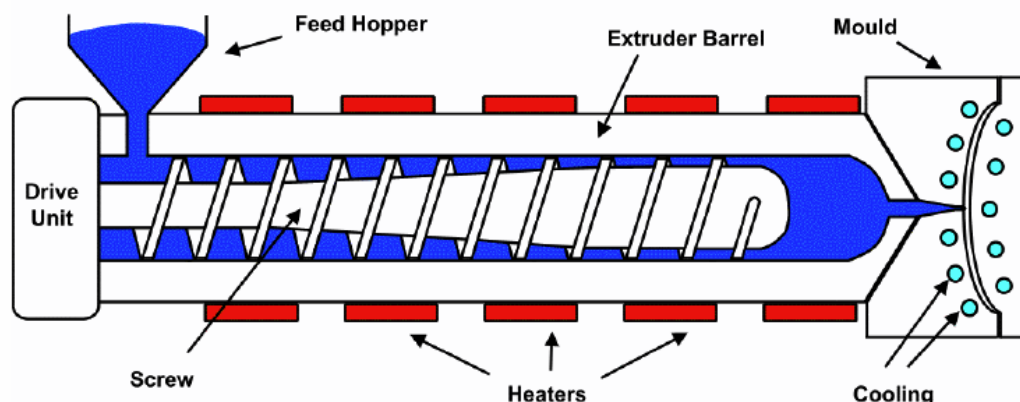
ability to incorporate a layer of post-consumer recycled material. This can be blended with production waste and sandwiched between layers of virgin material. By this means a high quality external finish can be assured, and there is no risk of contamination of the contents. A further benefit is that expensive pigments need only be incorporated in the outer layer. An alternative method of making hollow plastic containers is injection blow moulding.

Injection moulding

Many shapes, whether used for packaging or for other purposes, are produced by injection moulding. The basis of an injection moulding machine is an extruder which has a screw that can be

of the screw.

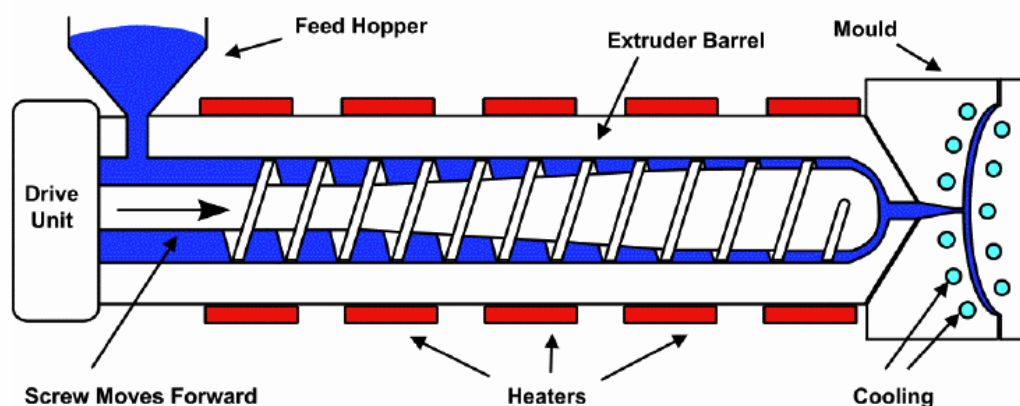
The barrel of the extruder is then driven forward, forcing the molten plastic into the mould. A cooling system in the mould causes the plastic to solidify, after which the



moved forward and back in the barrel. At the outlet of the extruder, in place of a die there is a mould. Channels conduct the molten plastic from the extruder into the mould cavity.

mould is opened and the moulded package is ejected.

An extremely wide range of packaging products can be made by injection moulding. Items as small as the actuator in



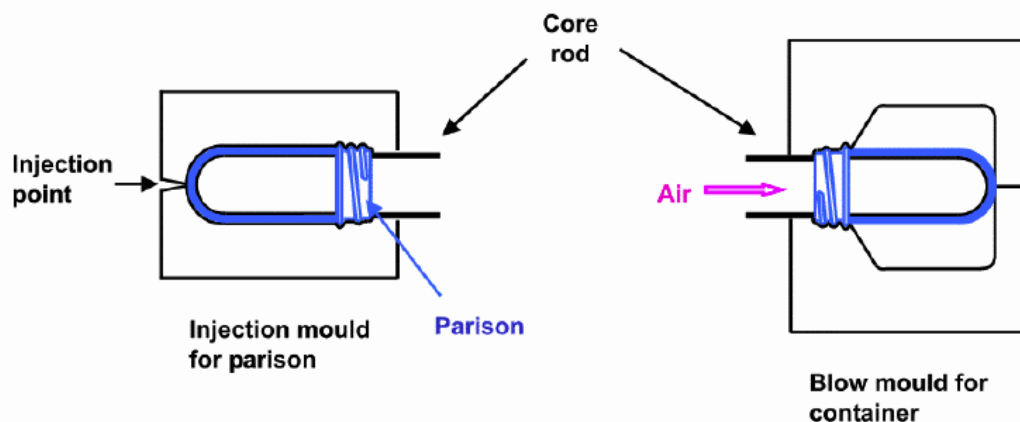
In the first stage of the process, a charge of molten plastic is moved to the front end of the extruder barrel by the rotation

an aerosol valve and as large as pallets and returnable crates can all be made by injection moulding.

Injection blow moulding

Injection blow moulding is an alternative to extrusion blow moulding as a process to make containers. It is a two-stage process, in the first of which a parison is produced by injection moulding. This is

pressure causes the parison to expand and fill the mould. Compared with extrusion blow moulding, higher air pressures are required because the cooler parison has a higher viscosity. The mould is only



carried out in a way similar to the process described in the previous section, but using a mould which has three parts. The third part is a core rod which transfers the parison to the second stage.

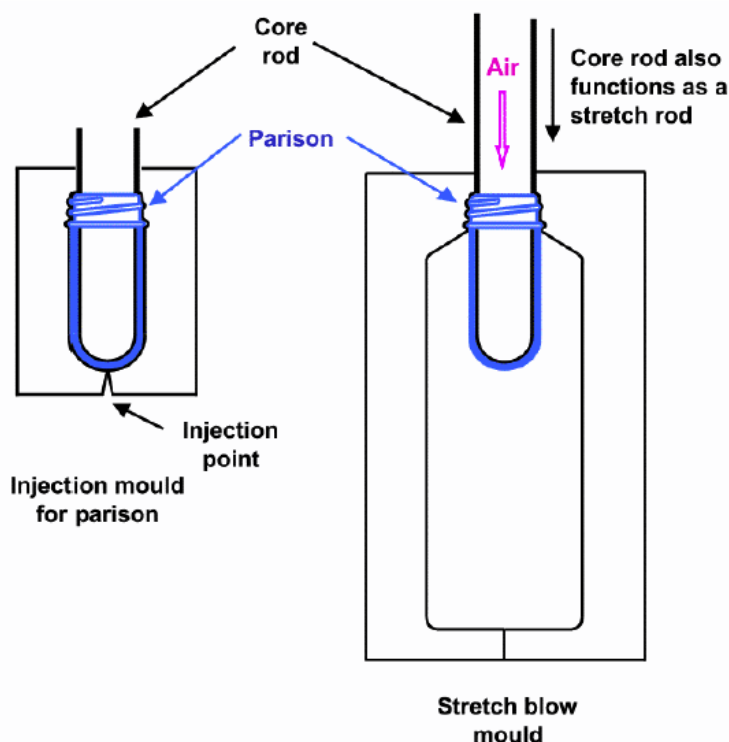
The parison is cooled by only the amount needed to enable it to maintain its shape during transfer, complete with its core rod, to a second mould. Here, air at high

marginally longer than the parison, so the plastic is effectively not stretched in its longitudinal direction.

An indication that a container has been produced by injection blow moulding is often a small blip in the centre of the bottom. This is the point where plastic has been injected during the initial moulding of the parison.

Stretch blow moulding

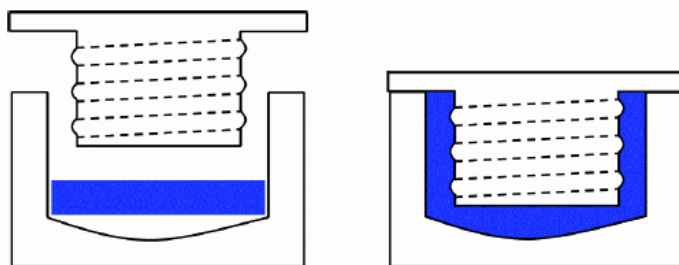
Stretch blow moulding is carried out in a 2-stage process similar to injection blow moulding. However, in the second stage, the parison is made to fill the mould by a combination of air pressure and by a rapid movement of the core rod which produces stretching in the longitudinal direction. A consequence of this double action, stretching and blowing, is that the plastic become biaxially oriented. This gives the container added strength, and enables containers to be made with thinner walls, achieving the goal of more from less. Most of the bottles used for soft drinks are made in this way.



Compression moulding

One of the earliest shaping techniques developed for use with plastics is compression moulding.

fill the space in the mould. Compression moulding is used mostly with reinforced plastics in applications other than



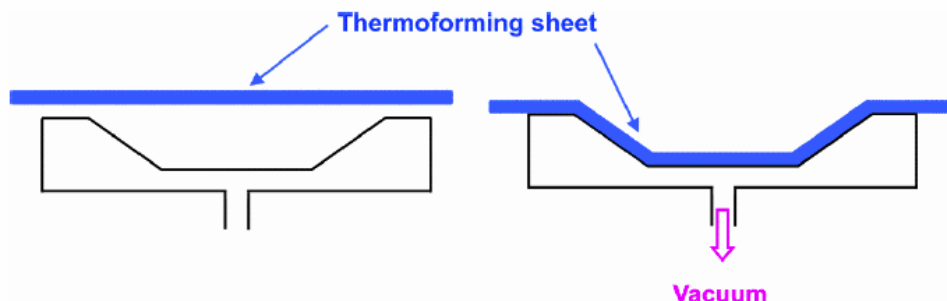
In this process, a pre-shaped blank is placed in a mould which is then closed. The closing pressure forces the blank to

packaging. For packaging materials, a typical use can be the manufacture of closures in thermoplastics.

Thermoforming

For simple shapes, both large and small, thermoforming is a low cost alternative to processes such as injection moulding and blow moulding. Compared with these processes, thermoforming requires lower pressures and the machinery can be

half of a mould. Different techniques are available to make it take the shape of the mould, one of the most common being vacuum forming, illustrated here. Other thermoforming techniques include pressure forming, where, as the name



consequently less rigid and therefore less expensive to produce.

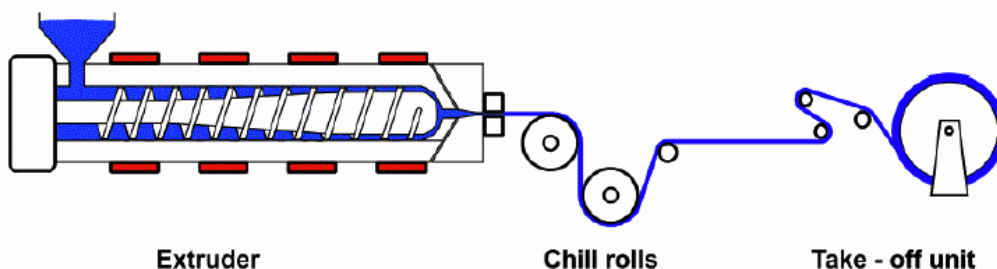
In the thermoforming process, a plastic sheet, usually produced by an extruder, is softened by heat, for example by passing through an oven, and then placed on one

half of a mould. Different techniques are available to make it take the shape of the mould, one of the most common being vacuum forming, illustrated here. Other thermoforming techniques include pressure forming, where, as the name suggests, positive pressure is applied, and drape forming, where the softened plastic takes the shape of the mould under the influence of gravity, although the process is often assisted by use of a vacuum.

Cast film

Packaging film can be produced by extrusion followed by cooling on chill rolls.

During the production process, cast film can be oriented by stretching. This strengthens the film and can also improve its resistance



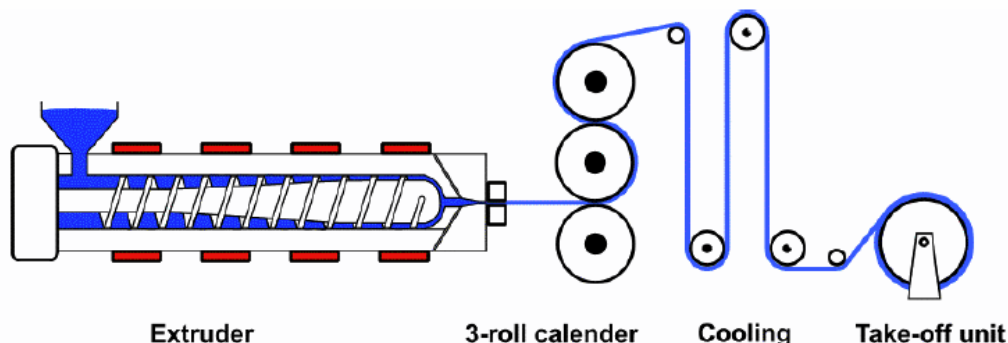
The temperature of the chill rolls is controlled in order to cool the film progressively. Film gauge is determined by the dimensions of the die and also the rates of extrusion and takeoff. When more rapid cooling is needed, the film is sometimes passed through a water bath.

to gas permeation. Orientation can be in one direction only (uniaxial orientation), or on both directions (biaxial orientation). Film which will be used to make bags is usually uniaxially oriented because most of the forces they experience occur in one direction only.

Calendering

An alternative method of producing film is to pass the extrudate through a calender. Unlike the chill-rolls used in the cast film process, pressure is exerted in the sheet between the rolls of the calender. This

that the film remains hot during the calendering process. Cooling is carried out in a later section of the process. Rigid sheet can also be produced by the calendering method. These are often used

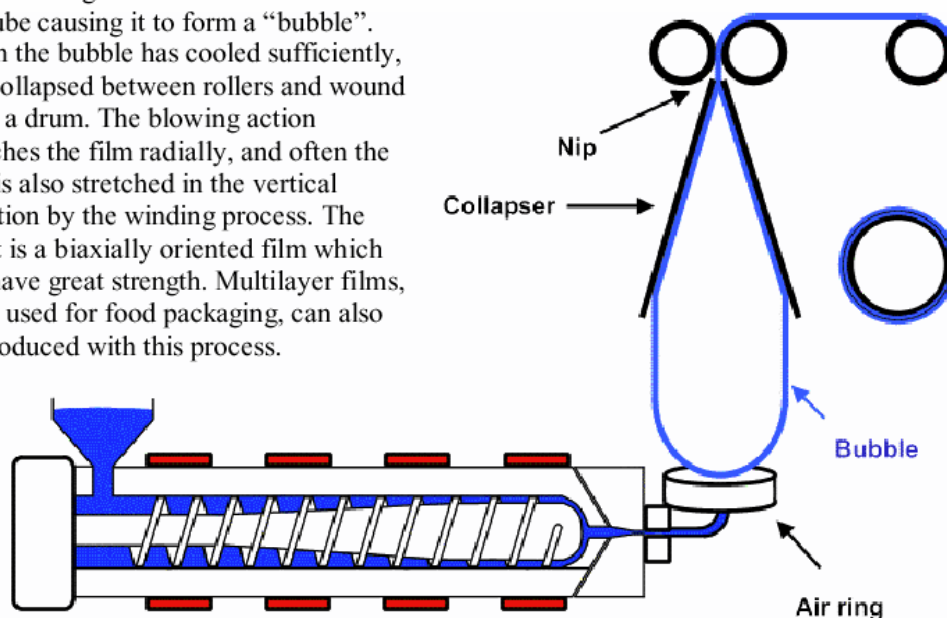


enables special surface characteristics, either smooth or textured, to be applied. Sheet thickness can be controlled by the size of the gap between the rolls. The temperature of the rolls is controlled so

for thermoforming or to produce foldable sheet for boxes. Very tight control of film or sheet thickness can be achieved with the calendering process which is often used for PVC

Blown film

A popular way of making film is by a process of extrusion through an annular die producing a tube. Air is blown into the tube causing it to form a “bubble”. When the bubble has cooled sufficiently, it is collapsed between rollers and wound on to a drum. The blowing action stretches the film radially, and often the film is also stretched in the vertical direction by the winding process. The result is a biaxially oriented film which can have great strength. Multilayer films, often used for food packaging, can also be produced with this process.



Appendix B: Material Guides



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FAX +32 (2) 675 40 02

For details of APME publications visit our website at <http://www.apme.org>

References

¹ Reference Document on Best Available Techniques in the Pulp and Paper Industry. European Integrated Pollution Prevention and Control Bureau. December 2001 <<http://eippcb.jrc.es/pages/FActivities.htm>>.

² Andrady, Anthony L. Plastics and the Environment. New Jersey: John Wiley and Sons, Inc, 2003.

³ EcoProfile. PlasticsEurope. 11 March 2005 <<http://www.apme.org>>.

Appendix C: Recycling Infrastructure

Recycling Process

The Environmental Protection Agency defines recycling as a three step process¹:

Collection and Processing

The four primary methods for collecting recycling are curbside, drop-off centers, buy-back centers, and deposit/refund programs. Recyclables are sent to a materials recovery facility for processing where they are bought and sold. Prices for the materials change and fluctuate with the market.

Manufacturing

Companies buy the cleaned and separated recyclables and manufacture them into new products.

Purchasing Recycled Products

Consumers purchase the recycled products and, once finished, send them back to the recycling plant, closing the loop.

Sources of Information

The Global Directory for Environmental Technology

<http://www.eco-web.com>

The Global Directory for Environmental Technology offers a comprehensive guide to environmental products and services, featuring 6,976 leading suppliers from 143 countries. Information about organizations, conferences and publications is complemented by editorial contributions from distinguished experts in their respective fields. Recycling infrastructure may be found per country by clicking on Index → Recycling → Material Recycling

Environmental Protection Agency

All of the following information may be found at EPA's website: <http://www.epa.gov/>

Businesses

- Visit <http://www.epa.gov/> for EPA's WasteWise program.
- Get involved with your local or state recycling organization. For a list of state organizations, visit the National Recycling Coalition's Web site: <http://www.nrc-recycle.org/>

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- Buy recycled-content products. Visit <http://www.epa.gov/> for EPA's Comprehensive Procurement Guidelines for lists of manufacturers of recycled-content products.

Programs

- The MSW Programs Page lists a variety of EPA recycling-related programs.

Publications

- EPA has compiled a list of recycling-related publications.

Associations

Alliance of Foam Packaging Recyclers
1298 Cronson Blvd., Suite 201
Crofton, MD 21114
Phone: 410 451-8340
<http://www.epspackaging.org/>

Aluminum Association
900 19th St. NW, Suite 300
Washington, DC 20006
Phone: 202 862-5100
Fax: 202 862-5164
<http://www.aluminum.org/>

American Forest and Paper Association
1111 19th Street, NW, Suite 800
Washington, DC 20036
Phone: 202 463-2700
http://www.afandpa.org/Content/NavigationMenu/Environment_and_Recycling/Recycling/Recycling.htm

American Plastics Council
1801 K Street, NW, Suite 701-L
Washington, DC 20006-1301
Phone: 800-2-HELP-90
<http://www.plastics.org/>

Association of Postconsumer Plastic Recyclers
1300 Wilson Boulevard
Arlington, VA 22209
Phone: 703- 741-5578
Fax: 703-741-5646
<http://www.plasticsrecycling.org/>

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Glass Packaging Institute
740 East 52nd Street
Indianapolis, IN 46205
Phone: 317 283-1603
Fax: 317 923-9906
<http://www.gpi.org/>

Institute for Local Self-Reliance
2425 18th Street, NW
Washington, DC 20009
Phone: 202 232-4108
Fax: 202 332-0463
<http://www.ilsr.org/>

Institute for Scrap Recycling Industries
1325 G Street, NW, Suite 1000
Washington, DC 20005
Phone: 202 737-1770
Fax: 202 626-0900
<http://www.isri.org/>

National Recycling Coalition
1727 King Street, Suite 105
Alexandria, VA 22314-2720
Phone: 703 683-9025
Fax: 703 683-9026
<http://www.nrc-recycle.org/>

Polystyrene Packaging Council
1801 K Street NW, Suite 600K
Washington, DC 20006-1301
Phone: 202 974-5321
Fax: 202 296-7354
<http://www.polystyrene.org/>

Rechargeable Battery Recycling Corporation
1000 Parkwood Circle
Suite 450
Atlanta, GA 30339
Phone: 678-419-9990
Fax: 678-419-9986
<http://www.rbrc.org/>

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Steel Recycling Institute
680 Andersen Drive
Pittsburgh, PA 15220-2700
Phone: 412 922-2772, 800 876-7274
Fax: 412 922-3213
<http://www.recycle-steel.org/>

Other related solid waste organizations.
<http://www.epa.gov/osw/infoserv.htm#generl>

References

¹ Recycling. 27 October 2004. US Environmental Protection Agency. 11 March 2005 <<http://www.epa.gov>>.

Appendix D: EPEAT

This appendix shows the final draft version of the Electronic Product Environmental Assessment Tool, which is intended to help institutional purchasers compare electronic products by their environmental attributes. Only the introduction and section pertaining to packaging is reprinted.



ELECTRONIC PRODUCT
ENVIRONMENTAL ASSESSMENT TOOL

FINAL DRAFT

VOLUNTARY ENVIRONMENTAL PERFORMANCE CRITERIA FOR COMPUTERS, LAPTOPS AND MONITORS

Version 1 February 9, 2005

Background on the Electronic Product Environmental Assessment Tool (EPEAT)

EPEAT is an environmental procurement tool designed to help institutional purchasers in the public and private sectors evaluate, compare and select desktop computers, laptops and monitors based on their environmental attributes.

Purpose of EPEAT

The development of EPEAT was prompted by a growing demand by institutional purchasers for an easy-to-use evaluation tool that allows the comparison and selection of electronic products based on environmental performance. The electronics industry welcomed and actively participated in the development of EPEAT and envisioned EPEAT as a way to communicate relevant and meaningful information to institutional purchasers about the environmental impacts posed by electronic products.

EPEAT will offer many benefits for institutional purchasers, manufacturers, and the environment, including:

- Providing institutional purchasers with:
- An easy way to specify and purchase computer products that meet challenging yet realistic environmental criteria simply by requiring that the equipment be EPEAT-qualified.
- An efficient and credible means for verifying that equipment meets the criteria.
- Flexibility to select equipment that meets the minimum performance criteria or to give preference to models with more environmental attributes by specifying a higher EPEAT qualification level.
- Credibility for the procurement decisions since the EPEAT criteria were developed through a consensus process that balanced the concerns of purchasers, industry, environmental groups and other stakeholders.
- Assurance that the same set of criteria is used by purchasers nationwide to ensure competitive product pricing, consistent availability and significant impact on the industry and the environment.
- Providing manufacturers with:
- One clear set of performance criteria for the design of products and services.
- Flexibility as to how they meet the higher levels of EPEAT qualification.
- A market advantage for environmentally preferable products.

Appendix D: EPEAT

- A low cost, user friendly system which will not delay the process for getting a new product to market.
- Providing environmental stakeholders with:
- A credible assessment of electronic products based on environmental criteria.
- A system that promotes the continuous improvement of environmental performance across the entire life cycle of electronic products.

Summary of How EPEAT Will Work

The EPEAT tool will evaluate electronic products according to three tiers of environmental performance – Bronze, Silver and Gold. The complete set of EPEAT criteria includes 22 mandatory criteria (i.e., all criteria must be met to achieve the Bronze, or “baseline”, EPEAT ranking) and 33 optional criteria (i.e., producers can pick and choose among these criteria to boost their EPEAT baseline “score” to achieve a higher ranking level).

Bronze: Product meets all 22 mandatory criteria

Silver: Product meets all 22 mandatory criteria plus at least 16 optional criteria.

Gold: Product meets all 22 mandatory criteria plus at least 25 optional criteria.

Before listing their products on EPEAT, manufacturers will sign a formal Memorandum of Understanding (MOU) that commits them to provide accurate product and company information and provides for remedies should inaccuracies be discovered. The assessment tool will be structured to allow manufacturers to self-declare, via a web-based interface, that their specific products meet EPEAT criteria. For each criterion, producers must, on request of the EPEAT organization, provide a specified set of verification data in order to demonstrate EPEAT conformance.

Most criteria refer to environmental performance characteristics of the specific product, and the manufacturer declares to those product criteria for each product of their choice. Some criteria refer to general corporate programs, such as a Corporate Environmental Policy, and the manufacturer declares to those criteria in a report that is provided annually.

To ensure that the self-declaration system functions in a transparent and verifiable manner, the EPEAT organization will randomly select a subset of qualified products each year to verify their qualification. In addition, a user of EPEAT may request that a specific product be verified, and the EPEAT organization, or other authorized agent, will select products to be verified if a credible source has identified a specific concern that appears to have merit. The EPEAT organization, or its agent, will contact the manufacturer who will be required to provide the verification data. In the event that a declared product fails to meet the criteria, the EPEAT organization will follow the process established in the MOU, which will initially focus on correcting the problem, but may ultimately include disqualifying the manufacturer from use of EPEAT.

How the EPEAT Criteria Were Developed

The EPEAT draft environmental criteria and the procedures for validation represent the results of an 18 month-long multi-stakeholder process. The EPEAT Development Team was composed of stakeholders that represented manufacturers, trade associations, institutional purchasers, environmental organizations, electronics recyclers, academics, and others¹. The process for developing the draft criteria included use of ANSI essential requirements², such as the need for openness, balance, consideration of all views, and consensus decision making.

Each criterion was evaluated alongside the others to ensure that EPEAT is a balanced and comprehensive tool that covers multiple environmental attributes throughout the product's life cycle. The criteria are stringent enough to promote better environmental design, manufacture, and end-of-life management, while reflecting existing technologies and technical limitations so that a supply of EPEAT products will be available to purchasers. Specific criteria are drawn heavily from existing U.S. and international legal and marketing requirements and standards such as Energy Star®, the European Union's Restriction on Hazardous Substances Directive, the IT-Eco Declaration, and ECMA International (European Computer Manufacturers Association). The EPEAT Development Team chose to build on existing legal and market requirements to reduce overlap and possibly conflicting requirements on product producers.

Using EPEAT in Product Procurement

The EPEAT criteria are designed to be used as a comprehensive whole. The Development Team strongly recommends that users of the EPEAT tool do not selectively pick and choose among the EPEAT criteria or amend or modify their potential product scope or application. Doing so would weaken the impact and results of the overall EPEAT process. Taken as a whole, the EPEAT system – the criteria, data and documentation requirements, manufacturer agreements, processes for after-market verification, and commitments to future updates and extensions – will provide purchasers with a simple and verifiable program for the selection of environmentally sustainable products. In addition, the criteria will provide a single, practical system for manufacturers to demonstrate the environmental performance of their products. The overall EPEAT result carefully balances stakeholder concerns and promotes overall environmental improvement. The EPEAT stakeholders request the EPEAT package be followed in its entirety.

Understanding EPEAT Criteria Types

All EPEAT criteria are divided into eight categories, which reflect different environmental attributes. The categories include the Reduction/Elimination of Environmentally Sensitive Materials, Materials Selection, Design for End-of-Life, Product Longevity / Life Cycle Extension, End-of-Life Management, Corporate Performance and Packaging. In addition, each of the individual criteria can also be classified based on whether it is mandatory or optional, and based on whether they relate specifically to the product or more generally to the manufacturer.

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Mandatory and Optional Criteria: In the “EPEAT Criteria Descriptions” section, these types are designated after the criterion number:

- *Mandatory criteria* are those that must be met in order for a product to be eligible for EPEAT.
- *Optional criteria* are those that can be used to achieve higher EPEAT levels, such as silver or gold.

Product and Annual Report Criteria: In the “EPEAT Criteria Descriptions” section, this criterion type is shown leading the specific wording of the criterion.

- *Product criteria* are those that apply to each specific product that a manufacturer lists with EPEAT, and are declared to in the product application process.
- *Annual Report criteria* are those that apply to a program or an offering of the manufacturer in general, and are not exclusive for the specific product. They are declared to in the Annual Report.

Interim Guidance for Using EPEAT

The EPEAT tool is still in the implementation phase and the EPEAT Implementation Team is working to identify a host organization and bring the EPEAT system to a “live” state as quickly as possible. The full system is expected to be available sometime in late 2005 or early 2006. Thus it is highly recommended that purchasers wait until the full EPEAT purchasing and verification tool and process are available since doing so will allow purchasers to have the best, comparable environmental information about potential products.

However, some purchasers may need to make purchasing decisions before the completed implementation phase. Hence, they may desire to use the EPEAT criteria in bid specs, market surveys and similar documents during the interim period. It is extremely important to note that an agency using the criteria before the formal release of the complete EPEAT tool will be solely and completely responsible for verifying compliance to the criteria.

Below is some guidance from the EPEAT Implementation team to help ensure the criteria are used appropriately during the interim period.

- DO only apply the criteria to electronics products (monitors, desktops & notebooks) that are included in the original EPEAT scope.
- DO only use the mandatory criteria (bronze level) and not criteria from the advance tiers (gold or platinum).
- DO understand that manufacturers may be making product and process changes to meet the EPEAT criteria and that not all criteria can be met today, e.g., some of the RoHS criteria. This may result in a smaller available product pool from which to select.
- DO refer to the criteria as FINAL DRAFT EPEAT CRITERIA and include the date and revision of criteria used.

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- DO include in your bid specs an option for requiring the use of the EPEAT tool, process and criteria when such products are available -- as per the following, example language.

"During the term of the contract, [Agency/Department] reserves the right to purchase exclusively or otherwise provide preference for specific models of desktop computers, notebooks and monitors qualified through the Electronic Products Environmental Assessment Tool (EPEAT) or its successor."
- DO NOT augment the attributes or mandatory criteria by adding other environmental requirements or adjusting the criteria's values. If purchaser must include other environmental criteria, it must be clearly noted that those specific criteria are not part of the EPEAT requirements.
- DO NOT refer to the product purchased during the interim period as in conformance with EPEAT or in conformance with EPEAT criteria. Also, do not refer to the purchased product as EPEAT certified, EPEAT approved, or EPEAT compliant during this time.

The Implementation Team believes following this guidance strikes an appropriate balance between making better purchasing decisions and not negatively affecting the implementation of the EPEAT tool or weakening its eventual impact.

If you have questions, please consult the EPEAT web site (www.epeat.net) or the contacts listed within it.

Process for Finalizing the EPEAT Criteria

The Development Team has completed its work, and a smaller Implementation Team is now working to implement EPEAT. A central question is what organization will host the EPEAT tool. A public comment period will be held on the draft criteria.

In order to be notified regarding the public comment period, please send your contact information to: epeat_comments@epeat.net

For further information on EPEAT see <http://www.epeat.net>

Definitions of Terms

Annual Report Criterion: A criterion that applies to a program or offering of the manufacturer in general, is not exclusive for the specific product, and is declared to in the Annual Report.

Bio-based: Under Section 9002 of the Farm Security and Rural Investment Act of 2002, bio-based products are defined as a product “that is composed, in whole or in significant part, of biological products or renewable agricultural materials (including plant, animal, and marine materials) or forestry materials.” The Guidelines for Designating Bio-based Products for Federal Procurement (Federal Register Vol. 68, No 244, p. 70730, Dec. 19, 2003) cites the intent to speed the development of new markets for bio-based products, and specifically excludes bio-based products with mature markets such as wood products made from traditionally harvested forest materials.

Blue Angel: The German environmental labeling program which is run by the federal environmental agency, the German institute of Quality Assurance and a private organization.
http://www.blauer-engel.de/englisch/navigation/body_blauer_engel.htm

Compatible: Definition for “compatible” relates to recycling of plastics with paints or coatings: ‘paints & coatings on plastic parts are proven to be compatible with recycling processes if they do not significantly impact the physical/mechanical properties of the recycled resin. “Significant” impact is defined as >25% reduction in notched IZOD impact at room temperature as measured using ASTM standard D256’ (Based on a criterion developed by the FEC Plastics Task Force.

ECMA: ECMA International in Europe establishes standards for the information technology and consumer electronics industries, including a self-declaration standard for the environment, TR70.
<http://www.ecma-international.org/>

Energy Star®: A label awarded for energy efficiency operated by the U.S. EPA and DOE.
<http://www.energystar.gov/>

IT-Eco Declaration: A self-declaration environmental standard for electronic products developed by the Nordic information technology organizations (NITO).
<http://www.itecodeclaration.org/>

Homogeneous material: A material that cannot be mechanically disjointed into different materials. For further explanation of when a material is homogeneous, see the information provided by DTI on the RoHS guidance document - DSTI is the consultant the UK is using on RoHS.
http://www.dti.gov.uk/sustainability/weee/RoHS_Regs_Draft_Guidance.pdf

Laptop/Notebook: Portable-style computer system

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Product: A marketing model and chassis type versus a singular configuration of the product. Different configurations may include options for processor, memory, hard disk etc. A product, for EPEAT, is every configuration that could be offered in a specific marketing model and chassis. If there is a configuration within a marketing model and chassis type that would change the environmental performance substantially, especially if it no longer met a criterion, then the manufacturer could not claim EPEAT for that configuration, even if the same model in other configurations did meet EPEAT. EPEAT currently applies to system units, laptop/notebooks, and monitors. A “complete” product includes, for example, the system unit and all its peripherals (a CPU, the keyboard, the mouse and power cord would be “one product”).

Product Criterion: A criterion that applies to each specific product that a manufacturer lists with EPEAT, and declared to in the product application process.

Monitor: A VDU used with a computer.

Reusable or recyclable: Materials or components can be removed or recovered from the whole electronic product and put back into productive use as a material or component, not including energy recovery, at a net positive economic value using standard recycling technologies, or demonstrated by a test at a commercial recycler. For further explanation of when a product or packaging can be claimed to be reusable or recyclable, see Section 260.7(d) of the Federal Trade Commission's Guide for Environmental Marketing Claims:

<http://www.ftc.gov/bcp/grnrule/guides980427.htm>

Renewable Energy: Resources that constantly renew themselves or that are regarded as practically inexhaustible are considered renewable. These include, but are not limited to, solar, fuel cells, wind, geothermal, hydro and wood. Energy source must be environmentally preferable to the non-renewable source.

RoHS: The European Directive for the Restriction on use of certain Hazardous Substances in electronic products.

http://europa.eu.int/eur-lex/pri/en/oj/dat/2003/l_037/l_03720030213en00190023.pdf

SCCP: Short Chain Chlorinated Paraffins, CAS number 63449-39-8.

System Unit: Desktop-style computer system.

VDU: A Video Display Unit includes a cathode ray tube, cathode ray tube device, flat panel screen or similar display device.

Summary List of EPEAT Criteria

M = Mandatory Criterion

O = Optional Point Criterion

(Annual Report Criteria are designated as such in parentheses)

1. Reduction/Elimination of Environmentally Sensitive Materials

1.1 Reduction of Use of Hazardous Substances

M 1.1.1 Compliance with provisions of European RoHS directive

1.2 Hexavalent Chromium

O 1.2.1 Elimination of intentional use of Hexavalent Chromium

1.3 Cadmium

O 1.3.1 Elimination of intentional use of Cadmium

1.4 Lead

O 1.4.1 Elimination of intentional use of Lead in certain applications

1.5 Mercury

M 1.5.1 Reporting on amount of Mercury used in light sources

O 1.5.2 Low threshold for amount of Mercury used in light sources

1.6 Flame Retardants and Plasticizers

M 1.6.1 Elimination of intentional use of SCCP flame retardants and plasticizers in certain applications

O 1.6.2 Elimination of intentional use of Deca-BDE

O 1.6.3 Larger plastic parts free of flame retardants

1.7 Batteries

O 1.7.1 Batteries free of Lead, Cadmium and Mercury

1.8 PVC and Chlorinated Plastics

O 1.8.1 Large plastic parts free of PVC

2. Materials Selection

2.1 Total Recycled Content

M 2.1.1 Declaration of post-consumer recycled content

O 2.1.2 Minimum content of post-consumer recycled material

O 2.1.3 Higher content of post-consumer recycled material

2.2 Renewable/Bio-Based Materials

M 2.2.1 Content declaration of renewable/bio-based materials

O 2.2.2 Minimum content of renewable/bio-based material

2.3 Dematerialization

M 2.3.1 Declaration of product weight

3. Design for End of Life

3.1 Design for Recovery through Recycling Systems that Utilize Shredding

M 3.1.1 Identification of materials with special handling needs

M 3.1.2 No incompatible paints or coatings

M 3.1.3 Easy disassembly of housings

M 3.1.4 Marking of plastics

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- M** 3.1.5 Identification and removal of batteries and circuit boards
- O** 3.1.6 Reduced number of plastic resins
- O** 3.1.7 Molded/glued in metal eliminated or removable
- O** 3.1.8 Minimum 65 percent reusable/recyclable
- O** 3.1.9 Minimum 90 percent reusable/recyclable
- 3.2 Design for Recovery through Disassembly
 - O** 3.2.1 Manual separation of plastics
 - O** 3.2.2 Marking of plastics

4. Product Longevity / Life cycle Extension

- 4.1 Manufacturer Warranty/Service Agreement
 - M** 4.1.1 Availability of additional warranty or service agreement
- 4.2 Upgradeability
 - M** 4.2.1 Upgradeable with common tools
 - O** 4.2.2 Modular design
- 4.3 Product Life Extension
 - O** 4.3.1 Availability of replacement parts

5. Energy Conservation

- 5.1 Power Management System
 - M** 5.1.1 Energy Star® 3.0
 - O** 5.1.2 Lower power usage
 - O** 5.1.3 Tier 2 Energy Star® 4.0
 - O** 5.1.4 FEMP "Executive Order 13221"
- 5.2 Power Management
 - M** 5.2.1 Documented power management features
- 5.3 Use of Renewable Energy
 - O** 5.3.1 Renewable energy accessory available
 - O** 5.3.2 Renewable energy accessory standard
- 5.4 Efficiency of Power Supplies
 - O** 5.4.1 Efficiency threshold and disclosure of efficiency

6. End of Life Management

- 6.1 Product take-back
 - M** 6.1.1 Provision of product take-back service (*Annual Report Criterion*)
- 6.2 Rechargeable Battery Recycling
 - O** 6.2.1 Provision of a rechargeable battery recycling program (*Annual Report Criterion*)

7. Corporate Performance

7.1 Corporate Environmental Policy

- M** 7.1.1 Demonstration of corporate environmental policy consistent with ISO 14001
(*Annual Report Criterion*)

7.2 Environmental Management System

- M** 7.2.1 Self-certified environmental management system for manufacturing facilities
(*Annual Report Criterion*)
- O** 7.2.2 Third-party certified environmental management system for manufacturing facilities
(*Annual Report Criterion*)

7.3 Corporate Reporting

- M** 7.3.1 Corporate report consistent with Performance Track (*Annual Report Criterion*)
- O** 7.3.2 Corporate report based on Global Reporting Initiative (GRI) (*Annual Report Criterion*)

8. Packaging

8.1 Toxics in Packaging

- M** 8.1.1 Reduction/elimination of toxics in packaging

8.2 Recyclable packaging materials

- M** 8.2.1 Separable packing materials
- O** 8.2.2 Packaging 90% recyclable and plastics labeled

8.3 Recycled Content

- M** 8.3.1 Declaration of recycled content
- O** 8.3.2 Minimum post-consumer content guidelines

8.4 Take-Back Option

- O** 8.4.1 Provision of take-back program for packaging

8.5 Reuse Option

- O** 8.5.1 Documentation of reusable packaging

EPEAT Criteria Descriptions

[19 pages omitted: these sections refer to the electronics and not packaging]

8. Packaging

8.1 Toxics in Packaging

8.1.1 Mandatory – Reduction/elimination of toxics in packaging

Product Criterion: Heavy metals shall not be intentionally added to any packaging or packaging component. For incidental presence (not intentionally introduced), the sum of the concentration levels of lead, cadmium, mercury and hexavalent chromium present in any package or packaging component shall not exceed 100 parts per million by weight (0.01%).

Applies to: Packaging of EPEAT products

Verification Requirements:

1. Declaration from manufacturer
2. Supplier letter

References and Details: "Intentional Introduction" means: The act of deliberately utilizing a regulated metal in the formation of a package or packaging component where its continued presence is desired in the final package or packaging component to provide a specific characteristic, appearance, or quality. The use of a regulated metal as a processing agent or intermediate to impart certain chemical or physical changes during manufacturing, whereupon the incidental retention of a residue of said metal in the final package or packaging component is neither desired nor deliberate, is not considered intentional introduction for the purposes of this Act where said final package or packaging component is in compliance with subsection c of Section 4 of this Act. The use of recycled materials as feedstock for the manufacture of new packaging materials, where some portion of the recycled materials may contain amounts of the regulated metals, is not considered intentional introduction for the purposes of this Act where the new package or packaging component is in compliance with subsection c of Section 4 of this Act.

"Incidental Presence" means: The presence of a regulated metal as an unintended or undesired ingredient of a package or packaging component.

Recycled Content Exemption: Packages and packaging components that would not exceed the maximum contaminant levels set forth in subsection c of Section 4 of this Act but for the addition of recycled materials; and provided that the exemption for this subparagraph shall expire January 1, 2010. This exemption shall not apply to any cadmium, lead, mercury or hexavalent chromium that has been recovered and/or separated from other materials for use as a metal or metallic compound.

8.2 Recyclable packaging materials

8.2.1 Mandatory – Separable packing materials

Product Criterion: All non-reusable packaging is separable. All the packaging materials must be able to be segregated into like materials without the use of tools (i.e., need to be able to have all the cardboard separable from the foams separable from the plastic bags).

Applies to: Packaging of EPEAT products

Verification Requirements:

1. Declaration from manufacturer
2. Internal test data by manufacturer showing that packaging is separable

8.2.2 Optional – Packaging 90% recyclable and plastics labeled

Product Criterion: All plastics are identified by material type (SPI, DIN or country specific) and 90% of the packaging (by weight) consists of readily recyclable materials that are commonly accepted in most recycling programs or can be composted or disposed of in municipal sewage programs. This includes: cardboard, boxboard, newsprint, cornstarch, (etc. etc.). Pallets are excluded from the weight calculation.

Applies to: Packaging of EPEAT products

Verification Requirements:

1. Declaration from manufacturer
2. Demonstration that material is normally recyclable or, if not, that there exists a market/use
3. Visual inspections

References and Details: For the definition of “recyclable” refer to Section 260.7(d) of the Federal Trade Commission's Guide for Environmental Marketing Claims:

<http://www.ftc.gov/bcp/gnrule/guides980427.htm>

For some specific packaging materials, the presence or lack of an infrastructure on a regional basis will need to be considered by the manufacturer wishing to demonstrate compliance with this criterion. Since EPEAT ratings will be used nationally, without regional variations, if a product is declared to this criterion, the manufacturer will need to provide a recycling vendor option in certain areas if the recycling infrastructure is not generally available in a region where the EPEAT product will be used.

8.3 Recycled Content

8.3.1 Mandatory – Declaration of recycled content

Product Criterion: Packaging incorporates recycled content (Y/N) and declares approximate recycled content (by weight or volume specified by manufacturer) in the packaging materials used (Range of recycled content in each material).

Applies to: Packaging of EPEAT products

Verification Requirements:

1. Declaration from manufacturer
2. Supplier letter
3. Declaration of recycled content

References and Details: Manufacturer declares whether or not packaging contains any recycled content AND must list each packaging material with the approximate range of recycled content that is in that material.

For example: Corrugated Cardboard: between 15 and 40%

EPS Foam: 2-5%

Molded Pulp: Minimum of 60% Post-consumer, up to 100%

8.3.2 Optional – Minimum post-consumer content guidelines

Product Criterion: PA CPG Guidelines

Meets or exceeds the minimum post-consumer content for respective packaging in the CPG Guidelines over the course of a year using a weighted average.

Applies to: Packaging of EPEAT products

Verification Requirements:

1. Declaration from manufacturer
2. Supplier letter
3. Designation of CPG guideline that is met

References and Details: <http://www.epa.gov/epaoswer/non-hw/procure/products/paperbrd.htm>

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Item	Post-consumer Fiber (%)
Corrugated Containers <300 psi	25-50
Corrugated Containers 300 psi	25-30
Solid Fiber Boxes	40
Folding Cartons	40-80
Industrial Paperboard (e.g., tubes, cores, drums, and cans)	45-100
Miscellaneous (e.g., pad backs, covered binders, book covers, mailing tubes, protective packaging)	75-100
Padded Mailers	5-15
Carrierboard	10-15
Brown Papers (wrapping paper and bags)	5-20

8.4 Take-Back Option

8.4.1 Optional – Provision of take-back program for packaging

Product Criterion: Manufacturer offers a take-back program for free where the packaging material can be collected/returned to mfg or recycler for reuse or recycling.

Applies to: Packaging of EPEAT products

Verification Requirements:

1. Declaration from manufacturer
2. Documentation of take-back service
3. Documentation of notification of user of take-back service

8.5 Reuse Option

8.5.1 Optional – Documentation of reusable packaging

Product Criterion: Manufacturer provides a reusable packaging process that reuses the packaging for the same or similar product, at a competitive price. Manufacturer designs packaging for a minimum of 5 reuses.

Applies to: Packaging of EPEAT products

Verification Requirements:

1. Declaration from manufacturer
2. Documentation of packaging reuse system

References

¹ For the full Development Team see www.epeat.net

² “ANSI Essential Requirements: Due process requirements for American national standards.” American National Standards Institute, January 2003.

Appendix E: Standards and Guidelines

The purpose of this appendix is to provide information about standards and guidelines that are commonly used within the packaging industry. There are a variety of organizations, general packaging guidelines, environmental packaging guidelines, associations and standards that are included in this list. This list is not meant to be a comprehensive list of packaging affiliated standards and guidelines; instead it is included to be used as a reference tool for packaging professional as needed.

ASTM (American Society for Testing and Materials): An open market forum for the development of high quality, market relevant international standards used around the globe.¹

BASF and NOVA: Major chemical companies. BASF produces chemicals, plastics, performance products, fine chemicals, crude oil and natural gas. NOVA Chemicals Corporation operates 2 commodity chemicals businesses: olefins/polyolefins and styrenics. BASF and NOVA Chemicals Corporation signed a long term styrene monomer supply contract. The agreement commits NOVA to supply monomer feedstock to BASF's downstream styrenics business in the NAFTA region. The contract also commits BASF to supply styrene monomer to NOVA chemicals in Europe.²

CEN (European Committee for Standardization) Standards – EN 13427:2000 – EN

13432:2000: Revised versions of five European packaging standards:

EN 13427:2004 – Requirements for the use of European Standards in the field of packaging and packaging waste.

EN 13428:2004 – Requirements specific to manufacturing and composition, focusing on source reduction.

EN 13429:2004 – Requirements for relevant materials and types of reusable packaging.

EN 13430:2004 – Requirements for packaging recoverable by material recycling.

EN 13431:2004 – Requirements for packaging recoverable in the form of energy recovery, including specification of minimum inferior calorific value.

EN 13432:2000 – Requirements for packaging recoverable through composting and biodegradation; test scheme and evaluation criteria for the final acceptance of packaging.³

A chart of the CEN standards can be found at:

<http://www.cenorm.be/CENORM/BusinessDomains/TechnicalCommitteesWorkshops/CENTechnicalCommittees/WP.asp?param=6242&title=CEN/TC%20261>

DIN EN 13429: (European document) Specifies the requirements for packaging to be classified as reusable and sets out procedures for assessment of conformity with those requirements, including associated systems. The procedure for applying this standard is contained in EN 13427. There are various other DIN Packaging and Distribution documents that specify requirements for different types of packaging.⁴

EIA (Electronic Industries Alliance): A national trade organization that includes a full spectrum of U.S. manufacturers. EIA provides a forum for industry to develop standards and publications.⁵

EIPS2000 (Electronics Industry Pallet Specifications): A document that was created to be used as a guideline to reduce total supply chain costs improving the quality and consistency of pallets used within the computer industry. It was created by the EIPS Task Group, a sub-committee of the Institute of Packaging Professionals.⁶

FMI (Food Marketing Institute)/GMA (Grocery Manufacturers of America): FMI, GMA, and Food Distributors International (FDI) released *Supply Chain Packaging: Voluntary Shipping Guidelines for the U.S. Grocery Industry*. The guidelines are intended to provide a better understanding of the criteria that should be considered when packaging a product for distribution in multiple channels.⁷

GSE A-5951-1745 (HP General Specifications for the Environment: Document Identifier is A-5951-1745-1): Describes HP's global specifications for restricting or prohibiting certain chemical compounds or materials in the company's products or manufacturing processes and contains general product content restrictions (battery, material content, packaging materials, product labeling and marking requirements, chemical registration requirements, ozone depleting substance restrictions, and others). All HP manufacturing facilities and suppliers involved in manufacturing HP's products, parts, or components must comply with these specifications.⁸ For PVC-specific information please refer to the following website:

<http://www.hp.com/hpinfo/globalcitizenship/environment/pdf/prop65spec.pdf>

HP Packaging test manual 5971-3628: Includes packaging test requirements.⁹

IATA (International Air Transport Association): A universal trade organization that brings together approximately 270 airlines. IATA's mission is to represent, lead, and serve the airline industry; they work to make the international air transport industry safer, more profitable and efficient. They are involved in numerous areas of operation including aircraft operations, airport development and infrastructure, cargo, finance, industry initiatives, passenger, regulatory and public policies, safety, and security.¹⁰

IBM Packaging Requirements Manual (Document # GA21-9261-11(a)): Includes the minimum packaging requirements for all shippers to and from IBM. It addresses the major areas of concern in electronics packaging including compliance, environmentally conscious packaging, package testing, primary packaging, secondary packaging, palletization, labeling, and wooden packaging.¹¹

ISO (International Organization for Standardization) 1043: Source of more than 14000 International technical standards for business, government, and society. ISO is a network of national standards institutes from 146 countries working in partnership with international organizations, governments, industry, business and consumer representatives. ISO standards contribute to making the development, manufacturing and supply of products and services more efficient, safer and cleaner. They make trade between countries easier and fairer. They provide governments with a technical base for health, safety and environmental legislation. They aid in transferring technology to developing countries. ISO standards also serve to safeguard consumers and to make their lives simpler.¹²

ISPM15 (International Standards for Phytosanitary Measures Publication No. 15): *Guidelines for Regulating Wood Packaging Material in International Trade*. ISPM 15 was developed to address the global spread of timber pests by regulating the movement of timber packing and dunnage (loose packaging material) in international trade. ISPM 15 describes a number of phytosanitary measures to reduce the risk of introduction and/or spread of quarantine pests associated with solid timber packing material (including dunnage). ISPM 15 was prepared by the Secretariat of the International Plant Protection Convention (IPPC) as part of the United Nations Food and Agriculture Organization's (FAO) global program of policy and technical assistance in plant quarantine.¹³

ISTA (International Safe Transit Organization): Their mission is to design and develop effective packaging, methods and logistic systems for product distribution worldwide.¹⁴

JEDEC Solid State Technology Association: JEDEC standards and publications are designed to serve the public interest through eliminating misunderstandings between manufacturers and purchasers, facilitating interchangeability and improvement of products, and assisting the purchaser in selecting and obtaining with minimum delay the proper product for use by those other than JEDEC members, whether the standard is to be used domestically or internationally. JEDEC standards and publications contain material that has been prepared reviewed and approved through the JEDEC Council level and reviewed and approved by the Electronic Industries Alliance (EIA) General Council.¹⁵ Examples of JEDEC standards can be found at: <http://www.semiconfareast.com/jedec.htm>

P2C2 (Protective Packaging of Computer Components): The name given to the technical committee of an Environmental Task group. The Environmental Task group was started in 1990 when Paul Russel of HP and Ed Iwasaki of Apple Computer teamed up with Ronald Perry at Sun Microsystems to work on a common environmental packaging guideline for the computer industry.

R3P2 (Reduction, Reuse, and Recycling of Protective Packaging): A result of the P2C2 committee, the R3P2 handbook was designed to guide packaging professionals to use environmentally friendly and responsible packaging in the Electronics industry. The main point of the document: Packaging must fully preserve the integrity of the products it contains while having a minimum negative impact on the environment.

Appendix E: Standards and Guidelines

References

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- ² American Plastics Council.org. Home page. 11 March 2005
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- ³ European Committee for Standardization. Home page. 12 March 2005
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<<http://packaging.hp.com/eips/Knowledge/EIPS2000-18APR2002.pdf>>.
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<<http://www.ippc.int>>.
- ¹⁴ International Safe Transit Association. Home page. 12 March 2005 <<http://www.ista.org>>.
- ¹⁵ JEDEC: The Standards Resource for the World Semiconductor Industry. Home page. 12 March 2005
<<http://www.jedec.org>>.

Appendix F: Standardized Packaging Symbols

This appendix is a supplement to the Labeling and Declarations section of Chapter 11 (pg 100). It covers mandatory and voluntary labeling related to characterization of a product's environmental attributes.

In the U.S., all environmental claims associated with a product are governed by the Federal Trade Commission's "Guides for the Use of Environmental Marketing Claims."¹ Internationally all environmental claims are defined by the International Organization for Standardization (ISO) 14021: Environmental Labels and Declarations-Self-Declared Environmental Claims².

Graphical symbol: Visually perceptible figure used to transmit information independently of language. It may be produced by drawing, printing or other means.³

Mandatory Environmental Labeling

The following describes how to use The Society of Plastics Industry code to identify plastics.

Society of Plastics Industry (SPI)

The SPI code has been developed to provide a consistent system for the United States to facilitate recycling of post-consumer plastics through normal channels for municipal solid waste management. Coding allows plastics to be separated for homogeneity of properties, thereby increasing the predictability of the properties of the recycled plastic. This is very important, because the success of a product will often be determined by choosing a plastic with the right properties. Additionally, coding may help increase recycling infrastructure by identifying a readily-available stream of plastics that are currently not recycled.

The following guidelines should be adhered to at all times⁴:

- Use the SPI code on bottles and rigid containers in compliance with the 39 state laws now in effect.
- Use the SPI code solely to identify resin content.
- Comply with the FTC Guides for the Use of Environmental Marketing Claims whenever the SPI code is used.
- Make the code inconspicuous at the point of purchase so it does not influence the consumer's buying decision (generally molded into the bottom of the container).
- Do not modify the elements of the code in any way (e.g., do not replace the resin acronym in the code and do not use other types of chasing arrows).
- Do not make recycling claims in close proximity to the code, even if such claims are properly qualified.

Appendix F: Standardized Packaging Symbols

- Do not use the term "recyclable" in proximity to the code.
- For more information read: Guide to the Correct Usage of the SPI Resin Identification Code⁵: <http://www.socplas.org/outreach/recycling/2124.htm>

Adoption of the SPI code is as follows:

- Required in 39 US States.
- Alaska, Arizona, Arkansas, California, Colorado, Connecticut, Delaware, Florida, Georgia, Hawaii, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Nebraska, Nevada, New Jersey, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Virginia, Washington and Wisconsin.
- Required in Taiwan
- Required on “controlled” containers subject to recycling fees
- Required on all plastic containers 8 ounces (200 ml) and greater
- Used but not required in Mexico and many other Latin American countries
- Currently permitted in all countries

The following images are available in pdf format at:
<http://www.socplas.org/outreach/recycling/resincodes.htm>



Material: Polyethylene Terephthalate
Material Number: 1
Abbreviation: PET



Material: Polyethylene Terephthalate
Material Number: 1
Abbreviation: PET



Material: High Density Polyethylene
Material Number: 2
Abbreviation: HDPE

Appendix F: Standardized Packaging Symbols



Material: Polyvinyl Chloride
Material Number: 3
Abbreviation: V



Material: Low Density Polyethylene
Material Number: 4
Abbreviation: LDPE



Material: Polypropylene
Material Number: 5
Abbreviation: PP



Material: Polystyrene
Material Number: 6
Abbreviation: PS



Material: Other
Material Number: 7
Abbreviation: OTHER

Additional information:

- Resins that have become a recycled product are marked with an R before the SPI abbreviation. For example: RPET, RHDPE, RV, RLPDE, RPP, RPS.
- Typically, recycled resins are used for less-stringent purposes.
- Recycled resins may still be recyclable.
- Material labeled “OTHER” may contain 100% recycled material but may not be suitable for recycling or be specifically identifiable.
- Other plastics are identified by ISO 1043-1.
- Engraving masters and camera-ready artwork for the SPI codes are available for purchase from SPI for \$5 to \$10 (USD) each.

Voluntary Environmental Labeling

Green Dot



Purpose⁶

- Stands for a closed-cycle economy (what is referred to in this guideline as cradle-to-cradle).
- Its imprint on a piece of packaging signals that the manufacturer has paid a license fee for the collection, sorting, and recycling of the packaging.
- The license fee is governed by the number of packaging units put on the market and the weight of the applied materials.
- The overall goal of the Green Dot is to organize the collection, sorting, and recycling of packaging waste.

Country Requirements

- The Green Dot is required in:
- France, Greece, Germany, Portugal, and Spain.
- Its use is voluntary in:
- Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Hungary, Ireland, Latvia, Lithuania, Luxembourg, Malta, Norway, Poland, Slovakia, Slovenia, Sweden, and Turkey.
- It requires licensing only in:
- Canada and the UK.

Labeling Requirements

- The darker arrow must point upwards to the right.
- The lighter arrow must point downward to the left.
- Standard colors: Pantone 343 C (dark green), Pantone 366 C (light green)
- Alternative colors: One color on a white background, In white on a color background.
- Recommended size: 10 mm (6 mm acceptable for extremely small packages)

Appendix F: Standardized Packaging Symbols

- Logo may be printed, stamped, checkered, or embossed.
- More information may be found at: <http://www.gruener-punkt.de/>.

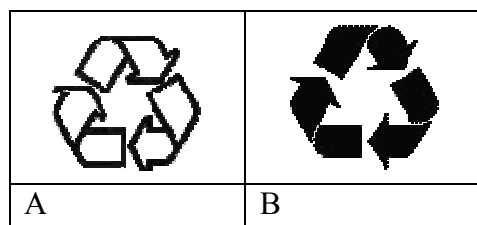
ISO 1043-1

ISO 1043-1 is a system of abbreviations for plastic polymers, copolymers, and blends. It also includes symbols for additional properties of the plastics and guidelines for joining and punctuating the abbreviations.⁷ The standard may be purchased at: <http://www.iso.ch>.

Recycling Symbols

Recycling symbols can be subdivided into two categories: those declaring a recyclable product and those declaring a product made from recycled content. The FTC Green Guides and ISO 14021 should be adhered to in all instances.

Recyclable Symbols



Symbol on the left (A):

- Traditional recycling symbol.
- Usually used by paper products.




Symbol on the right (B):

- Modified version of traditional recyclable symbol.

Use:

- Denotes recyclable products.
- Often accompanied with text (may be printed with or without text)
- For example: “This product can be recycled” or “recyclable”
- Laws governing recyclability will vary with region.

Recycled Symbols

		
A	B	C

Symbol on the left (A):

- If marked with this symbol, the product or package must be made with some recycled content.

Symbol in the middle (B):

- Percentage in the middle indicates what percentage of the product or package is made from recycled content.

Symbol on the right (C):

- The outer black circle denotes that at least some percentage of the product or package is made from recycled content.

Use:

- Denotes use of recycled material.
- May be printed with or without text (e.g., “Printed on recycled paper”).
- Usually accompanied by text explaining the percentage of recycled content.
- Typically used for paper or paperboard.
- Originated by the American Forest and Paper Association⁸.

Specific Recycling Symbols



The symbol to the left is specific to the use of recycled paperboard. It is a registered trademark of and controlled by the 100% Recycled Paperboard Alliance⁹. The symbol signifies that the paperboard has been made from 100% recycled content.

CARTON MADE WITH



MINIMUM 25% POST
CONSUMER CONTENT

The descriptive explanation around the symbol is not registered and may be interpreted as follows: The carton is made from 100% recycled content using at least 25% post-consumer recycled content. Post-consumer content refers to recycled content that has passed through the hands of the consumer. The remaining 75% is probably recycled content from manufacturing processes.



The Glass Packaging Institute's¹⁰ Recycling G denotes that the package is recyclable. There are no restrictions on the placement, size, or color of the G.



The Corrugated Packaging Council¹¹ has developed this symbol to denote corrugated material that is readily recyclable. It is not meant to imply that any recycled material has been used. It should not be used if the material is not readily recyclable (e.g., it has been treated with wax).

Appendix F: Standardized Packaging Symbols

References

- ¹ FTC Green Guides: Guides for the Use of Environmental Marketing Claims. Federal Trade Commission. 11 March 2005 <<http://www.ftc.gov/bcp/gmrule/guides980427.htm>>.
- ² International Organization for Standardization. Home page. 12 March 2005 <<http://www.iso.org>>.
- ³ Guidance - Graphical Symbols. 16 December 2004. European Committee for Standardization. 6 March 2005 <<http://www.cenorm.be/boss/supporting/guidance+documents/gd030+-+graphical+symbols/index.asp>>.
- ⁴ Outreach and Education. 2001. The Society of the Plastics Industry. 12 March 2005 <<http://www.plasticsindustry.org/outreach/recycling/2124.htm>>.
- ⁵ The Society of the Plastics Industry <<http://www.plasticsindustry.org/outreach/recycling/2124.htm>>.
- ⁶ The Green Dot. Duales System Deutschland AG. 12 March 2005 <<http://www.gruener-punkt.de/>>.
- ⁷ International Organization for Standardization. Home page. 12 March 2005 <<http://www.iso.org>>.
- ⁸ American Forest and Paper Association. Home page. 12 March 2005 <<http://www.afandpa.org/>>.
- ⁹ 100% Recycled Paperboard Alliance. Home Page. 12 March 2005 <<http://www.rpa100.com/>>.
- ¹⁰ Glass Packaging Institute. Home page. 12 March 2005 <<http://www.gpi.org/>>.
- ¹¹ Corrugated Packaging. Home page. 12 March 2005 <<http://www.corrugated.org/>>.

Appendix G: Planning Template

This template is meant to help the packaging professional work through the design procedure presented in this Guideline. Some of the questions used in the template have been adapted from the IoPP Packaging Reduction, Recycling & Disposal Guidelines.

The purpose of this template is to help the packaging professional ask the right questions in the right order to incorporate environmental considerations with a minimal impact on design time. The questions should help highlight where the environmental impact of a package is coming from, so the professional can determine if it can be reduced.

Environmental Packaging Procedure

Step 1: Identify Environmental Goals and Initiatives

1. What is the company's environmental policy?

2. What environmental issues have a high priority in your company?

3. What general processes are in place to meet environmental goals and initiatives?

____ Design for the Environment

____ Take-Back and Recycling Programs

____ Restriction of Hazardous Substances Compliance

____ Supplier Responsibility

____ Other: _____

4. Does the package meet the goals of applicable Environmental Stewardship Programs (such as company environmental policies, action plans, etc.)?

____ Yes, the package meets all goals.

____ No, the package does not meet the goals but problem areas have been identified (see below) and are being mitigated.

____ No, the package does not meet the goals; other requirements (i.e., business considerations) do not allow the package to meet the goals.

5. What environmental goals and initiatives does the package fail to meet?

Step 2: Identify the Destination of the Package

1. To what regions is the package going?

2. What are the end-of-life options at the destination for each material?

Material 1:	Material 2:	Material 3:	Material 4:
<input type="checkbox"/> Recycling	<input type="checkbox"/> Recycling	<input type="checkbox"/> Recycling	<input type="checkbox"/> Recycling
<input type="checkbox"/> Reuse	<input type="checkbox"/> Reuse	<input type="checkbox"/> Reuse	<input type="checkbox"/> Reuse
<input type="checkbox"/> Landfill	<input type="checkbox"/> Landfill	<input type="checkbox"/> Landfill	<input type="checkbox"/> Landfill
<input type="checkbox"/> Incineration	<input type="checkbox"/> Incineration	<input type="checkbox"/> Incineration	<input type="checkbox"/> Incineration
<input type="checkbox"/> Other: _____	<input type="checkbox"/> Other: _____	<input type="checkbox"/> Other: _____	<input type="checkbox"/> Other: _____

3. How will the storage conditions for this region affect the protection requirements of the package?

Step 3: Identify Relevant Regulations

1. To what regulating entities will your package be subject (international, federal, state, etc.)?

2. With what regulations must your package comply?

3. Will existing or proposed legislation (e.g., package taxes, bans, deposits, solid waste bills, etc.) affect the package during its service life?

☐ Yes, on the federal level: _____

☐ Yes, on the state level: _____

☐ Yes, on the local level: _____

☐ No

☐ Don't know

4.a. Are regulatory requirements consistent for all destinations?

☐ Yes

☐ No. How? _____

b. If "no", can the package be tailored to each destination, or should it be designed to meet regulations in all destinations?

Appendix G: Planning Template

5.a. Does your company act in an advisory capacity to federal, state and/or local governments to ensure that they have access to accurate packaging data?

☐ Yes. How? _____
☐ No

b. If “yes”, are the packaging structural design requirements fully considered by corporate lobbyists?

☐ Yes
☐ No

Step 4: Mode of Shipping Selection

1.a. What are the available shipping methods that meet the business requirements (time demands, cost, value of product, etc.)?

b. How will each of these shipping methods affect the protection needs of the package?

c. How will each of these shipping methods affect the environmental impact of the package?

d. How is the shipping cost determined?

☐ Truckload (volume)
☐ Actual Weight
☐ Dimensional Weight

e. Will the package require additional packaging at any of these steps?

☐ Yes: _____
☐ No

f. If “yes”, how will the outer or inner packaging used for shipment and distribution of goods be treated at end-of-life?

☐ Recycling
☐ Reuse
☐ Landfill
☐ Incineration
☐ Other: _____

g. Has a resource recovery and recycling system been established in cooperation with customers to collect and reuse distribution packaging waste that does not reach the ultimate consumer?

☐ Yes
☐ No
☐ No, but a system is in development

Appendix G: Planning Template

2. Is there an opportunity to use a reusable, returnable container program to reduce waste?

____ Yes

____ No

3. Are programs in place to require reusable or recyclable secondary packaging from suppliers?

____ Yes

____ No

____ No, but a system is in active development

Step 5: Identify Company Specific Requirements

1. What are the protective requirements for the package?

2. Has marketing been consulted to determine their needs and the target market?

____ Yes

____ No

3. Is there a “green” marketing campaign that this product can support?

____ Yes: _____

____ No

4. What are the handling requirements of the distribution system?

5. How high are your pallets and are they going to be double/triple stacked?

Step 6: Raw Material Selection

1.a. What materials were considered for this package?

Component 1: _____

Component 2: _____

Component 3: _____

Component 4: _____

Appendix G: Planning Template

b. What is the source of the selected materials?

Material 1:	Material 2:	Material 3:	Material 4:
<input type="checkbox"/> Renewable	<input type="checkbox"/> Renewable	<input type="checkbox"/> Renewable	<input type="checkbox"/> Renewable
<input type="checkbox"/> Nonrenewable	<input type="checkbox"/> Nonrenewable	<input type="checkbox"/> Nonrenewable	<input type="checkbox"/> Nonrenewable
<input type="checkbox"/> Virgin	<input type="checkbox"/> Virgin	<input type="checkbox"/> Virgin	<input type="checkbox"/> Virgin
<input type="checkbox"/> Recycled	<input type="checkbox"/> Recycled	<input type="checkbox"/> Recycled	<input type="checkbox"/> Recycled

c. Are any materials going to be charged a fee or tax in their destination?

☐ Yes. What? _____

☐ No.

d. What are the primary environmental impacts of the selected materials?

Material 1: _____

Material 2: _____

Material 3: _____

Material 4: _____

2.a. Do these material options meet the company-specific requirements?

☐ Yes

☐ No. Why? _____

b. Do the material options meet applicable regulatory requirements?

☐ Yes

☐ No. Why? _____

3.a. Is the package mono-material or multi-material (e.g., laminated or co-extrusion)?

☐ Mono-material

☐ Multi-material

b. If the package is multi-material, are current recycling systems capable of handling these multi-material packages?

☐ Yes

☐ No

c. If there is not a recycling system in place to process the multi-material package, is your company pursuing the development of such a system (either alone or in conjunction with industry, government, or academia)?

☐ Yes

☐ No

Appendix G: Planning Template

4. Which materials were selected for this package and why?

5. Is this combination of materials the most environmentally sound design possible without compromising product integrity?

☐ Yes

☐ No. Why?

6. Do the materials need to be further separated to increase their recycling value or to avoid impeding the recycling process?

☐ Yes. How?

☐ No

7.a. Has the package and its components (e.g., inks, dyes, pigments, stabilizers, solders, and adhesives) been made without the use of toxic cadmium, lead, mercury, and hexavalent chromium?

☐ Yes

☐ No. Why?

b. If the package material currently uses toxic materials, can they be removed without compromising the package's functions?

☐ Yes

☐ No. Why?

c. If not, does this violate any regulations at the destination of the package?

☐ Yes

☐ No

8.a. Can the package's materials be landfilled safely without leaching hazardous byproducts or otherwise causing harm to the environment?

☐ Yes

☐ No. Why?

b. If no, can the package be designed to avoid problems in landfill disposal?

☐ Yes. How?

☐ No

9. Can the package be incinerated safely to recover the energy value of the packaging materials without harmful ash residue or emissions?

☐ Yes

☐ No. Why?

10. Does the package contain sufficient combustible materials to be reprocessed for safe burning and energy recovery?

☐ Yes

☐ No

Step 7: Design the Package

1. Can any amount of packaging be reduced and the package still meet these requirements?

____ Yes, the package or one of its components can be eliminated.

____ No, all packaging or components that are not required have been eliminated.

2. Is the package easy to disassemble into its recyclable component parts?

____ Yes

____ No. Why? _____

3. Does the design of the package support the available end-of-life options?

____ Yes

____ No. Why? _____

4. Can the package be made smaller and/or designed to be compacted by consumers or waste management companies so that it takes up less collection/landfill space?

____ Yes

____ No. Why? _____

5. Does the package fit well on existing or new machinery lines?

____ Yes

____ No. Why? _____

6. Does the package meet the handling requirements?

____ Yes

____ No. Why? _____

7. Does the package provide space for marketing needs?

____ Yes

____ No. Why? _____

8. Does the package provide space for environmental labels?

____ Yes

____ No. Why? _____

9. Is the package easy and safe to open while meeting security concerns?

____ Yes

____ No. Why? _____

10.a. Has the actual weight of the package been minimized?

____ Yes.

____ No

Weight: _____

b. Has the dimensional weight of the package been minimized?

____ Yes

____ No

Weight: _____

Appendix G: Planning Template

11. Is the environmentally-responsible packaging program economically viable?

☐ Yes, the program has passed testing for viability.

☐ No, the program adds significant cost to the product.

☐ Don't know, no analysis has been performed.

Step 8: Environmental Characterization

1. What are the required labels for your package?

2.a. Are the notable environmental characteristics of the package effectively and appropriately portrayed on the package?

☐ Yes

☐ No. Why?

b. Could the environmental characterization be viewed as deceptive or misleading?

☐ Yes. How?

☐ No

3.a. Is labeling leading to a larger package than is necessary for the product?

☐ Yes

☐ No

b. If "yes", can the labeling be redesigned to fit on the amount of packaging required for protection?

☐ Yes

☐ No. Why?
