Improved Products Through Design-for-Environment Tools

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In the past, product development teams were often insulated from other disciplines within the company. Too often, products were developed without adequate input from marketing about customer needs, from manufacturing about realistic and cost-effective production, from the environmental group about potential negative impacts, or from other functions about their unique perspectives on key product attributes. The negative impacts of this insulation included product-introduction delays, lack of vital attributes in the final products, and ongoing friction between the product development group and other functions.

Over the past few years, cross-functional communication has increased dramatically. Leading companies have incorporated consideration of key stakeholder issues into the product development process from the outset. As a result, these companies have reduced redesign and rework, shortened time to market, and lessened the chance of product recall.

Within this context, the discipline known as „Design for Environment“ (DfE) has evolved very recently as a successful way of integrating environmental, health, and safety (EHS) concerns early and effectively into the product development process – alongside other key design parameters. Leading companies such as Baxter, Hewlett-Packard, Raychem, and Xerox have pioneered ways to create both a framework and the right tools to enable product-development teams to use EHS foresight and knowledge to enhance product design and create better products. Although it is not always easy to discern the relative EHS strengths and weaknesses of alternative design approaches, nor to foresee all the potential impacts of a product through its life cycle, it is possible to anticipate the likely consequences of a product's life in order to make educated tradeoffs or choose alternative approaches.

Let's take as a brief example the implications of choosing a new lead-free solder for an electronic device. The question of whether to choose this new solder over traditional lead solders would trigger a range of considerations for the product development team:

• Possible material cost differences

• A need for different manufacturing approaches, with possible cost differences

• Possible effects on the quality of connections and resultant performance of the electronic device

• Implications for distribution owing to weight differences or different handling and packaging requirements

• Implications for the established expectations and preferences of customers and sales and service people, who may need to be reeducated

• The cost, feasibility, and health and safety issues arising at the end of the product's life, such as remanufacture, reuse, recycle, or disposal

In choosing whether or not to use the lead-free solder, the manufacturer would have to understand the consequences in all the areas listed above. This is where DfE comes in.

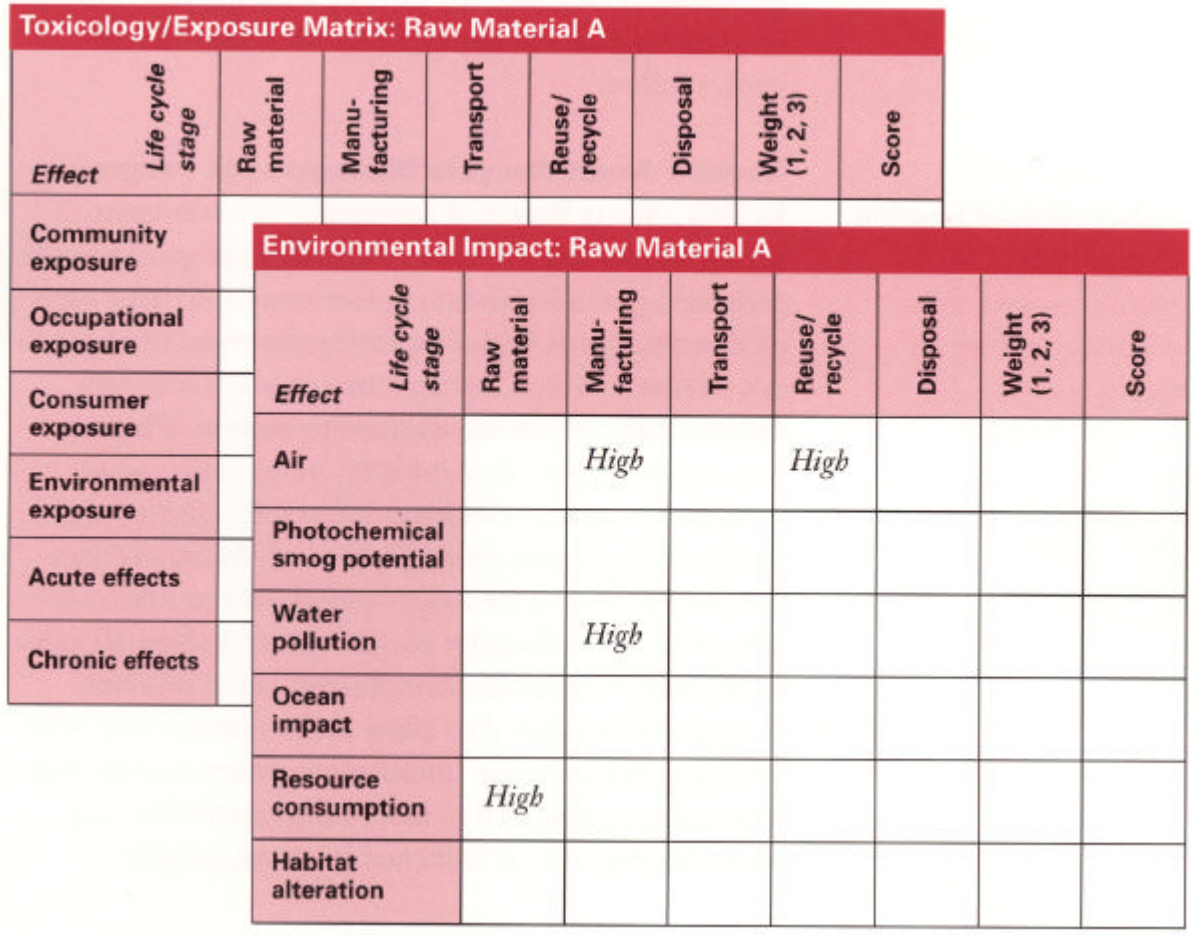
The Design-for-Environment Tool

At the heart of the DfE approach is a set of tools that helps design engineers interpret qualitative and quantitative data. This tool kit allows engineers both to measure EHS impacts and to identity opportunities to minimize those impacts across the product life cycle, with a particular emphasis on materials and manufacturing. More accurately, DfE is not one tool kit but many; each company needs its own, unique set of tools that takes into consideration corporate values, priorities, and systems.

In Exhibit 1, we show the kinds of evaluations one company is making to examine three different raw materials for both environmental impact and toxicology implications across the life cycle of its product. (A similar approach could be used to compare manufacturing processes.) For each competing material, the product team identifies high-priority areas of concern. For each of these high-priority areas, the team will conduct in-depth analyses, using both company data and externally generated data about their lexicological effects and the impact of these materials on the environment. The scores for each cell in the matrix will reflect the position of competing materials relative to the material in question or to each other. Through full understanding and discussion of the comparative scores and their implications, the company is in a good position to make fully informed decisions about EHS factors against the other product parameters under consideration. Thus, it can begin to identify opportunities for minimizing EHS impacts within the context of other design and product-life issues.

Exhibit 1

A Representative DfE Matrix – Evaluating the Impacts of a Raw Material



Toxicology/Exposure Matrix: Raw Material A

Effect / Life cycle stage	Raw material	Manu-facturing	Transport	Reuse/ recycle	Disposal	Weight (1, 2, 3)	Score
Community exposure							
Occupational exposure							
Consumer exposure							
Environmental exposure							
Acute effects							
Chronic effects							

Environmental Impact: Raw Material A

Effect / Life cycle stage	Raw material	Manu-facturing	Transport	Reuse/ recycle	Disposal	Weight (1, 2, 3)	Score
Air		*High*		*High*			
Photochemical smog potential							
Water pollution		*High*					
Ocean impact							
Resource consumption	*High*						
Habitat alteration							

At the start of the product development process, the product team should articulate DfE milestones along with traditional milestones with respect to strategy, business plan, product feasibility and final form, production, and product support. Exhibit 2 provides an illustration of representative DfE milestones alongside a traditional product development path.

DfE Leaders

Some leading companies have already demonstrated the business rationale for DfE by showing how DfE can yield significant competitive advantage. Their stories follow.

Xerox's Asset Recycle Management Program.

In 1991, Xerox launched a program to lower costs across its product life cycle. Partially in response to the proposed green legislation in Germany and other parts of Europe, Xerox began exploring the concept of product takeback, which incorporates product recovery, disassembly, and remanufacture or recycle. The company found there was significant potential residual value in its copier products – value the company was losing as the product was disposed of. Many product components had a far longer useful life than the product itself. Xerox found it could capture additional value in the form of reusable components if the product design were modified to allow easier disassembly. The company began to use uniform construction materials wherever possible and to label components for easy identification. Xerox launched its Asset Recycle Management (ARM) product-takeback initiative to recapture and remanufacture parts for use in new products. The results were staggering. In its first year, ARM provided $50 million to Xerox's bottom line as a result of lower manufacturing and raw material costs and reduced inventory charges. Recent calculations put the total ARM contribution at about $200 million over a three-year period.

Exhibit 2

A Side-by-Side Approach to DfE and Product Development

	Traditional milestones	DfE milestones
Strategic plan	Vision set for company's direction, markets served, market positioning, competitive environment, regulatory hurdles, core competencies, and profitability targets	Overall environmental vision and strategy established
Product business plan	Statement describing product's market opportunity, including its strategic „fit" for the business unit, and detailed plan on how to address the opportunity	Basic understanding of key environmental issues affecting the product
Product/ program definition	Complete product specifications, including full product concept(s) and „proof-of-principle" demonstrations for key technologies embodied in concept(s)	Understanding of competitors' „green" features and of company's competitive response; identification of acceptable materials and manufacturing processes
Feasibility demonstration	Demonstration that final product meets established technical and business objectives	Manufacturing/distribution processes and raw materials chosen; demonstration that product meets „green" requirements
Final-form demonstration	Showing that product is viable in anticipated final form and tested to meet technical specifications/demands of customers, distributors, technical support	Environmental focus group information integrated; product life cycle data assessed; environmental impact matrices completed
Production technology demonstration	Showing product can be produced on anticipated production scale and that it continues to meet other business requirements	Environmental implications of alternative production sites developed; EHS impact of production analyzed; EHS implication of „tolling out" analyzed
Production capability	Completion of production equipment and support infrastructure to bring product to market; products made and tested under actual conditions	Environmental monitoring data collected and analyzed
Product information	Validation of market acceptance, manufacturing capability, and support infrastructure; completed preparation for full-scale introduction (e.g., inventories, distributors, vendors)	Analysis of employee, neighbor, and regulatory environmental concerns completed; mitigation measures initiated

Product support	Continued support of product sales, continuous improvement efforts, and preparation of product replacements	Ongoing total quality environmental management process initiated

Hewlett-Packard's Product Stewardship Program. The goal of HP's Product Stewardship Program is twofold: to develop more competitive products and to integrate EHS considerations into the process without lengthening the product development time. Because HP's system is responsive to the existing product development approach and easy to use, it has helped the development engineers create better products without stretching time to market. HP has found that considering EHS issues has more impact if done early in the product development process. Like Xerox, HP has avoided mandating product stewardship programs in all business areas. Because HP's businesses – not corporate management – set HP strategy, a top-down approach would be counterproductive. Hence, HP is allowing the DfE initiative to spread across its divisions at its own speed, driven by the program's evident benefits.

Raychem's DfE Toolbox. Raychem, a billion-dollar supplier to the energy and telecommunications markets, recently assessed DfE's potential to more effectively meet customer needs in its European telecommunications business. Changing customer concerns and emerging EHS industry practices triggered the need to manage EHS issues through the end of the product's life. The challenge, once again, was to create a DfE approach to meet changing needs without extending product development time. A key to success for Raychem was a new DfE tool that relied on simplicity and ensured ease of use by the product development engineers (who had little experience in EHS matters). In particular, Raychem's DfE development team, comprising product development and EHS experts, conducted pilot tests of the prototype DfE tools to gain valuable feedback from the product engineers.

An Early Endorsement by AT&T. AT&T led the charge to integrate EHS management effectively into its product development and management processes. The company stressed ease of use and completeness of the EHS assessment. Today, AT&T is pushing DfE into its supply chain by partnering with suppliers to obtain environmentally appropriate materials. It is also using DfE to assess suppliers and potential partners. Its ultimate DfE goal is to strike a „healthy balance between environmental protection and business growth as part of the same total quality package."

Baxter's DfE Approach to Packaging Design.

Electronics and telecommunications are not the only areas for DfE leaders. Baxter International wanted to align its Cardio-Vascular Division's EHS efforts with the company's competitive positioning. Recognizing that customers valued low prices and reliability of delivery over environmental concerns, Baxter formed a Packaging Task Force as part of a corporate initiative to reduce the per-unit weight of packaging 15 percent by 1995 (based on its 1990 level). By talking with customers to gauge their flexibility in adapting to packaging changes, Baxter identified opportunities to reduce packaging and its costs while maintaining customer loyalty. A switch to a material that is more easily recycled eliminated a layer of packaging, saving the company $2 million annually. Across the company, the packaging reduction program saved $25 million through lower operating costs, higher margins, smaller volumes of solid wastes, and more satisfied clients. Obviously, DfE made a significant contribution to competitive advantage.

Lessons Learned from the Leaders

The successes of leading companies in integrating DfE into the product development process underscores several key lessons:

• Design the DfE initiative to fit the product development process, not the other way around. It is certain death for the DfE initiative if it disrupts the product development process or time frame. Product development teams welcome collaboration, but show resistance to wholesale DfE changes.

• Keep in mind that the DfE goal is to create more competitive products, not green products. Some early DfE programs missed this important rule and created new products that bombed in the marketplace. DfE is most effective when it catalyzes creative tradeoffs among important product attributes, including cost, performance, ease of manufacture, quality, and EHS effectiveness.

• Build collaboration among the product development and EHS staff. DfE is a team activity that requires combined talents. An attempt to make this an EHS initiative creates lopsided results and erodes crucial buy-in across the organization.

• Ensure that DfE belongs to the design team, supported by EHS. Once the program is under way, the EHS staff can take on an effective role as a service provider to the product development team. (A recent assessment shows that EHS professionals contributing to successful DfE programs have excellent interpersonal skills and a strong service mentality, a significant shift from the traditional EHS focus on technical capabilities.)

• Simple, flexible, easy-to-use DfE tools and management systems are mandatory – especially at the beginning. This is probably the most significant challenge in launching DfE.

• Remember that DfE is not life cycle analysis (LCA), an assessment of a product's mass-and-energy balance throughout its life. Though it received early support as the best DfE tool, LCA has proven far too expensive, time-consuming, and cumbersome to use in most real-time product development processes. This realization prompted leaders such as AT&T, HP, and Raychem to develop simple, flexible DfE tools that captured the life cycle approach without the problems associated with an LCA. (Today, LCAs are used typically to support DfE as needed.)

DfE is not a high-risk endeavor, though it can cause some disruption at first. Getting DfE to fit the company culture and organization requires careful design and management of the process. Forcing DfE into the organization too rapidly, without proper buy-in, tends to release „organizational antibodies" that set out to destroy the invading process. Typical responses include skepticism on the part of line managers, tensions within traditional teams across the company, and a general perception that DfE will add costs, not benefits. The best way to avoid these problems is to start small and use a product line as a pilot project. This approach will build momentum behind the DfE concept and generate critical learning around what works and what doesn't within your organization when it comes to DfE.

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