

**A Guide to Designing and Manufacturing
Environmentally Friendly Products**
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Executive Summary

Introduction

In today's world the health, safety and environmental (HS&E) aspects of products and services are increasingly important to our customers and society as a whole. Customers, shareowners and other stakeholder groups are now placing a premium on products and services that are environmentally friendly.* Incorporating criteria to minimize environmental impacts into the design of products and processes embraces our value of customer satisfaction and integrity by adding environmental value to our products and by addressing the potential environmental aspects of our operation and product. The term used for this strategic focus is Design for the Environment.

Design for the Environment provides opportunities for the corporation to:

- reduce product development and manufacturing cycle times
- reduce raw material costs
- reduce regulatory compliance — complexity and costs
- reduce environmental liabilities
- increase operating efficiencies — reduce non-value added work
- increase market penetration
- reduce disposal costs
- provide competitive advantage

The goal of Design for the Environment is to prompt all AlliedSignal employees achieve the goal of designing and manufacturing environmentally friendly products while protecting employees, customers, the general public, and product quality. To do this, all aspects of the design, marketing, manufacturing, distribution, use and disposal of AlliedSignal products must be considered.

This includes:

- incorporating HS&E and customer considerations in the early stages of R&D and design
- selecting environmentally responsible raw materials
- designing closed loop production processes with no environmental discharges
- reducing total packaging and non-recyclable content of remaining packaging
- considering environmental impacts in marketing and distribution decisions
- designing for disassembly and recycle/reuse
- reducing the environmental concerns of AlliedSignal's customers by considering the ultimate fate of the product

While all functions can contribute to reducing the overall environmental impact of AlliedSignal's products and processes, there are a critical few that can make the greatest contribution. They include:

- Research and Design Engineering
- Process Engineering
- Manufacturing Operations
- Marketing, Sales and Distribution
- Package Design
- Procurement/Purchasing

* The term environmental is meant to broadly cover all health, safety and environmental (HS&E) impacts.

Implementing Design for the Environment

Design for the Environment is actually a process management tool that consists of eight phases:

1. Identification of the target product, process or activity
2. Formation of a cross-functional analysis and design team
3. Identification of inputs (raw materials, energy, equipment, and supplies), outputs (products, waste streams, and emissions) and customer environmental requirements for the product or process
4. Identification of the significant health, safety and environmental aspects of the product or process
5. Collection of suggestions for minimizing the environmental impacts — barriers and opportunities
6. Selection of the best alternatives based upon cost effectiveness, environmental impact and customer impact
7. Monitoring improvement through metrics based on key customer requirements
8. Continual improvement

Design for the Environment Rating: This tool is a “bottom-line” measure of the overall “environmental friendliness” of products and processes. The Design for the Environment Rating includes criteria for products, processes and total environmental cost.

Cross-Functional Responsibility for Design for the Environment

The following key areas all contribute significantly to the Design for the Environment effort:

- Research and Design Engineering — Strive to design products and formulations to reduce or eliminate impacts on health and the environment.
- Process Engineering — Incorporate pollution prevention concepts that minimize waste and incorporate recycling and reuse concepts.
- Manufacturing — Implement quality manufacturing practices to minimize rework, reduce waste and provide a safe and healthy work environment.
- Marketing — Interact with customers to balance the multiple requirements for functionality, appearance, cost, and packaging with environmentally friendly requirements.
- Packaging Design- Eliminate packaging wherever possible and reduce the overall amount of remaining packaging material by considering the possibility of packaging return/reuse/recycle systems.

Although, the above functions are particularly important, *all* employees have a significant role in Design for the Environment and can contribute to reducing the environmental impact of our products, processes and operations. For example, procurement (purchasing) can play a significant role by purchasing environmentally safe raw materials and products from suppliers who are “green” minded.

Design for the Environment provides a competitive advantage.

What is Design for the Environment?

Design for the Environment is a strategic management process that elevates Health, Safety and Environmental considerations to critical elements of product performance requirements. These considerations represent value that can be added to new existing products and processes. Companies that recognize new market requirements, and act accordingly, will gain a competitive advantage.

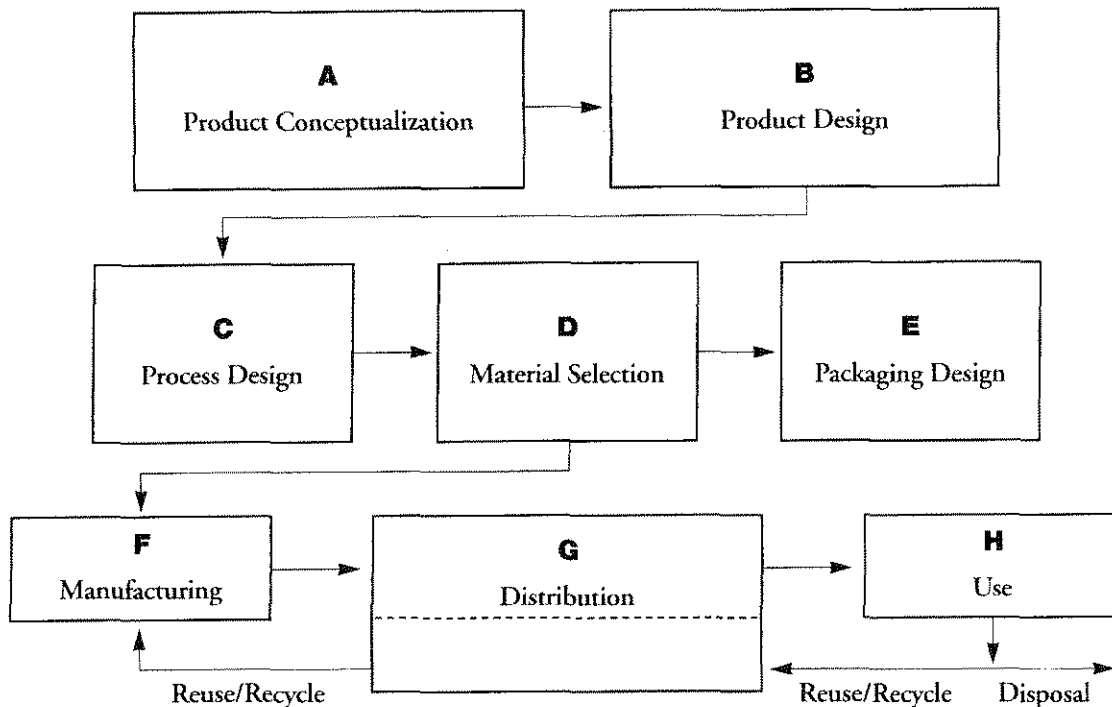
Customer requirements and marketplace dynamics are not the only reasons for implementing Design for the Environment. Government regulations and compliance requirements are becoming increasingly costly. Design for the Environment is a process for eliminating the drivers of these regulatory and compliance costs: use and production of toxic materials, generation of hazardous wastes and health risks to employees and customers.

Health, safety and environmental regulatory requirements exist at the federal, state and local levels and must be factored into any product or process design. Although such regulations are too voluminous to include here, this Guide presents a process to anticipate and factor in such requirements. Details on these regulations can be provided by our Health, Safety and Environmental professionals.

Figure 1 is the Design for the Environment process map. It assists in the identification and elimination of the "root causes" of many problems in the early stages of product conceptualization and process design. Careful selection of materials and design of the product and manufacturing process will prevent delays caused by the need to redesign or reformulate later.

Design for the Environment anticipates health, safety and environmental impacts during the business planning cycle.

Design for the Environment Process Map



A

- Customer preference
- Market leverage
- Appearance, functionality, and cost
- Multiple usage

B

- HS&E properties
- Size and Number of components
- Design for — Recycle; Revision; Remanufacture; Disassembly

C

- Energy use & recovery
- Closed loop manufacturing — reclamation; recycle
- Waste segregation
- Automated process control

D

- Hazardous/toxic materials — lubricants; solvents; inks
- Composite materials
- Compostability/biodegradability
- Feedstocks

F

- Quality and Employee health and safety
- Preventative maintenance
- Operating procedures and training
- Process management
- Design for the employee — ergonomics

H

- Customer training and Instructions/manuals
- Applications and appropriate uses
- Product durability

Implementing Design for the Environment

The Product Life Cycle — Design for the Environment recognizes that in today's business climate, regulatory compliance and environmental, health and safety issues are an integral part of overall product performance requirements. More and more, our customers are evaluating recycling and establishing their own waste reduction goals and expecting the same from their suppliers. The companies that recognize this new marketplace ethic and act accordingly will have a competitive edge.

Product Life Cycle — Design for the Environment is compatible with AlliedSignal's cycle-time reduction goal. It encourages the consideration of environmental, health and safety issues associated with materials selection and design in the concept phase, thereby avoiding potential delays caused by the need to redesign or reformulate later. Regulatory requirements are identified early, and the time required for regulatory submissions and permit approvals, and/or toxicity, environmental, performance and other testing can be planned into the product development time-lines.

Design for the Environment Matrix



Customer Performance Requirements

Product Use
Regulatory
Public Perception Concerns

Material/Process Selection

Toxicity/Safety
Renewable/Recyclable
Energy Use
Env. Fate/Degradability
Regulatory Restrictions
Availability of HS&E
Friendly Substitutes

Packaging

Minimize Use
Returnable Containers
Disposability
Material Selection
Coding and Labeling

Product and Process Risk Assessment

Waste and Emission Reduction

Worker Safety and Health Aspects of Manufacturing

Safe Transportation and Handling

Product Safety/Hazards Communication

Use/Misuse/Hazards Guidance
Labeling/MSDS/Literature
Claims/Advertising
Product Stewardship

Site Environmental Assessment

Products and Materials

Reusable, Recyclable, Returnable

Disposal Recommendations

Emergency Response/Community Planning

Research and Design Engineering



Research and Design Engineering professionals have the greatest influence over the environmental friendliness of products and processes. Decisions made by design engineers are critical determinants for how products are manufactured, distributed, used, and ultimately disposed. By the nature of their technical knowledge, they have a significant opportunity to prevent environmental impacts. They can develop formulations and product configurations that:

- dissipate safely in the environment
- can be reused and recycled in a responsible fashion
- can be manufactured in such a way that hazardous work practices and toxic waste streams are eliminated or minimized

The importance of environmentally conscious design is increased by the fact that decisions made about functionality, product configuration, and material specifications create constraints in downstream operations. These decisions limit the freedom that other employees have for reducing the environmental impact of AlliedSignal's operation. In fact, decisions made at the product conception and design

engineering stages determine 80% of the down-stream costs. These decisions greatly influence:

- capital expenditures for production and pollution control equipment
- raw material purchasing and handling
- manufacturing procedures
- the ultimate safety of employees, consumers, and communities

When designing for the environment, all upstream and downstream effects are considered during the design process by asking these types of questions:

- Can renewable resources and raw materials be used in this product?
- Can the product and its components be designed for reuse, recycling, or remanufacture?
- Can materials be used which minimize the exposure of employees and consumers to toxic and hazardous materials?
- Can less toxic materials be substituted for hazardous or highly regulated materials?
- Can the overall use of materials and resources be minimized in the product?

Principles of Design for Disassembly/Recycle

Minimize material variety & toxicity

Maximize ease of disassembly

Reduce the number of parts

Reduce the number of assembly operations/process steps

Simplify and standardize component fits/interfaces

Research and Design Engineering Questions

- ☐ How can current products and processes be improved with environmental concerns in mind?
- ☐ Can the amount of non-renewable raw materials consumed in manufacturing products be reduced or replaced completely with renewable raw materials?
- ☐ Can recycled materials be substituted for primary raw materials?
- ☐ Can composite materials be minimized or eliminated completely to improve recyclability and reuse?
- ☐ Can the product be designed for reusability, remanufacturability, or recyclability, not disposability?
- ☐ How can the product be designed to be easily disassembled to facilitate recycling and remanufacturing?
- ☐ Can the actual number of components be minimized?
- ☐ Which materials used in a product or process are hazardous or regulated and can they be eliminated?
- ☐ What are the costs of hazardous waste disposal, safety equipment, pollution control systems, and training associated with different materials?
- ☐ Have all legal/regulatory requirements been considered in the development work?
- ☐ How can research trials be planned to avoid excess manufacture and disposal of hazardous, toxic, and solid waste?
- ☐ Will the use of the product by the consumer require excessive energy consumption or generate air, water, or soil pollution?

Process Engineering



The design of a product and its related manufacturing process are closely linked. Special engineered materials or components require special production processes. Processes that previously required hazardous/toxic solvents, lubricants and monomers are now being replaced with more environmentally friendly processes. Two notable examples are the use of soy-based inks and citrus-based cleaners. In both cases, modifications to the design of the final product and production equipment were required. Thus, there is a close interaction between process and product design that must be considered.

Process engineering, like Research and Design Engineering, has specific technical expertise that can support the research and development of new environmentally friendly processes. Specific process

design issues that surface when considering designing for the environmental include:

- processes and materials that minimize worker health and safety concerns
- processes to maintain segregation of wastes
- reclamation and recovery systems
- alternative solvent, cleaning, and lubricating systems
- energy efficiency and recovery

The challenge for process engineering is to maximize the value of all materials. Waste streams can be converted into by-products or used as inputs into other processes. The old adage "What is one person's trash is another's treasure" takes on a new significance in environmentally conscious manufacturing. The emphasis shifts to closed loop manufacturing, in which all waste streams are captured and reused/recycled, providing the opportunity to minimize environmental impacts and reduce operating costs.

Key Principles of Pollution Prevention

Maximize recycle and reuse

Eliminate waste streams

Use less toxic materials

Strive for closed-loop manufacturing

Process Engineering Questions

- ☐ Have production processes been designed to minimize use and release of toxic or hazardous materials?
- ☐ Have production lines been evaluated and efficiency optimized by redesigning, replacing, or retooling critical equipment?
- ☐ Has the performance of effluent pre-treatment operations and end-of-pipe pollution prevention controls been optimized?
- ☐ Has solvent substitution received the highest priority in process development?
- ☐ Has the cost of disposal of solvents and other cleaning agents used in manufacturing components been considered in purchasing decisions?
- ☐ Has the cost of safety equipment, training, and exposure monitoring been considered when selecting solvents and lubricants?
- ☐ Has the cost of waste and scrap disposal been considered when selecting equipment and materials?
- ☐ Have closed loop manufacturing systems been considered (e. g., continuous rinses might replace batch rinses)?
- ☐ Have reclamation, recycling, and reuse systems been included in the process design?
- ☐ Does the process design maintain segregation of waste streams?
- ☐ Have heat transfer and co-generation systems been considered where appropriate?
- ☐ Have energy efficiency pumps and motors been evaluated for use in manufacturing systems? Have local utilities and agencies been contracted for funding assistance?

Manufacturing Operations



Manufacturing is where environmental management efforts have traditionally been focused. This is the area where waste streams and emissions manifest themselves most visibly regardless of where the root cause resides. In Design for the Environment, this area continues to play an important role in controlling environmental impacts.

The preferred strategy for environmental quality improvement is source reduction. Preventing pollution and *minimizing waste streams at the source* eliminates the need to report them, treat them, ship them, or dispose of them. Primary source reduction strategies, product changes, raw material changes, process changes and technology changes, are largely dependent upon product and process design. It becomes critical for manufacturing employees to work closely with research, design engineering, and process engineering to clearly identify root causes of wastes streams in manufacturing processes.

Similarly, daily operating practices and procedures can be modified to minimize environmental impacts. These include:

- *modifying order quantities*
- checking purity of feedstock and raw materials
- carefully monitoring operating temperature and pressures

In manufacturing, probably more so than in the other functions, employees can provide a wide variety of low cost, high-impact suggestions that collectively create significant environmental performance improvement.

Manufacturing's Role in Design for the Environment

Identify, characterize and track waste streams and environmental emissions

Optimize daily operating practices to reduce pollution

Develop opportunities for recycle/reuse

Minimize health and safety risks

Manufacturing Questions

- ☐ Have all major point sources and fugitive emission sources been identified and minimized?
- ☐ Have less toxic or hazardous chemicals been substituted?
- ☐ Has a formal preventive maintenance program been established to keep machines and connections (valves, hoses, and pipes) in peak performance condition?
- ☐ Have automatic measuring, control and alarm devices been installed to reduce probability of human error?
- ☐ Has chronically leaking or troublesome equipment been redesigned, replaced or upgraded?
- ☐ Has equipment that cannot consistently operate within production tolerances been redesigned or replaced?
- ☐ Has Design for the Environment training for employees been provided?
- ☐ Has high/low-temperature equipment been insulated, sealed, or otherwise protected to reduce energy loss?
- ☐ Have chemical storage protocols been evaluated to ensure that incompatible chemicals are physically separated and properly labeled?
- ☐ Has off-specification material been recycled or used in innovative ways to eliminate waste?
- ☐ Have opportunities been investigated for potentially beneficial uses for production wastes, by-products, and off-specification material?
- ☐ Has the manufacturing process been modified to eliminate or reduce scrap?
- ☐ Have exposures to employees and the public been evaluated to assure healthful operating conditions?

Marketing



Marketing plays a multi-faceted role in the Design for the Environment process. As the primary liaison with the customer, marketing becomes the critical conduit for information about customer needs, requirements, values and concerns. The roles that marketing play in Design for the Environment include:

Conveying customer needs and requirements — Product performance, appearance and cost are still the main critical purchasing parameters. However, customer preferences are beginning to shift toward reusable, environmentally safe products. Marketing's knowledge of customer values and requirements can assist in balancing environmental friendliness, cost, and product performance, thereby achieving a competitive advantage.

Providing input in the design — As solid waste disposal becomes a greater concern, customers will use recycling and reuse alternatives to a greater degree. Marketing needs to determine the recycle and reuse requirements of the customers and provide that information to the design team.

Customer education — Marketing should educate customers to the many advantages of using products designed for the environment. This is best achieved in a partnership, where the environmental requirements of the customers and suppliers are clearly understood.

Communicating environmental information — Marketing needs to clearly communicate the health, safety and environmental properties and safe handling requirements of AlliedSignal's products to customers. Marketing should instruct the distribution chain to communicate this information to the end-use customer.

Marketing's Role in Design for the Environment

- Determining customer needs
- Conveying customer requirements
- Providing input to design
- Communicating environmental information

Marketing Questions

- ☐ Have Marketing representatives participated on product teams to optimize tradeoffs between requirements of shelf space, product appearance, environmental impact, and product use?
- ☐ Have the environmental attributes and safe handling requirements, including safe use and disposal been communicated with accurate, credible facts and statements?
- ☐ Have environmental issues affecting AlliedSignal's customers been clearly communicated to the product design team?
- ☐ Do we clearly understand how consumers use each product? Has that information been communicated to design engineers?
- ☐ If higher prices result from environmentally conscious manufacturing, have the reasons for cost differentials been communicated to distributors and customers?
- ☐ Have customer preferences for environmentally safe products and processes been identified and communicated?
- ☐ Have focus groups, surveys, and customer advisory panels been used to identify customer environmental requirements?
- ☐ Have recycling and reuse systems that will increase customer willingness to recycle or reuse products been identified?
- ☐ Have customers been encouraged to purchase bulk quantities to minimize packaging and increase sales volume?

Packaging



Packaging constitutes almost one-third of the municipal solid waste stream. Germany already has instituted legislation that makes manufacturers responsible for the collection and recycling of packaging material associated with their products. Legislation in several U.S. states and voluntary packaging-reduction programs clearly demonstrate that packaging material reduction is now a key business issue for AlliedSignal. The nature of packaging design and utilization is far reaching and cuts across all functions.

The traditional view of package design, use and disposal must change. The first question that must be asked is: "Is the packaging necessary?" Often, redesign of primary packaging can eliminate the need for secondary and tertiary packaging, thereby reducing operating costs. Any remaining packaging is then scrutinized for volume and waste reduction. "Light weighting" and use of alternative materials are strategies to further reduce the amount and weight of packaging. Products also can be "concentrated" or sold in larger quantities to reduce packaging material.

Product packages can be designed to be consumable, recyclable, returnable, refillable, or reusable. This is consistent with the environmental values of customers in the '90's.

Innovative packaging material made of recycled and post-consumer material is available. Other packaging material made from renewable source material which easily and safely degrades in the environment, is also available.

Given that such a large volume of packaging material currently ends up in landfill, strong efforts should be taken to eliminate toxic and hazardous materials from packaging. Several states in the Northeast also have recently passed legislation that limits the amount of certain heavy metals in packaging material. Soy-based inks are available as substitutes for traditional inks consisting of heavy metals.

Packaging is a critical component of overall product design. It must protect the product during shipment, and influence customers to buy the product. The combination of visual appeal, ability to maintain product quality, ensure public safety, and the ability to run efficiently on production equipment creates a complex combination of tradeoffs that must be thoroughly evaluated.

Packaging Minimization Hierarchy

- Eliminate completely
- Minimize toxic/hazardous materials
- Minimize total weight & volume
- Returnable, refillable or reusable
- Recycling or recycled content

Packaging Questions

- ☐ Has packaging been eliminated where possible?
- ☐ Has packaging which serves only aesthetic purposes been eliminated?
- ☐ Has the remaining packaging been designed to be compact, durable, and reusable?
- ☐ Have soy-based or vegetable-based inks been used where possible?
- ☐ Does packaging material consist of post-consumer or recycled material?
- ☐ Is the packaging material biodegradable, compostable, or recyclable?
- ☐ Have toxic materials been eliminated from packaging?
- ☐ Has packaging material containing heavy metals been eliminated?
- ☐ Are products packaged in bulk quantities where possible?
- ☐ Are returnable, reusable shipping containers and pallets utilized when possible?
- ☐ Are the environmental features in packaging and the product highlighted in the labeling?
- ☐ Does the packaging provide instructions for proper use?
- ☐ Are the packaging and product itself clearly marked for reuse, return, or recycling?
- ☐ Have systems for the return and reuse of packaging material been created?

Product Lifecycle Cost Factors

Traditional product costing considers the direct cost of materials, labor and equipment to design, produce and market a particular product. When evaluating total product life cycle costs, both traditional and non-traditional costs need to be considered. It should be recognized that product life cycle costing is an emerging costing methodology. Listed below are some associated costs:

1. Direct production and marketing

- raw material costs
- direct labor expenses
- indirect maintenance, quality control, and related support costs
- construction costs for new/expanded facilities
- marketing and promotional expenses

2. Materials, equipment, and other expenses required to support the manufacture of a particular product or service

- hazardous material disposal costs
- fees for scientific research and obtaining regulatory permits/approvals
- HS&E staff costs for reporting and monitoring compliance
- employee training for handling of chemicals and hazardous material
- pollution control equipment (diking, scrubbers, water treatment systems)
- protective safety equipment
- increased medical costs associated with exposure to hazardous materials

3. Packaging material

- raw materials for packaging (boxes, cushioning material, shrink-wrap)
- glues and adhesives for securing the packaging

- maintenance costs for cleaning and repairing packaging equipment
- disposal costs for packaging waste
- warehouse facilities for packaging material
- utilities and staffing costs for packaging material warehouse

4. Shipping

- pallets and bulk containers for transport
- purchase of tractors, trailers, and railcars
- maintenance expenses for transport fleet
- shipping expenses for contract carriers
- disposal costs for oil, antifreeze, etc.
- taxes, insurance, and license fees
- deposits and collection fees

5. Use or misuse of a product

- printing of instruction sheets and manuals
- administrative support for labels and safety data sheets
- technical support and customer service
- warranty costs
- product liability expenses and legal fees

6. Product disposal

- landfill or garbage pickup fees
- special disposal surcharges
- charges for scrapping or disassembly
- future liability for remediation and cleanup of landfills or contaminated manufacturing facilities
- reclaiming or recycling component materials

Many of these costs can be substantial. Design for the Environment helps to minimize the overall cost and minimize the cost of ownership to the customer.

Reduced environmental costs = customer value

First Steps for Implementing Design for the Environment — Using the Total Quality Process

The series of steps detailed below is one way to approach Design for the Environment. Employees are encouraged to adapt this framework to develop a methodology that best fits their products and operational practices.

A. Identify the Target Product, Process or Activity.

- Analysis and Design team defines the scope of its effort:
 - An entire product or process, or
 - Only a component of a larger assembly or a subprocess
- Existing products or processes are easier to analyze than a new ones
- As a learning tool, select a smaller, existing product or process and conduct a trial analysis

B. Form a Cross-functional Analysis and Design Team.

- A typical team includes representatives from many different functions, e. g.:
 - Research & Development
 - Design Engineering
 - Process Engineering
 - Package Engineering
 - Manufacturing
 - Purchasing
 - Marketing/Sales
 - Health, Safety and Environment
 - Product Stewards

C. Identify the Inputs and Outputs of the Process — Customer Environmental Requirements.

- Identify the materials, supplies, physical resources, tools, and equipment used
- Identify all outputs:
 - Salable products
 - Packaging and shipping material
 - Hazardous waste streams
 - Non-hazardous waste streams

- Air emissions
- Water effluents
- Energy
- Identify customer environmental requirements
 - Disposability
 - Disassembly potential
 - Safe handling
 - Toxicity
- Attempt to develop a cost estimate Consider costs that are:
 - Incurred by AlliedSignal
 - Incurred by other parties
 - Indirect costs
 - Passed on to the customer needlessly

D. Identify the Significant Health, Safety, and Environmental Aspects of the Product or Process.

- Focus on the ones suspected to have the greatest health, safety, and environmental impacts
 - Non-renewable raw materials and energy sources
 - Materials containing toxic materials, heavy metals, carcinogens, reproductive toxins or mutagens
 - Regulated materials
- Identify the amount and type of packaging material, incoming and outbound
- Identify how packaging and shipping material is disposed of or reused
- Examine the distribution system of the incoming materials and outgoing product
- Identify how waste streams are handled
- Evaluate how customers use the products. Does the use or misuse of the product create environmental impacts that may be avoidable?
- List your most significant opportunities for improvement (5-Ups)

E. Identify Suggestions for Minimizing the Environmental Impact — Barriers and Opportunities.

Select those inputs and outputs that have the greatest impact. Brainstorm suggestions for how to minimize those impacts and gather the facts as to:

- Can a lower toxicity raw material be utilized?
- Can a cleaning step be eliminated?
- Can a more environmentally friendly solvent be used?
- Is bulk packaging available?
- Are returnable containers feasible?
- Are production planning and inventory management systems in place to ensure that proper quantities are ordered and that expired materials are minimized?
- Who are the key players to implement the changes? Add them to the team.

Often minor changes in procedures and operating practices can significantly reduce the environmental impacts.

F. Select the Best Alternatives Based on Cost Effectiveness, Environmental Impact and Customer Impact.

- Carefully consider the impact of the alternative suggestions in the same fashion that the original product or process was evaluated to ensure that:
 - the customer is satisfied
 - the new product or process has a significantly lesser environmental impact than the original product or process
 - the improvement has the intended downstream impact through the life-cycle
 - costs for the changes are fully identified as well as estimated savings
- Develop the documentation for the authorization process to make the suggested changes in the process or product
- Initiate any actions the team is empowered to implement - procedural, maintenance or other options to improve the process.

G. Monitor Improvement Through Metrics Based On Key Customer Requirements.

H. Continual Improvement.

- Repeat the process for the next target of opportunity

A stepwise approach makes implementing Design for the Environment achievable.

Design for the Environment Rating

Design for the Environment identifies ways to reduce environmental impacts and operating costs. The following charts provide an easy way to rate the environmental friendliness of products and processes, especially compared to competitive products and processes. Initial attention should be on areas where a competitive advantage can be gained or where environmental impacts can be reduced.

The six criteria for the "Product" Design for the Environment Rating are:

1. **Reuse/Recycle/Remanufacture Capability** — the degree to which the current life cycle of a product and its components can be extended by reuse in its current form, recycling for alternative use, or remanufacturing for continued use of its original function.
2. **Packaging Design** — the degree to which the product packaging is eliminated completely or reduced. The degree to which packaging is free from toxic materials and is reusable or recyclable.
3. **Material Toxicity** — the degree to which the raw materials and the final product are free from hazardous and toxic materials.
4. **Raw Materials** — the degree to which raw materials are renewable resources or post-consumer material. The degree to which the total amount of raw materials has been minimized.
5. **Manufacturing Impact** — the degree to which the environmental impacts of manufacturing and distribution of the product have been minimized.
6. **Consumer Use** — the degree to which safeguards have been created to minimize the environmental impact of the actual use of the product. Includes the degree to which the product has been designed for ease of use, safety of use, and energy efficiency. Consider the potential for additional environmental impacts due to misuse of the product.

The six criteria for the "Process" Design for the Environment Index are:

1. **Volume of Toxic/Hazardous Waste Produced** — the absolute amount of toxic and hazardous wastes produced.
2. **Toxicity of Toxic/Hazardous Waste Produced** — the degree to which the wastes produced are carcinogenic, mutagenic, or otherwise hazardous.
3. **Volume of Toxic/Hazardous Material Used** — the absolute amount of toxic and hazardous material used in the manufacturing process.
4. **Toxicity of Toxic/Hazardous Materials Used** — the degree to which the materials used in the manufacturing process are carcinogenic, mutagenic, or otherwise hazardous.
5. **Solid Waste Produced** — the absolute amount of solid, non-toxic/hazardous waste produced.
6. **Utilities Utilization** — the amount of energy and water used in the manufacturing process.

Each of these criteria are evaluated on a 5-point scale. A rating of 5 indicates a low degree of adverse environmental impact (high environmental friendliness). A rating of 1 indicates a high degree of environmental impact (low environmental friendliness).

The members of the Design for the Environment analysis team should develop a consensus rating for each criterion. Benchmarking other companies is another useful tool for developing this rating.

The sum is the overall Design for the Environment Rating. This number should be used to measure continuous improvement.

Product Design for the Environment Rating

<i>Product:</i> _____ <i>Date:</i> _____	
Criterion	Rating
Raw Materials	
Material Toxicity	
Manufacturing Process Impact	
Reuse/Recycle/Remanufacture Capability	
Packaging Design	
Consumer Use	
TOTAL	

- 5** Best known practice or standard
(High Environmentally Friendly)
- 4** Greatly exceeds the prevailing industry practice or standard
- 3** Generally exceeds the prevailing industry practice or standard
- 2** Comparable to prevailing industry practice or standard
- 1** Lags prevailing industry practice or standard
(Low Environmentally Friendly)

Process Design for the Environment Rating

<i>Product:</i> _____ <i>Date:</i> _____	
Criterion	Rating
Volume of Toxic/Hazardous Materials Used	
Toxicity of Toxic/Hazardous Materials Used	
Volume of Toxic/Hazardous Waste Produced	
Toxicity of Toxic/Hazardous Waste Produced	
Solid Waste Volume Produced	
Utilities Utilization	
TOTAL	

- 5** Best known practice or standard
(High Environmentally Friendly)
- 4** Greatly exceeds the prevailing industry practice or standard
- 3** Generally exceeds the prevailing industry practice or standard
- 2** Comparable to prevailing industry practice or standard
- 1** Lags prevailing industry practice or standard
(Low Environmentally Friendly)

place
postage
stamp here

Chief Technology Officer
AlliedSignal Inc.
101 Columbia Road
Morristown, NJ 07962

☐ **I have read the *Guide to Designing and Manufacturing Environmentally Friendly Products*.**

- 1** ☐ I am An Employee ☐ A Customer ☐ Other _____
- 2** My business is in ☐ Aerospace ☐ Automotive ☐ Engineered Materials ☐ Research and Technology ☐ Other _____
- 3** I work primarily in ☐ Research, Development and Engineering ☐ Manufacturing ☐ Marketing ☐ Other _____
- 4** My familiarity with Design for the Environment is ☐ High ☐ Moderate ☐ Low
- 5** I would like more information on _____

Name _____

Address _____

Phone _____



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