Supply Chain Environmental Management

Lessons from Leaders in the Electronics Industry

Prepared by the Clean Technology Environmental Management (CTEM) Program of the United States-Asia Environmental Partnership, managed and implemented by Louis Berger Group, Inc.

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Foreword

This report was prepared for the United States–Asia Environmental Partnership (US-AEP), a program of the U.S. Agency for International Development (USAID), under its Clean Technology and Environmental Management (CTEM) unit and Benchmark Environmental Consulting.

This report introduces the subject of supply chain environmental management (SCEM), provides a context for the issue, and includes case studies of best practice examples in SCEM. The report is not intended to be a comprehensive analysis of the issue. Rather, it provides a summary of the topic and examples of SCEM programs of leading firms.

Acknowledgments

US-AEP is a ten-year effort to mobilize public and private sector resources to assist Asia in sustaining economic development while improving the environment. The program is designed to match Asian environmental needs with U.S. environmental experience, technology, and practice. The Clean Technology and Environmental Management (CTEM) Program of US-AEP is designed to meet these goals.

Under the guidance of Managing Director Julie M. Haines, the CTEM Program is intended to increase understanding and international cooperation regarding the environment and industrialization. The CTEM Program initiates a wide variety of activities including identifying clean technologies and practices used in U.S. industry that can be transferred to the Asian marketplace and assisting in technology transfer by identifying opportunities for collaboration and information sharing through providing written materials and other resources to both Asian and U.S. industries. The CTEM Program is managed and implemented for US-AEP by the Louis Berger Group, Inc.

The Louis Berger CTEM team retained Benchmark Environmental Consulting to complete this assignment. Benchmark Environmental Consulting is a research and consulting firm based in Hartsdale, New York, USA. Benchmark provides research and environmental management consulting to industry, governmental agencies, environmental groups, and international organizations interested in developing progressive ways to integrate the goals of sustainable development and environmental management into organizational policy and practice. Benchmark staff prepared a previous US-AEP CTEM report, Global Environmental Management: Candid Views of Fortune 500 Companies.

US-AEP/CTEM and Benchmark would like to thank all participating firms and individuals who, through interviews and provision of materials, made these case studies possible.

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Acronyms

AESOP	Asia Environmental Supplier Outreach Program
AMD	Applied Micro Devices
CAPS	Center for Advanced Purchasing Studies
CFCs	Chlorofluorocarbons
CIQC	Computer Industry Quality Conference
CMP	Copper metal polishing
DFE	Design for environment
DFEHS	Design for environment, health, and safety
DI	Deionized
ECP	Electroplating
EHS	Environment, health, and safety
EPD	Environmental product design
EPIC	Equipment and Process Integration Center
ERSI	Environmentally related supplier initiative
GDP	Gross domestic product
HP	Hewlett Packard
NGO	Nongovernmental organization
PIBA	Pacific Industry and Business Association
SCEM	Supply chain environmental management
SCM	Supply chain management
TRI	Toxics release inventory
US-AEP	United States–Asia Environmental Partnership
USAID	United States Agency for International Development
UTC	United Technologies Corporation
WCS	World Class Suppliers

Executive Summary

Electronics has become an integral part of modern life. Demand for electronic products—computers and telecommunications, semiconductors, electrical equipment, and consumer electronics—is growing, particularly in less developed countries, where the electronics industry has been a force for modernization. Much of the industry's new growth has been in labor-intensive segments of Asian production, whereas capital- and research-intensive stages of production remain concentrated in the United States, Japan, and Europe.

The ubiquitous nature of electronics in the Asian and global economy has prompted the US-Asia Environmental Partnership (US-AEP) to examine the environmental issues surrounding the electronics sector. The Clean Technology and Environmental Management (CTEM) component of US-AEP is focused on promoting market-based initiatives in the pursuit of cleaner technologies and sustainable economic growth. Accordingly, US-AEP/CTEM commissioned a study to identify major environmental issues related to the electronics industry and bring to light the latest trends in addressing environmental concerns. The study is based on a survey of seven international electronics firms and draws on other available industry-wide studies and data.

It is hoped that this report will contribute to the growing body of knowledge on clean technologies and sustainable economic development. It is intended to inform leaders and interested parties in industry, public sector and civil society, both in Asia and the U.S., whose destinies are woven together in an increasingly interdependent world.

The trend toward supply chain management. The electronics industry, like all industry, has realized that the quality and cost of their products depend on their suppliers throughout the world and has become increasingly concerned with supply chain management (SCM). This has resulted in two related trends in the industry:

Increasing involvement of procurement in design engineering. Procurement has the potential to cost-effectively deliver considerable value and play a significant role in business development, while establishing supplier relationships that ensure high quality and environmental standards. A trend toward involving suppliers at the design phase is clearly benefiting the electronics industry.

Rationalization of suppliers. Electronics companies are relying on fewer but larger suppliers for incoming products. As small suppliers lose contracts, they may alternatively seek to occupy highly specialized niche markets or sell to intermediate customers. Increasing supplier-to-supplier sales would extend and redistribute risk through the supply chain. As a result, legal and environmental health and safety (EHS) departments in companies are increasingly involved in evaluating contracts for potential risk.

Environmental issues in the electronics industry. The electronics industry has typically been considered relatively "clean," compared with other industry sectors. Nevertheless, manufacturing wastes in the industry and disposition of electronic products are raising important technical, financial, and environmental issues. Domestic and international air, water, ground, and disposition regulations and standards now affect every step in product life cycle and are becoming an important cost consideration in electronics manufacturing. Electronics companies have

taken both manufacturing wastes and product environmental impact seriously and are increasingly concerned about the many associated impacts of electronic products, in some cases, even taking responsibility for the full life cycle of a product. Environmental concerns are often addressed along with contractor and employee health and safety issues, primarily through integrated EHS programs. Because supplier policies and practices can improve the EHS performance of a company's products, some EHS programs are being extended to a company's suppliers through supply chain environmental management (SCEM).

Driving forces for supply chain environmental management. SCEM merges a firm's environmental management policies and goals with its SCM programs. SCEM is receiving increased attention in many sectors, particularly electronics, and holds strong implications for suppliers. Firms in the electronics industry are subject to both external and internal forces that are driving them towards SCEM. External forces include regulations, commercial customers, and advocacy groups, while internal forces are integrally linked to management issues, such as risk management, company benefits, societal concerns and corporate image.

Industry's response to SCEM forces. To gain a deeper understanding of industry approaches to SCEM, case studies were carried out with seven major firms in the electronics industry: Advanced Micro Devices (ADM), Xerox Corporation, Intel Corporation, Quantum Corporation, Applied Materials, Hewlett Packard and United Technologies Corporation (UTC). These case studies exhibit how some American firms with global operations are using various SCEM tools in Asia and the United States to achieve cleaner technology, enhanced EHS records, and business benefits through stronger supplier relationships. Some of the common SCEM tools employed by these firms are be summarized below:

Prequalification of suppliers (AMD, Intel and Xerox)

- Require or encourage environmental criteria for approved suppliers
- Require or encourage suppliers to undertake independent environmental certification

Environmental requirements at the purchasing phase (AMD, Hewlett Packard and UTC)

- Build environmental criteria into supplier contract conditions
- Incorporate EHS staff on sourcing teams

Supply base environmental performance management (AMD and Hewlett Packard)

- Supplier environmental questionnaires
- Supplier environmental audits and assessments

Build environmental considerations into product design (Xerox, Quantum and Intel)

- Jointly develop cleaner technology with suppliers
- Conduct life cycle analysis in cooperation with suppliers
- Engage suppliers in design for environment (DFE) product innovation
- Coordinate minimization of environmental impact in the extended supply chain
- Develop tools that assist in the DFE effort

Cooperate with suppliers to deal with end-of-pipe environmental issues (Applied Materials and Xerox)

- Reduce packaging waste at the customer/supplier interface
- Reuse/recycle materials in cooperation with the supplier
- Launch reuse initiatives (including buy backs and leasing)

Reverse logistics (Nortel – not included in this study)

- Give supplier an incentive to reduce the customer's environmental load

Influence legislation to facilitate better SCEM policies (Intel)

- In cooperation with suppliers, lobby to strengthen environmental regulation
- Lobby on behalf of SCEM initiatives

Work with industry peers to standardize requirements (Hewlett Packard)

- Create interfirm procurement group to collaborate on environmental issues
- Standardize supplier questionnaires

Inform suppliers of corporate environmental concerns (AMD, Xerox and UTC)

- Issue statements of EHS priorities to suppliers
- Draft and distribute comprehensive SCEM policy

Promote exchange of information and ideas (UTC and Intel)

- Sponsor events to facilitate discussions between customers and suppliers on environmental issues
- Host training and mentoring programs

American firms included in this report's case studies have generally started their SCEM efforts with local (U.S.) suppliers. This experience is, however, already being exported to Asia, and more will be in the future. For example, the UTC case study exhibits an Asian supplier outreach pilot; Hewlett Packard and Xerox have global SCEM programs in place; and AMD's Bangkok facility performs waste audits. The Asian programs already in place indicate great potential for wide-spread extension of SCEM in the region.

Ten emerging themes: challenges and opportunities. The seven case studies have revealed ten emerging themes in SCEM, which present both challenges and opportunities for all firms—customers and suppliers—in the electronics sector. These themes are summarized below.

1. *Companies are experiencing external and internal pressures for SCEM.* As noted, external and internal pressures are driving firms towards SCEM. Among the companies represented in this report, European take-back regulation is a particularly important external driver. It has helped companies to see the issue of product responsibility in a new way and prompted companies to work proactively. Advocacy groups—NGOs and shareholders—are also becoming increasingly interested in SCEM and are working harder to encourage companies to implement SCEM programs. Fundamental advantages to a firm's internal efficiency, profitability and image have driven firms to engage in supplier environmental programs. Individually, these and other issues are important; cumulatively, they are an important driver for change.

2. *Customer firms are applying SCEM by forming cross-functional procurement teams and by seconding environmental staff to design and procurement departments.* Several companies included in the report meet supply chain management needs by using cross-functional design and/or procurement teams. With the shift beyond SCM to SCEM, EHS staff are being included on these teams to ensure that the company's environmental needs are met. The case studies in this report reveal that environmental objectives are consistently favored when effective mechanisms bring procurement and environmental staff together, when risk

is sufficient to lend environmental staff credibility in purchasing decisions, or when the company has made environmental considerations a high priority or has made a strong commitment to SCEM programs.

3. *Design for the Environment (DFE) constitutes a fundamental shift in the supplier/customer relationship.* The design stage is the place in the life cycle of a product that has the most potential to shape the product itself and the processes that are used to create it. As long as companies continue to emphasize the development of green products and reduction of downstream risks and wastes, DFE will gain importance. For suppliers, this trend is likely to result in increasingly common environmental product specifications and the opportunity to work with companies on developing products that use cleaner production processes and materials. Suppliers are also being asked to collaborate on finding solutions to environmental problems. This represents both an opportunity and an obligation for suppliers. Suppliers who demonstrate skill and ingenuity in their involvement with environmental solutions will likely receive customer loyalty. They will also save effort and expense for their customers by eliminating problems early in the supply chain.

4. *SCEM proposes a new model for the relationship between companies and their suppliers.* The importance of customer-supplier partnerships was most directly illustrated in the case studies on promoting the exchange of information and ideas, but it is an aspect of nearly all the case studies. These partnerships represent a shift from the old business model of communicating with suppliers primarily through purchase orders to one of shared problem solving. In its most advanced form, the supplier is encouraged to become a consultant to the customer. The case studies in this report give examples of ways in which suppliers are going beyond merely providing products, services, and materials to actively meeting the needs of companies and participating in forming solutions. In the long term, successful suppliers are likely to be those who anticipate customers' needs—including EHS needs—and provide solutions.

5. *The implementation of SCEM is still in its infancy.* The use of audits, questionnaires, and product specifications is central to SCEM and was evidenced in most of the case studies. Firms are now refining these processes and making them more effective and user friendly for both company and supplier. However, these initiatives are not being used in a systematic way. This is likely to change as firms mature in their use of SCEM and see opportunities for adding value and rationalizing costs.

6. *The trend is to reduce the number of "Tier 1 suppliers" and lengthen the supply chain.* Rationalization of the supplier base, evidenced in statistical surveys and in the case studies, is becoming a trend. Although this may not necessarily mean that many supplier companies lose business, some will. Niche providers and specialist providers will be best insulated. The real impact of the reduction in the number of suppliers may be to lengthen, rather than shorten the supply chain. In the electronics industry, many of the parts required in production are niche or highly specialized products. These will still have a market, but not necessarily with multinational customers. Global companies will reduce the number of Tier 1 suppliers, but this may simply reorganize the supplier structure so that their enduring Tier 1 suppliers contract with old Tier 1 suppliers, making them Tier 2 suppliers, and so forth. This shift will restructure supplier relationships but may not mean a loss in business for smaller suppliers.

7. *SCEM can be a means of environmental risk management.* Risk management was emphasized by both EHS professionals and procurement officers in the course of interviews for this report. SCEM programs, the concentration of suppliers, and the lengthening of the supply chain will mean that financial and environmental risk is pushed back down the supply chain, onto suppliers. Inventive SCEM programs, however, will help suppliers minimize their own risk as well.

8. *The benefits of SCEM may be uneven.* SCEM has the potential to benefit both suppliers and customers. Among suppliers in developing countries, however, concern exists on whether the benefits to suppliers of SCEM will be evenly distributed. In the semiconductor sector, for example, companies in developed countries often export the lower-tech, labor-intensive phases of production to developing countries. These segments of the supply chain may not have the same opportunities to benefit from SCEM initiatives as those associated with the design phase. This suggests that in some segments of the semiconductor industry, suppliers may face environmental requirements without receiving the benefits of collaboration. This may or may not be applicable elsewhere in the electronics sector, and suppliers may often be able to participate actively in shaping SCEM programs.

9. *The marketplace will start to reward environmentally sound products and processes.* Savvy suppliers and regions will recognize the competitive advantage that green products and processes are likely to present in coming years and will position themselves accordingly. As more companies begin to implement sophisticated, comprehensive SCEM programs, it will be a key advantage to suppliers to have clean technologies already in place. Companies that take steps now to begin the process of greening their operations—eliminating or minimizing hazardous material use, favoring cleaner technology, adopting DFE processes, and minimizing environmental risks—will find that they are well positioned to answer rising concerns about environmental management.

10. *SCEM complements "just-in-time" management at many points.* Many of the issues in SCEM have already been rehearsed with "just-in-time" management—the increased importance of customer-supplier partnerships, reduction in the number of suppliers, integration of suppliers at the design stage, and pushing risk downstream onto suppliers. The implication of this is that it is not an entirely new aspect in the customer-supplier relationship, but a strategic one and likely to endure.

The strategic and environmental advantages of SCEM ensure that it is a major issue—a different business model—for the next decade and beyond. SCEM may prove to be the most effective way that global firms can spread clean technologies and promote global voluntary environmental management. Companies have the power to effect enormous changes in the environmental performance of their suppliers worldwide without intervention or regulatory involvement. Governments, bilateral organizations like US-AEP, and multilateral aid agencies may also play a complementary and supportive role.

Introduction

Background and Objectives

A hundred years ago, electronics had more to do with an abstract branch of physics than with people's daily lives. Thomas Edison was still alive, the light bulb and phonograph were new inventions, and the television and computer were yet to come. Removing all electronic products and services from society would scarcely have been noticed.

Now, electronics is integral to modern life. The level of concern over the Y2K issue illustrates the pervasive impact of electronics on our lives today. Virtually everything that we do is somehow related to or depends on electronics. It is essential in computers, televisions, telecommunications equipment, military hardware, automobiles, and the aerospace industry. Furthermore, it is part and parcel of services that we take for granted, including banking, trade, and communications. The trend toward incorporation of electronic products is increasing—in everything from medical equipment to work-out machines. Clearly, the demand for electronic products is growing.

The ubiquitous nature of electronics in the Asian and global economy has prompted the US-Asia Environmental Partnership (US-AEP) to examine the environmental issues surrounding the electronics sector. The Clean Technology and Environmental Management (CTEM) component of US-AEP is focused on promoting market-based initiatives in the pursuit of cleaner technologies and sustainable economic growth. Accordingly, US-AEP/CTEM commissioned a study to identify major environmental issues related to the electronics industry and bring to light the latest trends in addressing environmental concerns. The study is based on a survey of seven international electronics firms and draws on other available industry-wide studies and data.

Overview of the Electronics Industry

Not every region of the world has widespread access to electronic goods and services, but demand is growing in less developed countries and areas. The electronics industry has, in fact, been one of the driving forces of modernization and, consequently, one of the most dynamic sectors in the global economy. As labor-intensive services migrate to less-developed regions, an increasingly sophisticated economy relies on technological innovation to stay afloat. At the same time, developing economies that prove competent in electronics manufacturing are able to develop more quickly, add more value, and produce a higher amount of export products than those that do not work to achieve technological expertise.

Today, the electronics industry dominates the market as a result of increasing reliance on electronic goods and the shift toward a technologically advanced economy. This is indicated by the amount of attention that the business media pays to electronics companies. Business reports carefully follow industry leaders as beacons for the larger economy, and reporters announce shifts among the technology stocks as key indicators for the stock market. Electronics firms also play a key role in enabling the business transactions of companies in other sectors. The technology promoted by electronic firms facilitates electronic transactions among companies, the transmission of share prices to investors, and myriad forms of business communications. Increasingly, businesses in all sectors depend on electronics.

As the electronics marketplace grows, it becomes more difficult to define the shape of the industry. It has four distinct sectors: computers and telecommunications, semiconductors, electrical equipment, and consumer electronics. Each has a huge range of products and services. The electronics and computer industry combined is the largest manufacturing employer in the United States and accounts for nearly 11 percent of the U.S. gross domestic product (GDP). The output of the global electronics industry reached $700 billion in 1990 and is expected to reach $1.3 trillion by 2000, about 4 percent of the world's GDP and 14 percent of value added in manufacturing.

Globally, the growth of electronics as a percentage of GDP has not been evenly distributed. In dollar terms, much of the new growth has been in the "tiger" economies in Asia. A report from the United Nations Environment Programme on the semiconductor industry in the Philippines shows that the country's electronics industry grew from 23 percent of national exports in 1985 to 58 percent in 1997 and that semiconductors (the largest sector within the nation's electronics industry) grew from 22 percent of exports to 44 percent. Revenue from electronics increased from $1.1 billion in 1985 to $10.6 billion in 1996—that is, by a factor of ten in 11 years—whereas exports of other items have remained relatively stable.

This growth, however, has not been evenly distributed among the various stages of production. Labor-intensive segments of production account for much of the growth, whereas the capital- and research-intensive stages of production remain located in the United States, Japan, and Europe. In the semiconductor sector, for example, a study of twenty-two leading companies from five industrialized companies showed that more than 50 percent of their manufacturing and assembly facilities are located in developing countries. Assembly and product testing is the labor-intensive segment of the production process. Meanwhile, wafer design and fabrication, the capital-intensive production processes, occur primarily in industrialized countries. As a result of this distribution pattern, the value added of the Filipino semiconductor industry, estimated in a 1992 study by the Semiconductor Electronics Industry Foundation was 11.9 percent of revenues. So, despite huge export revenues, the actual contribution of the nation to the global value added has been quite low.

Analysis of Trends in the Electronics Industry

The Importance of Supply Chain Management

Businesses in all sectors have come to realize that the quality and cost of their products depend on their suppliers, and supply chain management (SCM) has become an increasingly prominent business concern. This is equally true in the electronics industry. The Arizona-based Center for Advanced Purchasing Studies (CAPS) has been tracking procurement practices in various industrial sectors since 1996.[1] The data in the table below is taken from that study and demonstrates the attention being paid to supply chain management. The data are excerpted from procurement analyses of the semiconductor, electrical equipment, electronic equipment, and computer and telecommunications sectors of the CAPS study. In each sector, between nine and eleven firms provided information, which were aggregated in the CAPS summaries.

Table 1: Procurement Trends in the Electronic Sector

Subsector	Amount spent to operate purchasing function per active supplier (US$ 000)	Average amount received per active supplier (US$ x 000)	Active suppliers that received 90 percent of company purchases (%)	% Change in number of active suppliers during the one-year reporting period
Electronics	2.9	295.0	25.0	-8.1
Semiconductors	1.0	153.0	11.5	0.9
Electrical Equipment	1.4	130.0	20.7	-4.4
Telecommunications and Computer Equipment	2.7	310.0	12.1	-4.4*

*Represents direct material suppliers

Source: Center for Advanced Purchasing Studies, March 25, 1999.

[1] Center for Advanced Purchasing Studies, Benchmarking Project (1996 and ongoing), <www.capsresearch.org/research/benches> (March 25, 1999).

Two major observations arise from Table 1, related to cost of procurement and the number of suppliers:

Cost of operating procurement functions: The cost of operating the procurement function is generally only about 1 percent of the amount paid to suppliers in contracts. This suggests that procurement has the potential to deliver considerable value and influence a significant amount of business without high operating costs. While the cost savings that procurement provides are reported in the CAPS summaries, the service that purchasing departments provide in establishing supplier relationships that ensure high quality and environmental standards is also significant and has the potential to grow.

Number of Suppliers. Perhaps the most significant revelation of Table 1 is the trend toward reduction of active suppliers. Three out of four sectors showed a significant drop in the number of active suppliers during the one-year reporting season (column 4); the fourth sector (semiconductors) showed only a marginal increase. Moreover, the figures in column 3, "Percent of active suppliers that received 90 percent of company purchases," indicate a concentration of purchasing spending among a small portion of suppliers. The lower the percentage, the more concentrated the companies' spending. On average, the firms surveyed spent 90 percent of their purchasing dollars on only 11 to 25 percent of their total suppliers. In all four cases, this demonstrates a concentrated purchasing program that relies heavily on a small proportion of suppliers for the bulk of incoming products. In the electrical equipment sector, nearly 80 percent of the firms included had goals in place to reduce the supplier base (other sectors did not report on this aspect).

In the semiconductor and computer and telecommunication sectors, which demonstrate the most concentrated purchasing efforts, 90 percent of the purchasing dollars went to just more than 10 percent of suppliers. Three key conclusions follow from this fact:

- Procurement dollars are not evenly distributed. A few large suppliers receive most of the firms' purchasing business.

- Most of the other small suppliers may risk losing their contracts if companies continue to attempt to reduce their number of suppliers. Because a noticeable trend already exists to reduce the supply base and the one sector reporting on the issue shows that most firms are intentionally trying to cut down on the number of suppliers, the potential exists for a dramatic continuation of this trend. The concentration of purchasing means that a large number of suppliers could be eliminated without a large loss to the company in terms of incoming supplies. Already in the semiconductor sector, only twenty-five firms receive more than 70 percent of the companies' purchase orders. These figures suggest that suppliers may need to explore ways of avoiding a loss in business. This should be possible by occupying highly specialized niche markets or selling to an intermediate customer rather than directly to the multinational—an option that may be more available in the electronics sector than elsewhere.

- The trend toward reduction of suppliers may result in extension of the supply chain. As the number of suppliers selling directly to the firm falls, supplier-to-supplier sales will increase. A redistribution of risk down the supply chain will accompany this trend.

Other relevant results of the CAPS study, not consistently reported across the electronics sectors, include:

- Of firms included from the electrical equipment sector, 77.8 percent had goals in place for achieving supply base reduction.

- In the semiconductor sector, the top twenty-five suppliers to each firm accounted for 71.7 percent of the sector's purchasing spending.

- Supplier personnel in the computer and telecommunications sector worked directly with design engineers in developing new products in 91 percent of all companies. On average, 10.6 percent of the supply base was involved with this effort.

- Of those firms in the electrical equipment sector incorporating suppliers into their business, integration occurred in design engineering in 87.5 percent of all firms.

- Of all firms in the computer and telecommunications sector, 64 percent had divisions, products, or services that were ISO 14001 certified; 63 percent had divisions, products, or services in the process of applying for ISO 14001 certification; 55 percent required their suppliers' operations to be ISO 9001 certified; and none of the firms required their suppliers' operations to be ISO 14001 certified.

- Of all firms in the computer and telecommunications sector, 64 percent required the legal department to approve and/or sign off on contracts.

- Small business suppliers received 22.4 percent of total U.S. procurement dollars in the semiconductor sector and 21.6 percent in the computer and telecommunications sector.

The CAPS study provides a useful framework for understanding purchasing trends for industry writ large and for the electronics sector in particular. Two overall trends stand out:

- A trend toward rationalization of suppliers.

- The increasing involvement of the procurement function in design engineering.

For sectors reporting on the incorporation of suppliers into business, the integration of suppliers at the design phase is a clear trend. In the computer and telecommunications sector, more than 90 percent of firms report cooperation between suppliers and design engineers in new product design. Among electrical equipment firms that integrate suppliers, nearly 90 percent do so at the design phase. The benefits of cooperation between suppliers and design engineers are obvious from these figures.

In the CAPS study, the sectors do not report consistently on ISO 9001 or 14001 certification or requirements, but the limited results reported indicate that ISO 9001 is a supplier requirement whereas ISO 14001 is not. Only the computer and telecommunications sector reports on both, but more than half of these firms require ISO 9001 certification of suppliers. None, however, require ISO 14001, although a majority of the computer and telecommunications firms are themselves ISO 14001 certified or in the process of achieving certification.

A final result of the CAPS study of interest is that over half of the computer and telecommunications firms require the legal department to sign off on contracts. This suggests that risk may play a significant role in the purchasing function. Law suits are being brought by consumers against mobile phone manufacturers are, for example, resolved in part through the

records of purchasing contracts. Cognizant of the risk involved in purchasing, legal departments increasingly require involvement in the purchasing process. Likewise, some companies require that EHS departments evaluate contracts for potential risk.

Environmental Issues in the Electronics Industry

The building blocks of this industry (semiconductors, electronics packaging, printed wiring boards, assemblies, and displays) have typically been considered relatively "clean" in terms of environmental impact, compared with other industry sectors. The electronics industry only emits 1.6 percent of total U.S. Toxic Release Inventory (TRI) emissions annually (Microelectronics and Computer Technology Corporation, 1994, page 5). Nevertheless, manufacturing by-products of the electronics industry and the disposition of electronic products are raising increasingly important technical, financial, and environmental issues. Domestic and international air, water, ground, and disposition regulations and standards now affect every step in the life cycle of electronic products and are becoming an important cost consideration in electronic systems manufacturing.

Manufacturing wastes and the environmental impact of products are issues the electronics industry takes seriously from both an environmental and a business perspective. Electronics manufacturing generates waste streams that are rigorously controlled and treated at a high cost to manufacturers, and the amount of waste that must be treated will increase if the current trend to expand the definition of hazardous waste continues.

The industry used chlorofluorocarbons (CFCs) quite intensively in the past but has worked to eliminate CFCs from the manufacturing process since the Montreal Protocol. This has required developing alternatives—a technologically intensive process. But most electronics companies now report that their manufacturing operations are CFC-free.

Moreover, the electronics industry impacts the environment in numerous places besides the manufacturing waste stream. At the packaging and shipping phase, during use, and at the end of its usable life, a product affects energy use, the use of natural resources, and generation of pollution and solid waste. As companies move beyond the reactive stance of dealing only with regulatory threats, they are becoming increasingly concerned about the many associated impacts of their products. At the most sophisticated stage of environmental concern, companies assume product stewardship and take responsibility for the full life cycle of the product, including at the end of its useful life.

Contractor and employee health and safety issues are another important area of consideration that is often addressed in conjunction with environmental concerns because of the structure of companies' EHS departments and because of the health concerns associated with certain chemicals. Several categories of health and safety concerns exist: employee health and safety, contractor safety, and product safety. Accordingly, companies have a variety of processes in place to deal with these needs.

Companies that are concerned about their EHS practices are increasingly looking outside of their own facilities for improvements. They are also turning to their suppliers, cognizant of the role that suppliers' policies and practices play in the products that the firms ultimately deliver. Because much of the potential for improving the environmental performance of the products lies downstream in the supply chain, firms are beginning to consider how they can work with suppliers for environmental results.

From Supply Chain Management to Supply Chain Environmental Management

The shift to SCEM is a logical extension of SCM—a merging of a firm's environmental management policies and goals with its SCM programs. This report, in many ways, is particularly prescient, because it represents the intersection of three emerging forces and issues in the global economy: environmental management, SCM, and the electronics industry. SCEM is a growing issue that is receiving increased attention in a variety of sectors, particularly electronics, and it holds strong implications for suppliers. The factors that are causing the development of SCEM are outlined below.

Forces Towards Supply Chain Environmental Management

External Forces for SCEM

External forces for SCEM include regulations, commercial customers and advocacy groups.

Regulations: Product Take-Back and Waste Management

European legislation requiring electronics manufacturers to recycle their products at the end of their useful life has forced companies to reexamine their products, a process that has inevitably resulted in cooperation with suppliers. Some firms have moved aggressively to put in place product take-back schemes. In Europe, Alcatel, Ericsson, Motorola, Nokia, Panasonic, and Philips joined together under the umbrella of the European Telecommunications and Professional Electronics Industries Trade Association (ECTEL) to sponsor a program to induce consumers to return old mobile phones for dismantling and recycling and to determine the economics of recycling. The Xerox Corporation cites European legislation as one of the forces driving their remanufacturing program. To ensure that it could design products that are free of regulatory obstacles worldwide, Xerox compiled a list of the world's most stringent environmental regulations.

Environmental considerations are increasingly being pushed forward into research and development and into design, because the success of a take-back program is linked directly to the product's design. It is ironic that end-of-life regulations should impact supplier relationships at the beginning of the product life cycle, but the above example demonstrates the impact of design and the environmental connections among the different stages of a product's life.

Take-back regulations have not been implemented outside of Europe, but firms in general are aware of the possibility of regulation and see the advantage in working proactively to prevent the need for regulatory involvement. Policy in the United States at the moment favors voluntary measures to achieve the goals of the European legislation. The President's Council on Sustainable Development, for example, suggests that extended product responsibility is an important step toward corporate sustainability but one that is best achieved through voluntary measures and public-private partnerships.

Commercial Customers

Many companies are not only producers but suppliers as well, and the practice of SCEM is expanding beyond first-tier suppliers to reach second- and third-tier suppliers. The implication is that SCEM can beget SCEM: companies that are suppliers to other firms are sometimes

encouraged to initiate environmental programs with their own suppliers for the sake of further extending SCEM.

Advocacy Groups

Advocacy groups for SCEM include nongovernmental organizations (NGOs) and investors and shareholders.

Nongovernmental Organizations

In 1982 the Silicon Valley Toxics Coalition was formed in response to discovery of substantial groundwater contamination in Silicon Valley caused by a leaking underground storage tank at a semiconductor plant. In June 1996, the coalition published its draft "Silicon Principles" dealing with global EHS management and asked the high-tech electronics industry to endorse them. The principles are part of a campaign intended to increase grassroots participation in national and international technology policy development. Included in the principles is a requirement that firms:

- Establish corporate policies requiring equal standards for subcontractors and suppliers
- Establish technical assistance and technology transfer to encourage pollution prevention at all stages of production, rather than shift the pollution down the production chain to smaller contractors
- Hire contractors who adhere to good labor and environmental policies, and in particular, hire union contractors where they exist. (Salazar 1998: 23–24)

This is not the only example of advocacy groups seeking to influence SCEM. On February 11, 1998, Mitsubishi Motors and Mitsubishi Electric of America signed a memorandum of understanding with the Rainforest Action Network concerning Mitsubishi's environmental procurement policies. As part of the memorandum of understanding, Mitsubishi announced that it intended to end the use of old-growth forest products and phase out the use of tree-based paper and packaging products by the year 2002 in favor of alternative fibers.[2]

These examples demonstrate that NGOs are looking beyond companies' own environmental policies to consider the impacts of supply chain issues on the environment. The Mitsubishi example also shows that NGOs are looking beyond domestic operations at what companies are doing in other parts of the world, because many of the forestry operations of concern to the Rainforest Action Network are located in Asia.

Investors and Shareholders

Investors are paying increasing attention to companies' environmental records. Socially and environmentally screened portfolios are gaining popularity, and fund managers are beginning to take environmental efforts with suppliers into consideration. Messages of investor concern reach companies most directly, however, through shareholder resolutions. The New York–based Interfaith Center for Corporate Responsibility has filed shareholder resolutions concerning SCEM with Hewlett-Packard and Intel. The center's shareholder resolution requests that the company "report, at reasonable cost and omitting proprietary information, on the company's contract supplier standards and compliance mechanisms for all manufacturing and waste management vendors, subcontractors, [and] suppliers with contracts in excess of $1,000,000 annually."[3] The resolution goes on to detail the elements of the report. This effort demonstrates that investors

have real concern about companies' SCEM practices, stemming from a suspicion that competition may encourage contracting of suppliers that have low EHS standards and that operations in countries with weaker environmental regulations may be environmentally unsound.

Internal Forces for SCEM

Not all of the forces for SCEM are external; many are common-sense responses to corporate needs. Among them are some of the biggest forces behind the shift to SCEM. These include:

- *Risk management*. One of the most compelling factors promoting corporate SCEM is the threat of liability and risk issues regarding suppliers' environmental practices. With twenty-nine Superfund sites in Silicon Valley, the electronics industry understands the benefits of cleaner production and knows that suppliers need to be involved in that process. Furthermore, the potential of an interruption of service or a liability issue concerning a supplier prompts companies to assess and minimize risk.

- *Benefits of SCEM.* Many companies are finding fundamental advantages to being involved with their suppliers' environmental programs. These basic benefits to business include cost reduction through pollution prevention programs, benefits of cooperation at the design phase, and feedback that companies may receive from suppliers on their own environmental programs.

- *Concern for environmental impacts.* As companies attempt to enhance their own environmental records, many realize that their success is incomplete without improvements on the part of their suppliers as well.

- *Corporate image.* Closely related to many of the factors above, one of the forces for SCEM is concern about protecting brand-name reputation. This is of special concern for a company when it is the target of a media campaign, but a majority of companies recognize the advantage of presenting strong environmental images and the necessity of incorporating SCEM. The corporate image motive is enhanced by the practice of ecolabeling, which is already an important market motivation in Europe.

Industry Response

The various forces driving SCEM forward have increased interest in the issue among companies, but the implementation of SCEM programs has not been uniform. Various tools for SCEM have developed in the past few years. This has resulted in a collection of methods available to managers wishing to implement SCEM programs. Table 2 summarizes these various initiatives and their components.

This list is probably not comprehensive, but it represents a fairly thorough accumulation of what is happening in the field of SCEM. More important, the various categories and tools are not completely distinct; in practice, they can overlap. A questionnaire, for example, might have questions about packaging reduction or a DFE initiative might be necessary to make a successful leasing or take-back program possible.

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[2] Rainforest Action Network. "Landmark Settlement Reached in Long-Running Environmental Boycott of Two Mitsubishi Companies." <http://www.ran.org /ran_campaigns/mitsubishi/QT/release.html> (April 14, 1999).

[3] ICCR shareholder resolution. Contact ICCR at info@iccr.org for more information.

In order to gain a deeper understanding of the application of SCEM in the electronics industry, case studies of seven major electronics firms were carried out. These case studies exhibit leading practices in the application of SCEM tools, which appear to have tremendous potential importance for business and environment in both the United States and Asia. The case studies showcase American firms with global operations that are exploring the issues of SCEM. Some of their programs are currently focused on Asia. Others are being applied primarily within the United States, but the firms involved have indicated interest in extending their current SCEM practices

Table 2: Tools in SCEM: A Collection of Environmentally Related Supplier Initiatives (ERSIs)

Prequalification of suppliers

- Require or encourage environmental criteria for approved suppliers
- Require or encourage suppliers to undertake independent environmental certification

Environmental requirements at the purchasing phase

- Build environmental criteria into supplier contract conditions
- Incorporate EHS staff on sourcing teams

Supply base environmental performance management

- Supplier environmental questionnaires
- Supplier environmental audits and assessments

Build environmental considerations into product design

- Jointly develop cleaner technology with suppliers
- Conduct life cycle analysis in cooperation with suppliers
- Engage suppliers in design for environment (DFE) product innovation
- Coordinate minimization of environmental impact in the extended supply chain
- Develop tools that assist in the DFE effort

Cooperate with suppliers to deal with end-of-pipe environmental issues

- Reduce packaging waste at the customer/supplier interface
- Reuse/recycle materials in cooperation with the supplier
- Launch reuse initiatives (including buy backs and leasing)

Reverse logistics

- Give supplier an incentive to reduce the customer's environmental load

Influence legislation to facilitate better SCEM policies

- In cooperation with suppliers, lobby to strengthen environmental regulation
- Lobby on behalf of SCEM initiatives

Work with industry peers to standardize requirements

- Create interfirm procurement group to collaborate on environmental issues
- Standardize supplier questionnaires

Inform suppliers of corporate environmental concerns

- Issue statements of EHS priorities to suppliers
- Draft and distribute comprehensive SCEM policy

Promote exchange of information and ideas

- Sponsor events to facilitate discussions between customers and suppliers on environmental issues
- Host training and mentoring programs.

overseas to Europe and Asia. The companies included were selected because they are leading firms engaged in best practice SCEM project examples. They do not represent a complete list of firms engaged in SCEM programs but provide an excellent starting point for discussion of best case practices. SCEM efforts are helping their firms achieve cleaner technology, stronger supplier relationships, enhanced EHS records, and business benefits.

The firms with case studies in this report are:

- Advanced Micro Devices (AMD)
- Applied Materials
- Hewlett Packard
- Intel Corporation
- Quantum Corporation
- United Technologies Corporation (UTC)
- Xerox Corporation

The case studies for these companies were formulated through phone interviews, written correspondence, company material on-line, and information provided by the participating companies. A more detailed explanation of the ERSIs categories listed in Table 2 follows, describing where the case studies presented fall among the categories. This is followed by in-depth case study descriptions for each firm in the next chapter.

Prequalification of Suppliers (AMD, Intel, and Xerox)

Prequalification of suppliers allows for early communication with suppliers on environmental issues and can send a strong message of concern about EHS issues. It also makes it possible for companies to draw a fairly straight line on the issue of environmental standards. Many firms have approved suppliers lists, but not all include environmental criteria when determining which suppliers qualify. At Intel, a prequalification process for contractor safety ensures high safety standards and has cut down on duplicate safety training. At AMD, the companies' environmental audit of suppliers has in the past even led to the removal of a firm from the approved suppliers list. At Xerox, suppliers must commit to working toward fulfilling the company's supplier EHS requirements before they can be an approved vendor.

Environmental Requirements at the Purchasing Phase (UTC, Hewlett Packard, and AMD)

The incorporation of environmental criteria at the procurement phase is at the core of SCEM, and, therefore, this subject overlaps with many of the other categories. A trend to include EHS staff on multidepartment procurement teams is illustrated in the case studies of UTC and AMD. Hewlett Packard has also grappled with the issue of how procurement can get involved with environmental criteria; their case study discusses the issue in the context of industry standard questionnaires.

Supply-Base Environmental Performance Management (AMD and Hewlett Packard)

Audits and questionnaires are a popular method of assessing suppliers' environmental practices. This, of course, is only sensible, because evaluation of environmental behavior is an important preliminary step in determining the direction of a SCEM effort.

The AMD case study discusses both its audit of waste service providers and questionnaire of chemical companies within the context of a risk management program. As part of Hewlett

Packard's global corporate procurement policy, suppliers now receive an environmental questionnaire; but the company chose to work with other companies in developing its standard (see "Work with Industry Peers" below).

Build Environmental Considerations into Design (Xerox, Quantum, and Intel)

DFE is a broad topic that overlaps with a number of other categories. The trend to identify and resolve potential environmental hazards early in the life cycle of a product pushes environmental analysis into the design phase, when it is convenient to involve suppliers in designing smarter products. This process happens in a number of ways, but, in all cases, the emphasis is on preventing environmental hazards through design. Products are being designed to avoid hazardous materials in manufacturing, reduce energy requirements during manufacturing and a product's life span, and have a minimal end-of-life impact, including through design for reuse and recycling.

A number of firms have innovative programs in this area. Quantum Corporation, together with Lucent Technologies and Texas Instruments, was involved in developing a new software tool that facilitates the flow of information on environmentally restricted substances and, in some cases, dramatically reduces the use of such substances. Intel has expanded the field of DFE to "design for environment, health, and safety" (DFEHS)—taking not only environmental considerations into account at the design phase, but health and safety factors as well. Xerox is engaged in an ambitious DFEHS program to design equipment for remanufacturing .

Cooperate with Suppliers to Deal with End-of-Pipe Environmental Issues (Applied Materials and Xerox)

Cooperating with suppliers to reduce end-of-pipe environmental impacts goes against conventional logic; suppliers are involved during preproduction, and waste is generated postproduction. But, as the DFE model shows, thinking about waste early in the production process can avoid it late in the process; many opportunities exist for involving suppliers in cutting down waste. Compaq requires their suppliers to have a waste minimization program in place. Motorola is part of a pilot mobile phone take-back program in Europe that necessitates strong supplier relationships. Applied Materials, as a supplier, has installed a closed-loop, waste abatement water-recycling system in their process integration facility to show customers how they can potentially reduce waste in their own fabricating facilities (fabs). Xerox expects suppliers to minimize waste in packaging and help with eliminating their own products' waste.

Reverse Logistics

Reverse logistics is an emerging trend in which a firm decides it will change the incentive system on how much a supplier produces and rewards conservation rather than overproduction. Nortel, the Canadian telecommunications equipment manufacturer, is trying to reduce the chemical content of its products by paying its chemical suppliers a fixed price for their services (rather than paying them by the volume of chemicals). Nortel also offers technical assistance to its suppliers. Suppliers, therefore, have an incentive to suggest efficiency improvements.

Influence Legislation to Facilitate Better SCEM Policies (Intel)

In a few cases, SCEM identifies instances in which government policy does not serve environmental or corporate needs and companies may participate with suppliers to lobby actively for new policy measures. At Intel, the desire to deal responsibly with hazardous waste

from foreign facilities has driven the company to lobby the U.S. Congress to adopt the Basel Convention, which regulates international shipments of hazardous waste.

Work with Industry Peers to Standardize Requirements (Hewlett Packard)

This category shows that not all SCEM efforts are best approached by companies individually. Realizing that they often duplicate efforts in managing the supply chain in an environmentally responsible manner and not wanting to lose suppliers because of a unilateral imposition of additional requirements, customer companies have joined forces to send clear industry-wide messages to suppliers on EHS standards. This has cost implications for suppliers, as well as to environmental implications. Industry-wide standards, however, do set clear expectations for all suppliers to the industry.

In the semiconductor industry, Sematech has drafted the "Semiconductor Equipment and Materials International (SEMI) Guidelines for Safety," which are requirements for many customers in the field, including Intel. In a separate initiative in California, firms in the electronics industry realized that they were duplicating each other's efforts and causing extra work for suppliers by writing separate supplier environmental questionnaires. They joined forces and drafted an industry standard through the Pacific Industry and Business Association and the Computer Industry Quality Conference. Hewlett Packard's involvement with and use of the standard is discussed in its case study.

Inform Suppliers of Corporate Environmental Concerns (AMD, Xerox, and UTC)

As companies develop more sophisticated SCEM programs and policies, many find it useful to communicate these directly to suppliers. Often such statements to suppliers include a number of different features: corporate EHS policies, SCEM policies, specific expectations for suppliers, and other information, such as lists of chemicals of concern or banned substances. Some of the components, therefore, may be associated with strict requirements and expectations. Much of the purpose, however, is to communicate a general set of values and processes to suppliers and instigate a dialogue on SCEM.

A number of companies have or are developing such statements, although none of these are the direct subject of the case studies. For references to this topic, see the case studies on AMD, Xerox, and UTC.

Promote Exchange of Information and Ideas (UTC and Intel)

Although many of the other tools discussed may provide an opportunity for customers and suppliers to exchange ideas on environmental improvements, none are exclusively intended as an opportunity for interaction. This tool, however, is expressly intended to facilitate discussion. By sponsoring events that bring customers and suppliers together, companies find that the resulting discourse sparks strengthened relationships and the emergence of win-win solutions.

Intel sponsors an annual Materials Supplier Day, which is an opportunity for discussion of a number of supplier issues, including EHS management. UTC, together with US-AEP, hosted an event in Malaysia to pilot the Asian Environmental Supplier Outreach Program (AESOP), which was specifically intended to facilitate exchange of EHS strategies between UTC and its Malaysian suppliers.

Case Studies

Advanced Micro Devices (ADM)
Risk Management

Xerox Corporation
Design for Remanufacturing

Intel Corporation
Design for Environment, Health and Safety

Quantum Corporation
Developing a Data Base of Environmentally Restricted Substancess at the Design Stage

Applied Materials
Clean Technologies: Suppliers Leading the Way

Hewlett Packard
Industry Standards for SCEM

United Technologies Corporation
The Benefits of Partnership

Risk Management

Advanced Micro Devices (AMD)

THE CHALLENGE

Supply Base Environmental Performance Management

Other themes in this case study:
- Environmental requirements at the purchasing phase
- Prequalification of suppliers
- Inform suppliers of corporate environmental concerns

For similar case studies, see:
Hewlett Packard

Advanced Micro Devices, like every other firm, struggles with the question of how to balance its various needs and concerns. Faced with both business objectives and EHS goals, the company has sought a way to maximize the results of its efforts in a number of ways. The company's approach to supplier relationships, in particular, was in need of a standard of measure to translate various goals into one language. That language became the parlance of risk management.

Staff in AMD's EHS Department realized that supply-chain issues had the potential to seriously impact the company. It faced both business and environmental risks and the potential of being detrimentally affected by anything from an interruption of services to a liability claim. Recognition of these potential threats helped to bring the department's direction in dealing with suppliers into clearer focus. The company found that limited resources make risk-based management sensible because it helps to prioritize needs. The issue for the company, therefore, was to turn the language of risk management into a policy that could enhance its supply-chain practices in the interests of all concerned.

THE SOLUTION

In dealing with its suppliers, AMD has adopted a risk-based methodology to balance EHS objectives with performance goals and budget requirements. Within this framework, it has prioritized suppliers according to potential risk and has launched a program to assess and work with suppliers in each risk class. Within each category, AMD is identifying appropriate tools to evaluate suppliers, work with them on improvements, and manage risk.

The First Tier

AMD determined that its highest-risk suppliers were the companies it uses for transport and disposal of waste; so, its quest for risk management began with them. More than ten years ago, AMD began a program of on-site audits at the facilities of its waste suppliers with the intention of minimizing risk through an informed auditing process. Through these audits, AMD staff determine a recommendation status for waste suppliers. New suppliers are required to undergo a review prior to use by AMD, and existing suppliers are reviewed periodically. The frequency and intensity of the review process varies according to the potential risk to AMD, but all suppliers must be reviewed periodically to maintain approved-supplier status. Categorization of suppliers by risk within the waste bracket allows AMD to allocate its resources efficiently while minimizing liability.

Over time, the auditing process has evolved and become more refined. What began as an ambitious but resource-intensive attempt to perform frequent full audits has become a targeted analysis of those aspects of the suppliers' operations that are likely to impact AMD.

AMD's Risk Management Hierarchy

1st tier
Waste management firms

2nd tier
Chemical suppliers

3rd tier
Construction contractors

4th tier
Foundry/manufacturing subcontract support

5th tier
Manufacturing equipment

Today, the audit is a finely tuned analysis of a supplier on both environmental and financial grounds. "What we are looking for," reports Philip Trowbridge, coordinator of the auditing process, "is assurance that the firms are compliant and have the means to deal with any problems that might arise." AMD auditing staff approach the site with a previsit questionnaire filled out by the company containing basic background information. A detailed site inspection form that is specific to the type of facility being audited is used during the visit to record more detailed information on the major environmental program areas. On completion of the visit, the auditors write up the findings, outlining any significant issues. Significant issues are also addressed in a post-visit debriefing with the audited site. The results of the audits are stored and used as a reference in successive visits.

This documentation serves AMD in both practical and risk management perspectives. In addition, the company tries to do more than simply document and store the information revealed through the audit. When troublesome issues are raised, they are addressed through partnership interactions between AMD and the supplier. AMD provides feedback, discusses problems, and tries to provide insight into solutions. The goal of this process is always to resolve any problems in a manner that helps the supplier improve its operations and serve the interests of AMD.

> **"We want to work with our suppliers to assure that they provide the level of service that we require."**
>
> —Philip Trowbridge, AMD

Building strong relationships with suppliers is an obvious and positive result of the auditing process. If an audit finds problems, most suppliers react positively to AMD's efforts to help with their resolution. For its part, AMD will go out of its way to work with suppliers that do not meet current expectations to avoid having to disrupt the supplier relationship. The company cites a particular example in which a transport company with which AMD had a long and positive relationship made a change in their operations. The change resulted in unsatisfactory performance and threatened an interruption of services. Rather than simply removing the supplier from their approved vendor list, AMD worked closely with the firm on both operations and maintenance issues to make vital changes and bring the level of service up to AMD's expectations.

What were the benefits of this partnership? For AMD, "the benefits were somewhat intangible," says Trowbridge. "There is a comfort level that comes from working with a known entity and understanding that they are willing to improve their practices to help minimize our risk." For the supplier, the benefits were more clear. In addition to building a solid relationship with their customer, they improved their operations and were better able to provide high-quality service.

AMD Waste Audit Synopsis

Program Goals:

- Limit environmental risk
- Limit financial risk
- Demonstrate corporate environmental stewardship and prudence in waste management
- Develop a comprehensive, approved primary and secondary vendor list including second- and third-tier facilities, as necessary.

Program Objectives:

- Simple but complete documentation
- Optimized AMD personnel time and cost
- Establish a central record of audit information
- Maintain current contracts with all waste and recycling vendors.

Not all issues between partners end so happily. Faced with a supplier that is unresponsive to AMD's need to receive high-quality, minimal-risk service, the company will remove them from the approved vendor list. The trade-off between maintaining close supplier relationships and practicing sound risk management can be difficult, but generally the two issues are aligned. It is the exceptions that force a decision between the two.

AMD reports a number of changes that have occurred recently regarding the waste audits, each of which represents a shift to a more finely tuned process. The first is that AMD has joined a consortium of companies that chooses suppliers to be assessed, brings in consultants, and performs third-party audits. The advantages of the consortium are numerous. By performing audits as a group, the participating companies take advantage of economies of scale, which results in greater efficiency and cost savings for AMD and the other members. The third party audit provides an external perspective on the auditing process that AMD developed. In addition, the consortium contributes significantly to the financial information that is gathered about each supplier.

Following the third-party audit, AMD visits sites to confirm the work of the consultant and maintain supplier relationships. They have been pleased to find that much of their own process has been affirmed by the external involvement, a reassurance that the auditing process that they developed is relatively complete.

The aspect of the consortium that has been particularly helpful for AMD, however, has been determining the financial status of supplying firms. As noted earlier, the goal of the audit is not only to determine regulatory compliance but also to ensure the supplier's financial stability to deal with any problems that might arise. This is a new area of emphasis for AMD, and the input of the consortium here has been particularly useful. Financial information, including Dun & Bradstreet rating and financial analysis results, are now a standard part of a supplier's audit. This helps AMD achieve both its risk management goals and EHS objectives.

The Second Tier

Although AMD's waste management supplier audit program has been in place for quite a while, they are actively expanding their risk management policy to other types of suppliers. The next category that they are addressing is chemical suppliers, who represent the next greatest potential risk issue. Generally, the premise of the relationship is the same. AMD gathers information that will identify and mitigate risk, strengthen supplier relationships, and meet their EHS directives. The tools for analysis, however, are different. AMD has developed and is currently

implementing a general questionnaire for all suppliers and a second, more targeted questionnaire that is commodity focused—in this case, oriented to chemical suppliers.

> **"Our values commit us to actions that enhance the quality of life and protect the health and safety of our employees and the environment of the communities in which we do business. To achieve this, we need the full cooperation of our suppliers in providing information on current environmental, health and safety management initiatives within your organization."**
>
> —Letter to Suppliers, AMD

Each questionnaire combines a request for a self-assessment of the supplier's EHS policies and programs with questions requiring quantification. The questionnaires are a mixture of specific, multiple-choice questions and other questions requiring written answers and comments. The general questionnaire addresses the suppliers' EHS policies and procedures, reporting, staffing, documentation, and history. The questionnaire is intended for chemical suppliers and targets concerns specific to that type of operation, honing in on such areas as emergency response and preparedness, distribution safety, pollution prevention, process safety, health and safety, and product stewardship. AMD incorporated key elements of the Chemical Manufacturers Association's "Responsible Care tm Initiative" into the commodity-specific questionnaire. "We decided to leverage the chemical industry's own self-assessment criteria to evaluate our chemical suppliers," said Trowbridge.

What makes a good questionnaire? In addition to being thorough, asking the right questions, and giving respondents appropriate choices, ultimately the quality of a questionnaire lies in its use. Rich Weigand, EHS director at AMD, emphasizes that the use of the document is vital. "We really use our surveys," says Weigand, "We don't just file them." When suppliers send surveys back to AMD (often by e-mail), the answers are reviewed and an assessment of the response is compiled. Staff teams identify strengths and weaknesses and communicate with suppliers about potential changes. Suppliers can be ranked numerically according to their answers. AMD's Bangkok facilities use a strict threshold in their ranking system, and suppliers who fail to meet the cutoff are not approved as AMD suppliers. (Their survey incorporates not only EHS concerns, but elements such as quality and reliability.)

This raises the issue of the transferability of surveys between the United States and abroad and particularly to Asia. Operational procedures may be different abroad, but AMD has the long-term goal of strengthening their evaluation of European and Asian suppliers. An initial on-site review at AMD's waste disposal providers in Asia is currently taking place. AMD intends to increase the frequency of these visits and the amount of follow-up with the supplier, despite the different supplier relationships in Asia. These practices may not be consistent with current trends among Asian companies, but AMD feels that the lessons concerning risk management learned in the United States can have positive application abroad.

Environmental, Health, and Safety (EHS)
Performance Assessment
Part I

Date: Supplier Name:
Supplier Address:
City, State, Country:
Prepared/Approved by (Name/Title):
Phone Number: E-mail Address:

Please complete the following questionnaire by highlighting or otherwise marking the most appropriate answer.

1. Is your company or site certified according to EMAS, ISO 14001, or other EHS management system standard?
   a) ☐ No certification and not seeking certification.
   b) ☐ No sites certified, but short-term company plans include certification. (Please specify certification, timeline for completion, and sites pursuing.)
   c) ☐ Some sites are certified. (Please specify certification and date, as well as plans for certifying other sites.)
   d) ☐ All sites certified. (Please specify certification and dates.)

Comments:

2. Do all sites operate under a defined and documented management policy that describes a commitment to sound environment, health, and safety procedures?
   a) ☐ No documented policy incorporating EHS commitment.
   b) ☐ Management policy incorporating EHS commitments under development. (Please provide expected completion date: .)
   c) ☐ Management policy incorporating EHS commitments exists at some sites.
   d) ☐ All sites have management policy incorporating EHS commitments. (Please attach a copy with the returned survey.)

Comments:

3. Are personnel knowledgeable about the EHS management policies and procedures for their business?
   a) ☐ EHS management policies and procedures have not been communicated throughout the company.
   b) ☐ EHS management policies and procedures have been communicated to management and select personnel.
   c) ☐ EHS management policies and procedures have been communicated to all personnel throughout the company.
   d) ☐ EHS management policies and procedures are communicated on an annual basis to all personnel throughout the company.

Comments:

4. Has your company prepared a comprehensive corporate EHS report?
   a) ☐ No corporate EHS report exists.
   b) ☐ A corporate EHS report is being developed. EHS information is available on request.
   c) ☐ A comprehensive corporate EHS report is available. (Please provide a copy.)
   d) ☐ Comprehensive EHS reports are produced on an annual basis. (Please provide a copy of the most current report.)

Comments:

5. Do all manufacturing sites have dedicated, full-time EHS staff?
   a) ☐ No full-time EHS staff at any of the manufacturing sites.
   b) ☐ Staff with other responsibilities, a contractor EHS service, or some combination of the two handle EHS responsibilities.
   c) ☐ Dedicated, full-time EHS staff at some manufacturing sites.
   d) ☐ Dedicated full-time EHS personnel at all manufacturing sites with little or no corporate EHS support.
   e) ☐ Dedicated full-time EHS staff at all manufacturing sites supported by corporate EHS staff.

Comments:

6. Are routine environmental and safety inspections, audits, or assessments conducted at all manufacturing sites?
   a) ☐ No routine environmental and/or safety inspections, audits, or assessments are performed at manufacturing sites.
   b) ☐ Environmental and safety inspections, audits, or assessments are performed at manufacturing sites but with no regular frequency. (Please provide date of last audit/assessment.)
   c) ☐ Environmental and safety inspections, audits, or assessments are performed on a regular frequency (please provide frequency and date of last audit/assessment.)
   d) ☐ EHS audits or assessments are routinely performed with assigned responsibilities for corrective actions and follow-ups to resolution. (Please provide frequency and date of last audit/assessment.)

Comments:

7. Have there been any environmental or safety violations resulting in fines, penalties, compliance orders, or similar actions in the past 3 years?
   a) ☐ Violations resulting in a total amount of $1,000 or more (all sites combined) or one or more compliance orders within the past 3 years. (Please provide additional information.)
   b) ☐ Violations resulting in a total amount of less than $1,000 (all sites combined) or one compliance order within the past 3 years.
   c) ☐ No violations within the past 3 years at any company-owned or -operated site.

Comments:

8. Does the company participate in voluntary industrial, government, or community-based initiatives (Voluntary Protection Program (VPP), Responsible Care, WasteWise, ClimateWise, Green Lights, and others)?
   a) ☐ No participation in voluntary industrial, government, or community-based initiatives.
   b) ☐ Some participation in voluntary industrial, government, or community-based initiatives. (Please list.).
   c) ☐ Participating in numerous voluntary industrial, government, or community-based initiatives. (Please list.)

Comments:

9. Does your company monitor the EHS performance of its suppliers/contractors?
   a) ☐ No performance criteria are placed on suppliers/contractors.
   b) ☐ EHS performance criteria are being developed and documented.
   c) ☐ EHS performance criteria have been developed and selectively implemented.
   d) ☐ Criteria have been effectively implemented and enforced for all suppliers/contractors.

Comments:

10. Are EHS considerations a component of product/service design?
   a) ☐ No EHS considerations are incorporated into product or service design.
   b) ☐ EHS considerations are selectively incorporated into product/service design.
   c) ☐ EHS considerations are consistently incorporated into product/service design.
   d) ☐ Design for EHS concepts are fully integrated into product/service design.

Comments:

11. Has your company adopted and implemented global standards for EHS performance that are applicable to all manufacturing operations worldwide?
   a) ☐ No global EHS performance standards have been developed.
   b) ☐ Informal EHS performance standards have been developed and implemented worldwide.
   c) ☐ Global EHS performance standards have been adopted by the corporation, which is in the process of implementing them.
   d) ☐ Global EHS performance standards have been adopted and implemented.

Comments:

12. On a scale from 1 to 10, with 10 being excellent, how would you rate your company's EHS program?

Comments:

13. Describe here any components of your company's EHS program that were not covered or adequately addressed by the above questions.

Comments:

Part of a Company-wide Effort

The specific programs highlighted above are just part of a company-wide effort that AMD is making to strengthen its supply chain management. Through its World Class Suppliers (WCS) Program, the company strives to build partnerships with participating suppliers that provide high-quality services. AMD has defined expectations of suppliers and formed procurement teams to evaluate and work with suppliers. EHS staff are part of the teams, and EHS criteria form some of the considerations on which suppliers are judged. Not surprisingly, risk is a key component of the teams' assessments. Although the program is most applicable to the procurement of goods, it represents another effort toward supply chain and risk management.

> **WCS teams benchmark suppliers, conduct risk assessments, and recommend potential strategic relationships with suppliers for current and future needs.**
>
> —AMD Information on WCS Program

THE RESULTS

AMD's work with both audits and questionnaires is ongoing, as are the company's efforts to refine its risk management program. Ten years into the waste audit program, AMD notes that the attempt to monitor and work with waste suppliers in the interest of risk management has minimized the number of haulers and sites used. The auditing program has been successful in identifying waste service providers that pose unacceptably high risks to the company and has served the company's interests in strengthening company-supplier relationships. In addition, by approaching the waste audits from a risk management perspective, the EHS department has been able to address both environmental and business concerns effectively.

The chemical supplier questionnaire is an expanding area of emphasis for AMD, and it does not yet have enough results from the program to report on specific successes. Its EHS department hopes, however, that the questionnaire will assist them in influencing the procurement process regarding decisions on chemical suppliers. The questionnaire has the potential to help identify important areas of concern, which, EHS hopes, will lead to higher standards. The second tier of the risk management program has the important benefit of being able to capitalize on the lessons learned from the first tier, which will ideally help speed refinement of the questionnaire.

Ultimately, the success of a risk management program is measured by a lack of problems. If AMD does not face liability issues or claims or interruption of services from its suppliers, the program has succeeded. Viewing success as the absence of certain events could prove frustrating, because most people like to work toward tangible results. AMD reports, however, that positive results do accompany the lack of problems. In the process of preventing mishaps, the company has achieved the peace of mind that comes from working proactively to prevent problems, being reassured that its supplier partnerships are contributing to a stronger and more stable business relationship, and, in the process, meeting the goals of EHS.

COMPANY INFORMATION

AMD supplies integrated circuits for the global, personal, and networked computer and communications markets. Founded in 1969, AMD reported revenues of $2.4 billion in 1997 and employs approximately 13,000 people worldwide. AMD has manufacturing facilities in the United States and Asia, and soon in Europe. Asian facilities include test and assembly facilities in Penang, Malaysia, Bangkok, Thailand, Singapore, and Suzhou, China.

CONTACT INFORMATION

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Design for Remanufacturing

Xerox Corporation

THE CHALLENGE

Build Environmental Conditions into Product Design

Other themes in this case study:

- Prequalification of suppliers
- Cooperate with suppliers to deal with Intel Corporation end-of-pipe environmental issues
- Inform suppliers of corporate environmental concerns

For similar case studies, see:
Quantum Corporation

"Dig inside the Xerox Corporation's newest stand-alone digital copier, and the nuts and bolts of a big shift in manufacturing swing into view," began a recent *New York Times* article.[4] The article was about the shift to remanufacturing and featured Xerox's efforts to address this emerging trend. The "big shift" has been prompted by a number of issues.

The role of business is moving steadily toward product stewardship and extended product responsibility. In the future, companies will no longer be able to simply sell a product and wipe their hands of it, heedless of the disposal burden at the end of the product's life. In the past few years, Xerox has recognized both regulatory and market forces driving this trend. With a history of leasing products, the company has been dealing with the issue of end-of-life reuse, recycling, and disposal for quite a while. Developing take-back legislation in Europe illustrates that governments are increasingly requiring companies to accept responsibility for products at the end of their life. Xerox's customers themselves have requested that the company take responsibility for managing its waste streams. This vocal expression of concern from customers has added a powerful market dimension to the equation.

In the early 1990s, these factors led Xerox to look anew at its design and production processes. The company realized that if it were to be accountable for a product at the end of its life, it needed to design products to minimize end-of-life burdens. Xerox, however, has gone a critical step further and decided that it makes business and environmental sense to design products to maximize their end-of-life asset potential. Although "design for environment" often means including fewer hazardous substances and more recycled and recyclable materials, "design for remanufacturing" means creating parts and products that can be reused, not just recycled.

The changes that Xerox is undergoing represent a fundamental shift in how products are conceived, designed, and produced. Xerox has needed to rethink old ways of doing business, including dealing with suppliers. Design for remanufacturing demands that companies work with suppliers to make "smarter" parts and products. It is a complicated and difficult process, but it has also proved rewarding.

[4] "Second Time Around and Around" in Business Day Section, *New York Times*, July 14, 1998.

Xerox and Remanufacturing

The push for remanufacturing at Xerox is part of an ambitious set of worldwide company goals:

- *Waste-free factories/waste-free manufacturing.*

"Waste-free factory" status is achieved with 90 percent reductions in emissions, hazardous waste, and solid waste to landfill (using 1990 as a baseline) along with 25 percent use of recycled content in parts and packaging and a demonstration of efficient energy use. By using specific goals, plant managers can incorporate these metrics into their normal business processes and track their progress.

- *Waste-free products.*

This effort encompasses product design goals for minimal material usage and maximum "remanufacturability," energy efficiency, reduction in emissions, and efficient use of paper through duplex capability, and other paper-saving features.

- *Waste-free offices.*

The intention of this program is to enable customers to meet their waste-free office goals. For example, Xerox products, consumables, and packaging are designed for durability and reuse to minimize customers' waste issues. Xerox copy/print cartridges and toner containers are shipped to customers with prepaid return labels. Customers ship used cartridges back to Xerox, reusing the packaging from new cartridges. The returned cartridges are then remanufactured to the same quality standards as new ones.

THE SOLUTION

Having set up a fairly extensive set of requirements for suppliers, Xerox's EHS department has found that communication between the company and the supplier is a natural result. Often, communication is initiated by the supplier, which may not fully understand the requirements or compliance measures. One of the most rewarding results of this discourse is that some of Xerox's suppliers are now using its SCEM tools with their own suppliers, extending the reach of the SCEM effort to tier II suppliers and beyond.

The Lakes Family of Machines

Although design for remanufacturing is being incorporated by Xerox product design teams worldwide, it is being most intensively applied in a family of products dubbed the Lakes machines. Because environmental concerns and remanufacturing priorities have defined this product group from its inception, it provides the best example of how the company is addressing these issues.

The Lakes family of products is the test program for reaching company goals to minimize waste associated with office equipment products. At the heart of the Lakes product family is a "zero to landfill" goal, which means that the product is designed to be completely remanufactured, reused, or recycled at the end of its life. This is an ambitious goal. The first product from the Lakes line to be released was the Document Centre 265 DC, a mid-volume digital copier.

Designing machines that can be easily and effectively remanufactured entails a number of changes from traditional design and even from DFE. Some of these are:

- *Process and product changes.* The Lakes team needed new processes to handle the requirements of remanufacturing, in addition to new products. For example, a comprehensive parts data base was needed and created to track materials.

- *Design for disassembly.* For remanufacturing to be convenient and cost-effective, products needed to be disassembled easily.

- *Fewer parts.* It is important that products to be remanufactured include fewer parts to facilitate easy disassembly.

- *New part specifications.* Parts that are designed to be easily reused without a loss in quality or performance are at the heart of the remanufacturing issue.

- *New tools.* Remanufacturing requires new tools for product testing and tracking that ensures product quality and performance equivalent to that of newly manufactured equipment.

Together, these elements represent a new design paradigm. Suppliers had to be involved for this effort to be successful. "Such an ambitious project," says Anne Stocum, manager of environmental market leadership at Xerox, "required intense partnership with suppliers." Xerox, therefore, involved suppliers in the project early in the process. Ed de Jong, principal environmental systems engineer, explains the process: "We brought in all of our external suppliers early on and explained our philosophy to them. We wanted them to understand the project and to support it. And we needed their help." The suppliers for the Lakes machines were brought to the program site for a supplier symposium, at which the environmental vision behind the products was explained. Lakes staff discussed remanufacturing and the company's waste-free goals.

This event gave suppliers early exposure to new ideas and gave them the opportunity to decide whether or not to be part of the project. Those that "bought into" the concept accepted responsibility for actively participating in the design process for their parts or assemblies and for providing waste-free solutions for their products. Furthermore, most of the suppliers involved in the project accepted responsibility for remanufacturing their parts or for recycling any material determined to exist at the end of its life.

SCEM at Xerox

Design for remanufacturing goals are incorporated into Xerox's more general program to "green the supply chain." This program is defined in their Global Purchasing Supplier EHS Requirements (EHS 1001). Five specific requirements are:

1) Suppliers agree to comply with all applicable governmental EHS regulations.

2) Suppliers agree to provide Xerox with chemicals, supplies, parts, assemblies, and end items that have not been processed or manufactured using ozone-depleting substances (ODSs) and/or do not contain any ODSs.

3) Suppliers agree to provide packaging and packaging components, such as inks, dyes, pigments, adhesives, and stabilizers, that do not contain toxic heavy metals, including cadmium, lead, mercury, or hexavalent chromium.

4) Suppliers agree to work with Xerox to achieve the environmental leadership–driven goals for product design (where applicable), as the company specifies in EHS 1001. These specifications include prohibited/restricted materials, packaging material guidelines, recycled content and recyclability requirements, and hazardous materials minimization guidelines.

5) Suppliers are to mark all plastic parts, assemblies, and end items provided to Xerox with the resin content identification as specified by Xerox.

Other materials accompany these requirements, including a list of ODSs, product design environmental requirements, and a list of methods and requirements for part-marking identification.

Remanufacturing has, therefore, meant a considerable shift in focus for most of the projects' suppliers. Their business with Xerox is gradually involving fewer and fewer "new-build" orders and more and more remanufacturing. The Lakes team believes that most suppliers are satisfied with this change. Although they needed to adapt their operations, they are guaranteed ongoing business, as Xerox customers return the Lakes machines for remanufacturing.

Xerox established multifunction teams to see the Lakes project through various stages of development. These teams have worked closely with suppliers along the way, setting goals, involving suppliers in design and decision processes, and supporting suppliers after products reached the point of manufacture and remanufacture. Part of the design for remanufacturing process has been to add new components to part specification drawings. It is now standard for the drawings to include remanufacturing and disposition codes. These ensure that it is clear whether each part is to be reused, remanufactured, or replaced and how it is to be recycled at the end of its life. To facilitate the remanufacturing and recycling processes, suppliers are required to mark products clearly with this information. (See "SCEM at Xerox" box above.)

Quality issues

The Lakes team wanted to ensure that the remanufacturing process would deliver a high-quality product indistinguishable from a completely new product. To achieve high-quality standards, all previously used parts are cleaned, requalified, and tested to meet the same standards as newly built parts. The Lakes machines are all manufactured on one line, so machines with previously used components are equivalent in process, appearance, and service from those containing exclusively newly built parts. The final barometer of quality is the guarantee; remanufactured products have the same "total satisfaction guarantee" as other Xerox products.

Economic issues

Several economic issues are related to remanufacturing. The most obvious is that the remanufacturing process provides enormous savings in materials. Used products shift from being a disposal liability to an asset. Remanufactured parts recover both the cost of their raw materials and also much of the added value that the original manufacturing process contributes. (This contrasts with using recycled material, which recoups the cost of materials but not the added value of the original manufacturing process.) Originally, it may be more expensive to make parts that will be remanufacturable. Extra costs are quickly recovered, however, with two or three uses. In dollar terms, the costs of remanufacturing a part are substantially lower than manufacturing from raw materials. In environmental terms, of course, the impacts of remanufacturing are negligible in comparison with manufacturing from raw materials. The cost of DFE and design for remanufacturing is the final economic consideration. DFE is often perceived as costly. The designers on the Lakes team are trying to spread the message that this is not the case; they have found that DFE is no more expensive than regular design.

Extension to the Rest of the Company

The Lakes project was intended as a pilot program, and its lessons are being distributed to the rest of the company for application. The approach of the Lakes group represents a fundamental culture change, one that may be difficult to convince others to adopt. Yet the Lakes group has achieved significant success in meeting environmental and financial goals and has a strong track record for comparison purposes (see below). In addition to the environmental benefits, the Lakes team is convinced that they can prove to others that this new way of doing business is economically beneficial.

THE RESULTS

Remanufacturing has taken a firm hold at Xerox, extending from equipment and component parts to the consumable supplies used in the machines. At this point, 90 percent of Xerox-designed equipment is designed to be remanufactured. Within the Lakes Document Centre 265 DC copier, 97 percent of the component parts were designed to be recyclable and 84 percent to be remanufacturable. In 1997 machine remanufacturing and parts reuse prevented 30,000 tons of waste from going to landfills. The company offers a wide array of consumables return programs, partnering with customers to return cartridges, toner containers, and even waste toner to Xerox for reuse or recycling. The company provides take-back services to customers on demand; recent figures indicate that Xerox's cartridge return program for mid- and high- volume machines has enabled 65 percent of eligible cartridges to be returned to Xerox for remanufacturing.

Several gauges of success for the program exist. Costs and financial benefits, as always, are a keen consideration. "The major metric of success," notes Anne Stocum, "is financial savings." The program has succeeded in this category. The Asset Recycle Manufacture Organization, which was the Xerox group initially responsible for implementing recycling and remanufacturing goals, recorded savings of more than $50 million in its first year of operation. Remanufacturing programs continue to yield financial savings by avoiding raw material purchases and landfill costs. In fact, several hundred million dollars are saved each year. DFE, meanwhile, is proving no more expensive than other design processes. "The data from the Lakes program is being used to convince new product engineers that designing for the environment is not a cost. It may take more teamwork and knowledge, but Lakes has demonstrated that the best design for the environment is also the most cost-effective overall," reports Tim Sallade, manager of environmental design and compliance at Xerox.

Progress toward environmental goals is, naturally, another major metric of success. Remanufacturing is certainly helping the company move toward its goals of producing waste-free products in waste-free factories. The Lakes program goal of "zero to landfill" has not yet been met, but the team is making improvements, and they believe that they are close. Internally, they are satisfied that they have the process capability to meet the goal. Suppliers will be key in ensuring that the gap between goal and reality is reduced.

Xerox hopes that the emphasis on remanufacturing and high environmental standards will increase market share and customer loyalty. The Document Centre 265 DC is certified to several international environmental labels, including the German Blue Angel, which has strict requirements for product design for remanufacturing, energy efficiency, and emissions. Xerox officials are confident that remanufactured products have gained market acceptance. In terms of achieving customer loyalty, the company realizes that helping customers achieve waste-free offices is an attractive aspect of their program. The company policy of taking back everything that goes into an office—from equipment to packaging—helps customers achieve environmental goals and reduce landfill costs, and generates customer satisfaction.

An additional benefit of the company's environmental programs has been the assurance that they will not encounter international trade barriers or shipping prohibitions as a result of environmental regulations. Part of the DFE program in its early stages was to compile the world's strictest environmental regulations and make sure that Xerox products would not face limited market access due to regulations. The DFE process has also ensured that used parts being transported for remanufacturing and recycling will not face shipping obstacles because of hazardous waste

content. In an era of changing definitions of material toxicity and increasingly stringent regulations worldwide, Xerox has designed products that will not cause EHS-related problems.

> **"The more we close the loop in the product delivery process, the more we discover both the environmental and business benefits of doing so. By remanufacturing and designing for the environment, we reduce our costs, minimize the effect we have on the planet, and please our customers. We are convinced that being good to the environment is also good for business—and have every intention of keeping it that way."**
>
> —1997 Xerox EHS Progress Report

The shift to remanufacturing has resulted in benefits for suppliers as well. The savings from reduced landfill costs that benefit Xerox also benefit its suppliers, and suppliers benefit from reduced risk potential from hazardous wastes as well. As discussed above, suppliers are guaranteed ongoing business from the process of remanufacturing their parts. In addition, cooperating in the design process and participating in a new approach to manufacturing exposes Xerox's suppliers to new techniques and technology. As more companies adopt remanufacturing programs, these suppliers will have a competitive advantage in a market seeking a new approach to design and manufacturing.

The same "ahead of the game" argument applies to Xerox. Company staff firmly believe that remanufacturing is the way of the future—not for glamorous reasons, but for basic, practical ones. "It is happening. It has to happen," says Ed de Jong: "Companies simply can't afford to buy new materials all the time."

Although the relationship between Xerox and its suppliers is emphasized here, the story deserves some attention in a different light. The remanufacturing program and many of Xerox's environmental initiatives have been spurred and encouraged by its customers. Customer demand for extended product responsibility and waste management, in fact, was one of the motivating factors that brought about the remanufacturing focus. Kinko's, one of Xerox's large customers, has been vocal in asking Xerox for waste management assistance and in participating in working toward solutions. As a result of its efforts as a green supplier, Xerox received the "Best of Kinko's Vendors for Environmental Awareness" award in 1997. This serves as a reminder that product stewardship approaches are increasingly affecting the extended supply chain.

COMPANY INFORMATION

Founded in 1906 as The Haloid Company, the company was named Xerox Corporation in 1961. The company produces document-processing products, systems, and services. In 1998 revenues were $19.4 billion and the company employed 92,700 people worldwide.

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Design for Environment, Health, and Safety

Intel Corporation

THE CHALLENGE

In 1994 Intel's health and safety performance was on a par with its industry-average levels. It faced approximately three recordable injury cases per one hundred employees and more than five recordable injury cases per one hundred construction contractors annually. These were both, however, levels that the company sought to lower. In the same year, approximately one lost-day injury case occurred per hundred employees—a total of more than 5,000 days away from work due to injury or illness worldwide. This figure indicated not only harm and risk to employees but also a loss in productivity for the company. This situation spurred Intel's development of a system of "design for environment, health, and safety" (DFEHS).

Build Environmental Conditions into Product Design

Other themes in this case study:

- Prequalification of suppliers
- Promote exchange of information and ideas
- Lobby to change laws

For similar case studies, see:
Quantum Corporation
Xerox Corporation

The concept of "design for environment" (DFE) is fairly well established, if relatively new. Intel has had marked success in integrating environmental performance criteria into their design processes. By combining both DFE and EHS enhancements at the design phase, Intel has shown that it can further improve its corporate safety record considerably.

THE SOLUTION

Intel has implemented a number of programs and policies, beginning with the design stage, to improve health and safety performance. Each of these is based on the company's commitment to employee and workplace safety and is addressed in the corporate EHS policy (see box).

> **"We seek a healthful and safe workplace, free of occupational injury and illness. We emphasize individual responsibility for safety by all employees and at all levels of management. We expect employees to report potential safety hazards and issues and be involved in implementing solutions. We will not conduct any operations or market a product without adequate safeguards."**
>
> —Excerpt from Intel's EHS Policy

The company's policy emphasizes both corporate dedication to safety concerns and their expectation that this is an employee responsibility. From the start, the broad goals of a

"healthful and safe workplace" and refraining from "conducting or marketing a product without adequate safeguards" required specific programs. Most important, the company emphasized that safety programs should be incorporated from the design phase forward. The four elements of the DFEHS program that are illustrated in this case study are:

- The concept of DFEHS
- The Supplier Safety Prequalification Program
- Contractual safety guidelines: SEMI
- Materials Supplier Day

The Concept of Design for Environment, Health, and Safety

For Intel, DFEHS is a tool to facilitate an injury- and incident-free manufacturing environment. DFEHS is an outgrowth of the emerging trend in production processes of DFE. It represents a common-sense approach to avoiding costly mistakes in the design process. EHS-related retrofits can be avoided by incorporating end-user requirements in the design phase. Indeed, the goal of the program is to need no such retrofits at all after equipment arrives at Intel. By addressing all aspects of EHS compliance during the design phase, potential problems are avoided. This represents a comprehensive design strategy originating in the design concept phase and continuing throughout each subsequent phase. Intel notes that a key to success is that the process is a closed loop. Lessons learned from previous tool generations and facility designs are incorporated into new designs, and new EHS requirements can be introduced.

The benefits of the DFEHS model are that it:

- Promotes an incident- and injury-free manufacturing environment
- Drives toward full regulatory compliance
- Reduces product liability exposure
- Reduces time to market for new equipment models
- Lowers cost of tool development
- Reinforces the convergence of health, safety, and environmental considerations.

Keys for successful implementation of the model include the following:

- Management accepts accountability for program success.
- A single point of contact is responsible for implementation across all divisions, product lines, and so on. This individual is thoroughly linked to management and organization responsible for engineering, quality assurance, reliability, among others.
- Equipment and facility design engineers are held accountable for application of DFEHS.
- The DFEHS model is applied throughout the life cycle of the company's products, projects, and programs.
- The DFEHS process documents knowledge gained during all projects, product life cycles, and so on.

Intel has developed a careful analysis of the tasks that are required at each phase to ensure that vital steps are not overlooked. The success of the model, however, obviously depends on carefully integrated processes, that is, prequalification of suppliers and then contract specifications and strong lines of communication among people involved at all phases of design and use. Programs such as the supplier safety prequalification program provide the assurances Intel needs. After that, strong relationships must be built between equipment suppliers and Intel staff to

ensure that the full potential of the model is realized. Communication and outreach tools, such as the Materials Supplier Day, help Intel to form the supplier relationships needed to make the DFEHS strategy a success. Intel also uses tools developed by industry consortia, such as the Semiconductor Equipment and Materials International (SEMI) guidelines for Safety (S2-93) and Ergonomics/Human Factors Engineering (S8-95). SEMI's Guidelines are a set of minimum expectations that every manufacturing tool must meet before it comes into operation. Intel applies a similar risk-based approach to evaluating any new chemical or facility design before being implemented. The integration of these programs allows Intel to deal with safety issues at the beginning of the product design process.

The Supplier Safety Prequalification Program

In 1998 Intel noted that its existing policies designed to ensure contractor safety on Intel sites were successful at achieving reductions in injury levels, but inefficient. The policy had required supplier personnel to attend Intel EHS training courses prior to beginning work. This approach often duplicated the suppliers' own training procedures. Supplier personnel sometimes had to sit through redundant training programs, some for up to thirty hours. This duplication did little to advance Intel's safety goals—and was costly in time and energy. Clearly, refocusing was indicated.

That refinement came with the company's announcement of the Supplier Safety Prequalification Program early in 1999. Intel wanted to ensure that supplier personnel received safety training before beginning work, but through a new program. This program would not only be more efficient but also drive improved standards of performance within supplier companies. The new program requires that contractors be prequalified before they can start work. The prequalification process requires contractors to confirm that their personnel working on site have received the necessary safety training before they begin work. In most cases, this means that Intel does not directly administer safety training but does ensure that adequate training has been received. A supplier who has not completed the prequalification process will not receive approved status.

> **In the construction field, at any given time, we have several thousand people building something somewhere. Contractor safety has always been a real focus for us. In Malaysia, the Governor of Malaysia asked for and we provided a copy of our video on contractor safety. It really has been very well received.**
>
> —Larry Borgman, corporate director, worldwide EHS, Intel.

The program's execution involves a number of steps. After a supplier is selected, if it has not previously completed the company's prequalification package, it receives the package from the procurement department. This package includes a core booklet, a prequalification booklet, and an Intel safety video. After reviewing the list of required safety training and completing the questionnaire, the supplier returns the materials to Intel, where the package reviewed by the corporate EHS department. If all necessary training has been administered and no other problems are raised by the responses, the supplier receives approved status. If any lingering issues are raised by the prequalification package, Intel EHS staff work with the supplier to identify remaining needs and develop a closure plan. When all remaining issues are resolved, the supplier receives approved status.

As a result of the prequalification program, all suppliers complete safety training prior to receiving their site badge with a minimum of repetitive training and inefficiency. Intel continues to provide training that is specific to its sites or the company's requirements. The benefits of the

program are obvious: safety goals are met with a minimum of unnecessary costs. Suppliers benefit as well: they spend less time in training without any loss in training quality, and the improvements to their training systems are proliferated throughout their projects—whether they are working at Intel or not. Improved safety performance may also benefit the supplier through a reduction in accident and insurance costs.

Contractual Safety Guidelines: SEMI

Intel is part of the Sematech consortium of semiconductor manufacturers, which have together generated a series of "Safety Guidelines for Semiconductor Manufacturing Equipment." The member companies made the guidelines contractual requirements for any manufacturing equipment that they purchase. By offering industry consensus on the subject to suppliers, the member companies gave equipment manufacturers clear direction in the field of environmental and safety features, providing suppliers a clear idea of concerns to incorporate into the design process. The requirement of safety and environmental standards in manufacturing equipment is closely related to the DFEHS strategy. In both cases, the company is taking a proactive approach toward environmental and safety features in its manufacturing equipment.

Intel in Asia

Intel's emphasis on safety extends to Asian facilities. In China, in 1998, the factory site formally launched its first Safety Week. Numerous EHS topics were promoted, and the site published an EHS handbook for employees in both Chinese and English. The site also implemented mandatory use of safety glasses in all manufacturing areas, and contractor employees received training in planning for preventing new site incidents, as well as training in incident and injury investigation as well as first aid and CPR.

Sematech Member Companies

- Advanced Micro Devices
- Compaq
- Conexant
- Hewlett Packard
- IBM
- Intel
- Lucent Technologies
- Motorola
- Philips
- Texas Instruments

Materials Supplier Day

One outreach tool to suppliers that Intel developed is a Materials Supplier Day, a meeting with major suppliers hosted annually either in Asia or the United States. EHS is integrated into this day-long conference, which is intended to address a variety of supply chain issues. Larry Borgman, corporate director of worldwide EHS at Intel, reports: "We invite all our major suppliers. A major component of the supplier day event is to address environmental issues. We have display areas and presentations. This year, we focused on designing for environment, health, and safety. It's a good way to get suppliers to be part of our team. We provided them with a CD-ROM telling them what part we wanted them to play. It was very well attended, and the suppliers took a lot from the event."

THE RESULTS

Intel's focus on health and safety has achieved significant improvements in safety and costs. The U.S. Occupational Safety and Health Administration's (OSHA's) recordable injury rate for construction contractors averaged a reduction of more than 29 percent each of the last four years, dropping from more than five to just more than one recordable injury per hundred workers each year. These data do not incorporate results from the prequalification component of the DFEHS program, but Intel hopes that injury rates will continue to fall under the new program.

Influence Legislation to Facilitate Better SCEM Policies

SEEKING TO DISPOSE SAFELY OF HAZARDOUS WASTE IN THE DEVELOPING WORLD: Intel Lobbies the United States to Adopt the Basel Conventionv

In the United States, Intel Corporation seeks to use waste suppliers who recycle or reuse a high portion of the incoming waste stream. Noting that only a limited number of American firms provide the waste services that the company requires, Intel has made a point of doing business with those service providers that are able to offer a higher level of recycling. Some of its American waste service providers have proprietary processes that enable markedly higher levels of reuse and recycling, a point that has become a source of pride for the company.

Intel, however, does business in a number of countries with less advanced waste disposal systems. These include Costa Rica, Philippines, Malaysia, and China. In these regions, the company has found it difficult to locate appropriate waste disposal facilities. Some of the wastes in question are hazardous, making disposal a particularly troublesome issue. Although facilities for disposal of some of the low-level hazardous wastes exist in some of the countries, these are limited. For example, no appropriate recycling or disposal facilities for metal-bearing sludge exist in any of the developing country regions in which Intel operates. This situation forced a difficult set of choices: Intel could have considered any of the following options:

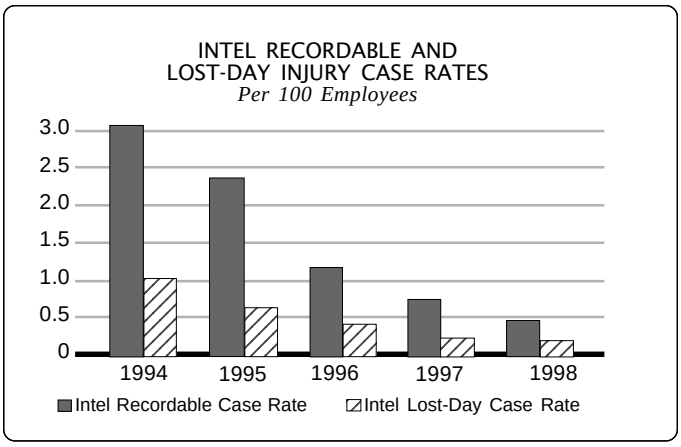
- Dispose of the wastes within the countries of operation in a manner that is legal but that might not be environmentally sound.
- Store the wastes on site in the long term in the hope that the situation will change in the future.
- Arrange for the export of wastes to facilities equipped to handle them.

None of the options seemed ideal, but the first to be discarded was the first—disposal in a manner that is not consistent with the highest environmental practices available elsewhere. Having quickly eliminated that possibility for ethical and prudent reasons, the company faced a choice between storage and export for treatment. Because of Intel's emphasis on recycling and sound treatment and disposal, the company chose to store the hazardous waste temporarily until it could be exported, appropriately treated, and disposed of, as necessary. This, however, was not simple.

To date, Intel has only been able to find waste treatment providers and facilities that meet the company's standards in the United States. Importing hazardous waste into the United States, however, is legally difficult. The United States is not a signatory to the Basel Convention, the international agreement ensuring that hazardous waste crossing international borders is handled in an environmentally sound manner. Consequently, importing waste to the United States from countries that have signed the agreement requires drafting and adopting a bilateral agreement between the United States (importing the waste) and the country exporting it. This is a long and difficult political process. Intel has facilitated the negotiation of bilateral agreements between the United States and Costa Rica and the United States and Malaysia to advance its goal of sound waste management in keeping with the company's high waste treatment and disposal standards. As a result of these bilateral agreements, Intel is able to use the same waste service suppliers for some international waste as for domestically generated waste. This means that the company's emphasis on environmentally sound management of waste is maintained.

The time and expense involved with negotiating bilateral agreements and the shipment of wastes for long distances, however, is burdensome for Intel. The company faces unresolved waste situations particularly in China and the Philippines, as well as elsewhere. To aid in these situations and as a result of its experiences, Intel has actively petitioned the U.S. government to become a party to the Basel Convention. Until that happens, however, the company will continue to struggle with the challenge of how to use waste suppliers that meet its high standards for reuse, recycling, and environmentally sound disposal.

Companywide, the number of employee days away from work due to injury or illness worldwide has fallen from more than 5,000 in 1994 to just more than 1,000 in 1998, despite a doubling of total employee numbers. Global recordable and lost-day injury case rates declined steadily and dramatically from 1994 to 1998. Intel's global recordable injury case rate dropped from an average of three per 100 employees in 1994 to just under one per employee in 1998 (see chart). These figures bring Intel in line with world-class safety performance, as defined by the lowest safety figures in any industry, and give Intel dramatically better safety figures than the industry average among major semiconductor manufacturers. The company estimates that its safety program will save the company $3.5 million in the next two years, adding financial savings to the laudable goals of the safety program.



"By looking at environmental, health, and safety performance in its largest context, you can remove barriers to successful implementation. When we say 'one EHS,' we mean it. Our environmental programs have benefited from the robust systems we have in place to manage health and safety, and our health and safety programs have benefited from the design focus of our environmental systems. Our success is built on the integration of EHS into everything we do, from process and facility design to community and shareholder relationships."

—Dave Stangis, EHS regulatory issues manager

Intel is also involved in another initiative to influence legislation aimed at improving safe disposal of hazardous waste in developing countries, as described in the box on the previous page.

COMPANY INFORMATION

Founded in 1968, Intel manufactures computer chips, boards, systems, and software. In 1998 the company ranked 125th of the Fortune Global 500. Intel has approximately 65,000 employees in more than forty nations worldwide and, in 1998, revenues of $26.3 billion. Operations are based in Santa Clara, California, USA, with other major sites in the United States, United Kingdom, Central America, Malaysia, Philippines, China, Israel, and Japan.

CONTACT INFORMATION

The company's web site is http://www.intel.com. More information on the material included in this case study can be found at http://supplier.intel.com and http://www.intel.com/intel/other/ehs.

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Developing a Data Base of Environmentally Restricted Substances at the Design Stage

Quantum Corporation

THE CHALLENGE

For many electronics manufacturers, environmentally restricted substance (ERS) management is at the top of the list of environmental design objectives because of significant regulatory and marketing concerns. ERS requirements can be split into two basic categories: requirements applicable to product marketing and requirements related to disposition. This case study discusses the Environmental Product Design (EPD) Database, a software tool created to facilitate the collection, management, and application of product environmental data from suppliers and product engineers.

Build Environmental Conditions into Product Design

Other themes in this case study:
- Work with industry peers to standardize requirements
- Promote exchange of information and ideas

For more case studies on DEF, see:
Quantum Corporation
Xerox Corporation
Intel Corporation

Requirements Applicable to Product Marketing

Numerous international laws and regulations govern how restricted substances can be used in products. One example of such a requirement is the German Prohibition of Chemicals Ordinance,[5] which bans the sale of products in Germany if the ordinance's limitations are not observed. The ordinance restriction on dioxins and furans has impacted electronics manufacturers worldwide, threatening lost market access that speaks directly to each company's bottom line. Certain halogenated organic substances used as flame retardants in plastic resins such as integrated circuit molding compounds (which may contain trace amounts of dioxins and furans or may release these compounds when incinerated) have been targeted by the German ordinance as well as become the target of regulations and studies in several other European countries.[6] This has resulted in a curtailing of the use of these materials, as international customers and suppliers modify product designs to meet and exceed statutory requirements.

Manufacturers wishing to use "environmental labeling" as a positive differentiator for Their products are also subject to substance restrictions. One example is the German "Blue Angel"

[5] German Federal Ministry. "Ordinance on Bans and Restrictions on the Placing on the Market of Dangerous Substances, Preparations, and Products Pursuant to the Chemicals Act."

[6] Swedish National Chemicals Inspectorate. The Flame Retardants Project, Final Report. KEMI Report No. 5/96.

label for computers and printers, which includes concentration restrictions on substances such as heavy metals, flame retardants, and connector compounds.[7] The high level of market recognition associated with this label among German consumers makes it very desirable for global manufacturers.

These examples illustrate practical differences in how international substance restrictions work. While the German restriction prescribes specific limitations on how certain substances may be used, the labeling scheme is different in each case, since labeling requirements are "voluntary" and ordinance restrictions are not (although labeling is becoming expected as a condition of doing business in certain markets). Regardless of these differences, each type of restriction must be considered early in sourcing discussions with suppliers, so as to minimize potential increases in cost and time to market that could result from last-minute changes.

Requirements Applicable to Product Disposition

Both state and federal hazardous waste regulations in the United States restrict disposal of waste electronic equipment if the equipment exhibits a hazardous characteristic such as toxicity (determined by leachate testing).[8] U.S.-based manufacturers, which have been subject to state and federal hazardous waste regulations for many years, have significant experience in complying with these requirements but less experience in designing products to minimize regulated substance content and avoid hazardous waste generation altogether. The design challenge is increased when products are sold internationally and will be subject to the disposal restrictions of the jurisdiction in which they reach their end of life.

Once applicable disposal requirements are identified and understood, designing products so that they will not be characterized as hazardous wastes at the end of their life is still challenging. For example, the leachate tests used in U.S. hazardous waste classification do not directly correlate to concentration or weight of a restricted substance in the component. Consider the difference between a component with a lead coating and one that is an alloy of lead and another metal. The coated part is more likely to be classified as hazardous waste because it has more surface area in contact with the weak acid solution used in the leachate test, and the lead alloy is likely to be more chemically stable and resistant to leaching.

Mandatory product take-back schemes, such as those that will be enacted by European Union (EU) member states in compliance with the forthcoming EU Waste Electronics Directive (WEEE Directive), are expected to have a significant impact on how the electronics industry manages restricted material use in products. The WEEE Directive, currently in draft form, will require manufacturers to take back products from end users at the end of the product's useful life and manage the product in an environmentally responsible manner. Furthermore, the directive is expected to require the phaseout of materials, such as lead and mercury, from electronic products. This directive is expected to have a significant bottom-line impact and will require close cooperation between manufacturers and suppliers to meet both take-back and substance phaseout requirements. Product take-back legislation is already effective in several EU member states concerned with increasing volumes of information technology and electronic equipment going to landfills.

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[7] German Institute for Quality Assurance and Labeling. 1994. German "Blue Angel" Environmentally Friendly Designed Workplace Computer. RAL-UZ78, St. Augustin, Germany.

[8] United States Environmental Protection Agency: Title 40 CFR Part 261, Resource Conservation and Recovery Act.

These requirements and associated industry-based product stewardship efforts are shifting the focus of product disposition from proper disposal to designing products so they will be easily recyclable. Improper restricted substance use can hinder recyclability.

THE SOLUTION

Solutions involve development of a product environmental data base and a systematic approach to managing restricted substances.

Data Base Development

Quantum Corporation, Texas Instruments, and Lucent Technologies have joined, in association with Environmental and Occupational Risk Management (EORM), to create the Environmental Product Design Database (EPD Database™) to manage product environmental data and associated international regulations.[9] The goal of the EPD Database was to satisfy the need for "one-stop shopping" for regulatory data and storage of component ERS content information. The data base is designed to replace paper-based systems for managing component-level data collected from engineering departments and suppliers.

Collecting component-level product information in a single database allows users, such as product designers, to identify potential regulatory restrictions on substances contained in a product. Awareness of potential substance use or disposal restrictions is important in predicting regulatory compliance and/or market access that can be achieved by a given product.

Microsoft Access™ was selected as the relational data base platform of choice for this application to allow rapid and low cost development. This platform is also flexible enough to accept data in a number of different data formats. Approximately forty representatives from the intended user community at Texas Instruments and Quantum were recruited to participate in the beta test, including procurement, engineering, account management, quality, and information systems.

Systematic Approach to Restricted Substance Management

Quantum Corporation and other companies are successfully implementing the restricted material management system approach represented in the figure below. Note that this process is integrated with and runs concurrently during each product development cycle. The EPD Database is a key component of the overall management system.

Step One: Determine Substances of Concern

The first step is to generate a combined restricted material list for the product or proposed product with input from stakeholders, including product engineering and marketing representatives. The goal of this step should be to make the restricted material list as short as possible while meeting all applicable restricted material requirements. The following substeps can be employed to achieve this goal:

9 Chambers, G.C.; VanLandingham, R.D.; Cox, D.G. 1997. "Partnering to Create a Standardized Environmental Management Tool: The Environmental Product Design (EPD) Database." Proceedings of IEEE International Symposium on Electronics and the Environment. San Francisco, 1997, The Institute of Electrical and Electronics Engineers, Inc.

- Determine the target markets for the product. This knowledge will help the environmental engineer select only those requirements expected to apply to the product. For example, if the product is targeted for sale only in the United States, it may not be appropriate to design the product with a non-U.S. ecolabel in mind. It is prudent to adopt a conservative approach in requirement selection to prevent potential market-access limitations.

- Create a combined list from the applicable requirements.

- Review the list and eliminate substances that, based on product knowledge, are known not to be contained in product subcomponents. For example, substances such as asbestos may be eliminated from the lists of many electronics manufacturers.

Limiting the length of the list to only those requirements that apply to a product and substances that may reasonably be expected to be contained in a product is important. For a typical electronic product, the list may be reviewed by several teams of engineers and hundreds of suppliers, each of whom must certify compliance with the requirements (see step two). Although the first step may appear to be relatively straightforward, obtaining and reviewing all applicable international requirements can be a daunting task.

Step Two: Obtain Supplier Component Certifications

Once the restricted material list is created, suppliers of product subcomponents are queried to identify which if any of the listed substances are proposed for use. To encourage a timely and accurate response, the query should be administered by the procurement group and tied to the component qualification process. In other words, qualification is contingent on supplier data submittal. This also achieves integration of restricted material data collection with existing processes to minimize potential impact to product development.

The presence of a restricted material in a product component does not in itself dictate component unsuitability. Because the applicability of substance restrictions cannot always be determined with a "yes or no" analysis, an individual familiar with the regulations and restricted material uses previously approved by the company should be involved in this process. To facilitate review of supplier data and retain institutional knowledge, a data base of approved restricted material uses should be created and maintained.

Step Three: Perform Risk Assessment

In cases in which restricted material use is proposed and not preapproved, a business risk assessment should be performed. The risk assessment should be performed by an experienced environmental professional who has information on strategic business issues associated with the product, such as target markets and production volumes. Issues that may be included in a risk assessment for proposed restricted material use include:

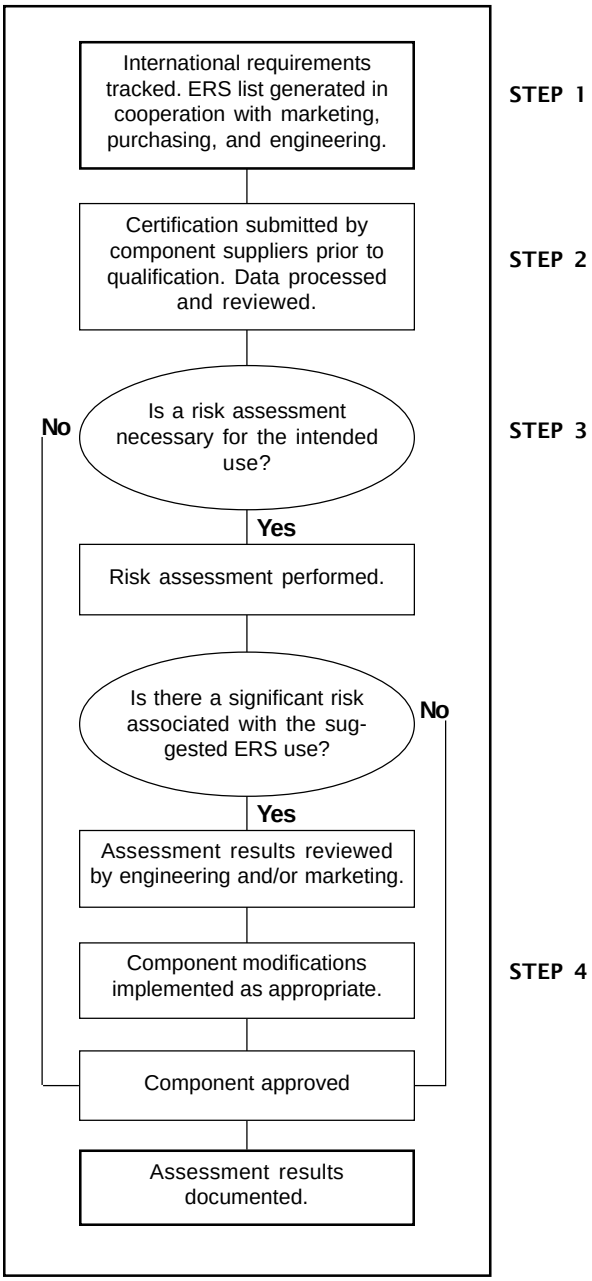
- What is the total quantity of the proposed restricted material use in relation to how the substance is currently being used in other applications within the industry? Will the new use result in a significant increase in the total usage quantity of that substance?

- What is the relevant risk/receptor analysis; that is, will the restricted material be evaluated by weight or concentration, or is a leachate test more appropriate?

- What is the leachability/bioavailability of the restricted material in the proposed application? Is the substance homogenous throughout the component, or is it a surface coating that would be more readily leachable in a landfill environment?

- How will the product typically be managed at the end of its useful life? Will the product be reclaimed, as in a product take-back program, or is it likely that the product will be disposed of in a landfill? Can the product or components be recycled and/or reused in a future product?

Restricted Substance Management System



A systematic approach to the risk assessment, based on a company's business drivers, should be employed to create consistent, supportable recommendations. One example of a relevant business driver is market share. Market share may be affected if customers choose not to purchase the product because it contains a certain restricted material. Other drivers for the technology industry include competitive "time to market," market access, and cost, which would be affected, for example, if special regulatory permission were required to market the product containing the restricted material.

One approach that has been used successfully is based on Graedel and Allenby's Abridged Life-Cycle Assessment methodology.[10] In the case of restricted material assessment, this methodology is based on evaluating relevant impacts (e.g., market access) during different life-cycle stages associated with the material's use (e.g., manufacturing and product distribution). Although the approach does not provide absolute measures of cost or risk, it can be a powerful tool for identifying relevant issues and determining the order of magnitude or relative risk in the short time periods available for product-related decisionmaking.

[10] Graedel, T. E.; Allenby, B. R.: Process and Product Audits: LCA's Inventory Analysis Stage. In: Industrial Ecology, pp. 122 - 134. Prentice Hall, Englewood Cliffs, NJ (1995).

Step Four: Modify Design

The risk assessment results are reviewed with key decisionmakers for the product, including engineering and marketing representatives. These results must be considered as part of the overall business decision.

Once a decision has been made on whether a restricted material is approved for a specified use, the decision should be recorded in a readily retrievable fashion so that the institutional knowledge gained in the exercise will be preserved. This supports consistency in decisionmaking and prevents duplication of effort.

ERS Management Challenges

The risks of not adopting a systematic approach to ERS management are compelling. Without a coordinated effort, electronic component manufacturers will develop separate and disparate data collection and transfer mechanisms and suppliers will be forced to deal with multiple manual and electronic tracking systems. Time and money are currently being diverted from what should be the goal of supplier environmental efforts, that is, improving product environmental attributes to support market and regulatory needs. Tremendous efficiency may be garnered from suppliers and customers within an industry using the same system, such as the EPD Database.

Organized ERS data sharing between customers and suppliers through a mechanism such as a centralized data warehouse reduces the time and resources currently required for ERS management. Suppliers participating in such an effort provide data on commodities basic to the industry, such as standard electronic components and/or plastic resins. Direct access to the data is provided to authorized customers and suppliers through mechanisms established for this purpose (e.g., an Internet web site), reducing the cycle time and resources currently required to request and obtain such data. Undertaking such a project has been challenging, requiring issues to be addressed such as collecting data so that trade secret disclosure is prevented. The effort has necessitated substantial communication and education among customers and between customers and suppliers.

THE RESULTS

Implementation of the EPD Database and the associated restricted substance management system has had tangible benefits for Quantum. Specific examples include:

- Faster response to original equipment manufacturing (OEM) customer-restricted substance inquiries, which must be completed prior to product sale and shipment. In many cases, response times have been reduced from greater than six months for detailed product restricted substance data to less than one day.

- Avoidance of nonessential uses of restricted substances. One design change identified as a result of the system, for example, eliminated the use of several tons of lead from the product line, resulting in lower liability for the product at the end of its life.

This case study was authored by David G. Cox, Environmental and Occupational Risk Management and Gregory C. Chambers, Quantum Corporation. See contact information on the following page.

Acknowledgements

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COMPANY INFORMATION

Founded in 1980, Quantum Corporation designs and manufactures storage products including hard drives, DLT tape systems, and solid state disk drives. The company is headquartered in Milpitas, California, USA, and has operations in the United States, Europe, and Asia, where the local headquarters is in Singapore. With approximately 6,300 employees worldwide, the company had sales in 1998 of $5.8 billion.

EORM was founded in 1990 to provide high-value, strategically oriented EHS consulting services to the high-technology industry. Today, with nearly 100 employees, five offices, and an international client base, EORM is an established leader in the application of EHS tools and strategies for the semiconductor, biotechnology, and other rapidly changing and competitive industries.

CONTACT INFORMATION

Quantum's web site is http://www.quantum.com. Information on the EPD Database can be found on EORM's web site at http://www.eorm.com/products/products.htm#EPD

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Clean Technologies: Suppliers Leading the Way

Applied Materials

THE CHALLENGE

After more than 30 years of using aluminum as the main wiring material in semiconductor chips, technology is starting to shift to copper for wiring in advanced devices. In contrast to earlier dry chemical technologies, copper uses two primary wet processes—electroplating and chemical mechanical polishing in the process flow. This has resulted in concern about the presence of copper in the fluid waste stream of chip fabrication facilities. A highly regulated heavy metal, copper creates a variety of permit issues that can create possible delays in bringing the process from research and development and qualification into production.

Cooperate with Suppliers to Deal with End-of-Pipe Environmental Issues

Other themes in this case study:
- Build environmental considerations into product design
- Promote exchange of information and ideas

For similar case studies, see:
Xerox Corporation
United Technologies Corporation

For Applied Materials, these challenges were significant. Their customers—virtually every major chipmaker around the world—could be affected by permit difficulties and process delays that result from the shift to copper. Other issues were of concern. Besides the environmental concerns of copper in the waste stream and the associated regulatory challenges, copper electroplating and CMP systems have significant water requirements. The need to treat and discharge water, particularly with copper present, is potentially expensive to manufacturers. Applied Materials understood that its customers would need to consider the cost of water treatment when selecting process and equipment options. The economics of water treatment varies according to a region's infrastructure and pricing systems, so, although the expense of treating and discharging in the United States is not prohibitive, it is much higher in Europe and Asia, where many of the company's customers are located.

The economics, regulatory issues, and environmental concerns related to the technology all suggested the need for a new approach. As a supplier of both types of wet copper technologies, the company has an interest in seeing that the transition required by the new tools is as smooth as possible for Applied Materials' customers and that EHS issues related to its products do not impede selection of its equipment. Furthermore, as an environmentally concerned company, Applied Materials understands the importance of providing the cleanest technology available on its process equipment. Although Applied Materials' core business is chip-making equipment, the company recognized that postprocessing environmental requirements were an issue of concern for their customers. These concerns led Applied Materials to develop a comprehensive copper abatement solution for its systems that could potentially be modeled by its customers.

THE SOLUTION

As a supplier concerned about EHS factors related to its products, Applied Materials expanded the scope of its efforts beyond the physical boundaries of its tools to identify Total Solutions.™ It installed a closed-loop water-recycling system in its own facility to demonstrate to customers how problems associated with the fluid waste streams could be addressed. Applied Materials was motivated by the fact that the system would not only benefit the company's own facility: the system would potentially offer added value to its equipment customers.

> **"We have a responsibility to provide environmentally clean solutions to meet our customers' capital equipment needs. This effort is being undertaken in that spirit."**
>
> —John Egermeier, director of operations, PSI Division, Applied Materials

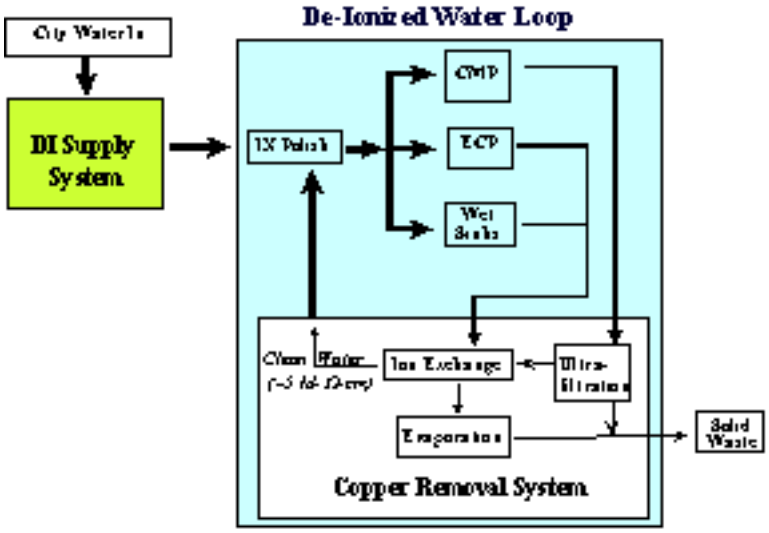
In late 1998 Applied Materials opened its Equipment and Process Integration Center (EPIC), which houses all the equipment needed for customers to develop and test a completely integrated manufacturing process for building copper wiring on chips before actually installing the tools in their facilities. Because the EPIC facility contains all of Applied Materials' copper-based technologies, its waste stream is chemically similar to that of a fully operational fabrication facility (fab) manufacturing copper-based chips. In addition to the water treatment issues that the company wanted to address, EPIC also provided an opportunity to design and demonstrate a solution to the copper waste stream issue.

> **"Applied Materials' Total Solutions™ approach to process technology goes beyond providing advanced hardware and processes that give our customers a certain result on the wafer to enhancing these tools wherever possible with proactive environmental solutions. The EPIC facility represents a macroscale environmental solution that augments our work with individual chip-making technologies."**
>
> —Terry Francis, general manager, Applied Materials' Green Initiative

After lengthy design reviews, Applied Materials decided to install a closed-loop, zero-discharge waste-abatement system, illustrated below, which would purify the water used in the wet processing tools, separate the copper, and provide recycled, deionized (DI) water back into the facility's DI water loop. The closed-loop system uses ultrafiltration for slurry separation followed by ion exchange to remove copper and other impurities from the wastewater streams. It then returns the water back to the facility as clean water feedstock for the process DI system.

Typically, the ultrapure water required for the system is generated from city water by a primary DI water system followed by an ion-exchange polish system. The goal of the copper removal system at Applied Materials is to recycle the water from the above processes and minimize the demand on the primary DI system.

The diagram shows that dionized water is used in the copper metal polishing (CMP), electroplating (ECP), and wet sink processes. Wastewater from the CMP process is then directed to an ultrafiltration system for solids removal. The wastewater from the ECP and wet sink processes is directed to the ion exchange system, where it is combined with the suspended solids-free effluent from the ultrafiltration system and deionized. The DI water is sent to the polishing ion exchange system and reused. The minimized regenerant waste from the ion exchange system is evaporated and the solid waste is sent to a recycling facility.



The integrated system was designed and installed by Hydromatix, a California company. A patent minimizing liquid waste generation from the ion exchange copper separation technology is held by Hydromatix. The fully automated ultrafiltration system was supplied by Pall Corporation.

Using the system described, copper-bearing aqueous solutions, primarily from CMP, ECP, and wet cleaning technologies, are recycled into DI water and returned to the copper facility for reuse. The only water consumed by the factory is small amounts of make-up water to replace the volume lost to evaporation. The only waste products that leave the system are highly concentrated, small-volume solids that are sent to appropriate disposal facilities.

At EPIC, the goal was to move toward zero discharge at the lowest possible cost. The benefits of a zero discharge system include both environmental and economic and business concerns.

The environmental benefits of a closed loop water system include:

- *Substantially reduced water requirements.* This is particularly beneficial in arid areas or those that experience water shortages, but is of value anywhere, because it means that less water is diverted from municipal supplies for the chip-making facility.

- *Zero discharge.* This alleviates the environmental risks and challenges of water treatment. Removing the potential for heavy metal contamination of water supplies is an obvious advantage. Lowering the demand on energy- and resource-intensive waste treatment processes is also a significant benefit.

- *Other factors.* A number of environmental and ecological problems are associated with industrial water use, even with proper water treatment facilities. These include such local disturbances as elevated temperatures in streams and rivers.

The economic and business benefits of the type of closed-loop system that Applied Materials installed are also considerable. They include:

- *Recycles DI water.* By putting DI water back into the copper system, the expense of and infrastructure needs for an ultra-pure water source are diminished.

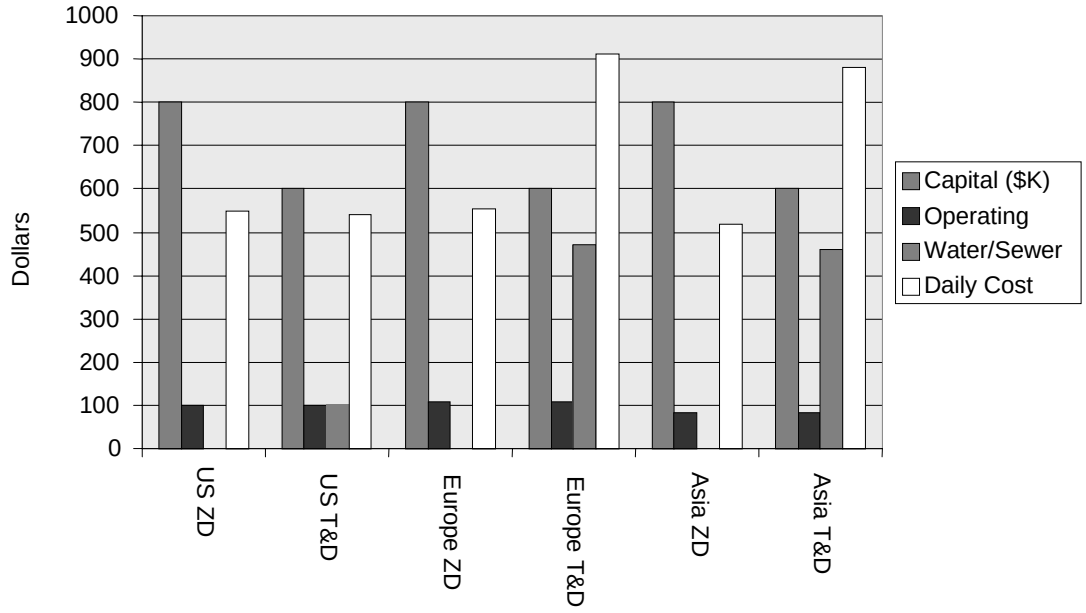
- *Avoids water and sewer costs.* These can be particularly high in Asia and Europe. Such cost avoidance can mean that the zero discharge system is considerably less expensive over time than continuing to treat and discharge water (see chart below.)

- *Avoids regulatory procedures.* The closed loop system requires little or no regulation.

- *Alleviates risk.* As a more environmentally sound method, the process lessens the likelihood of liability claims and so on. Rather than producing a sludge with low metal content, which needs to be sent to a hazardous waste facility, the by-product of the system is a solid high in metal content that can be sent to a metal recycler without liability.

This chart demonstrates the cost differences between a zero discharge system and conventional treat and discharge methods. It compares the costs of water use and treatment in three regions (the United States, Europe, and Asia) for both zero discharge and treat and discharge systems. The capital costs are represented in thousands and are higher for the zero discharge systems than for treat and discharge systems. The operating costs (the second bar in each example) are

Zero Discharge Compared with Treat and Discharge Economics



Notes: ZD is zero discharge. T&D is treat and discharge. The daily cost bar includes the average daily cost of capital depriciation for equipment. The additional capital investment for zero discharge is $200K (20 GPM) *so the zero discharge payback period for Europe and Asia is ~500 days.*

fairly consistent across both regions and system type. Note that no water/sewer costs occur in the zero discharge examples, whereas these costs are significant in the treat and discharge cases, particularly in Europe and Asia. Capital costs are included in the daily cost totals on a depreciated capital cost per day basis. The daily cost figures, therefore, are a sum of the daily depreciated capital cost, along with daily operating and water and sewer costs.

The chart shows that the zero discharge system is cost effective, even though it has higher up-front capital costs. This can be seen most clearly by comparing the daily cost columns within each region. It is particularly true in Europe and Asia, where higher water and sewer costs make treat and discharge systems extremely expensive. For example, the daily cost figures (the fourth bar in each example) for the U.S. zero discharge system and the U.S. treat and discharge system are about the same. This is because the higher capital costs (the first bar) of the zero discharge system are offset by the water and sewer costs (the third bar) of the treat and discharge system. In Asia, on the other hand, the daily cost for the zero discharge system is significantly lower than for the treat and discharge system. This is because of the high cost of water and sewers in the Asian treat and discharge example. Daily treat and discharge costs in Europe and Asia are nearly twice the total cost of the zero discharge system.

THE RESULTS

The pilot system at EPIC commenced operations in May 1999. The team working with the system is making minor adjustments to optimize the process and its performance. Performance data will be available sometime in summer 1999, when the system is fully operational.

According to John Egermeier, director of operations, PSI Division at Applied Materials, Our results to date indicate that with minor modifications, the EPIC copper abatement system should meet our performance goals for copper removal and recycled water quality."

Because Applied Materials' system is still in the commissioning phase, the company has not yet decided how it will make the technology available to its customers. Nevertheless, the example demonstrates the fact that equipment suppliers are going beyond just selling a process tool; rather, their product's value can be dramatically enhanced if it is available with associated environmental control technology. Rather than waiting for its customers to battle with the environmental, economic, and regulatory issues associated with its products, Applied Materials proactively took steps to demonstrate how these concerns could be alleviated. This indicates the increased importance of life-cycle product issues and represents a significant step toward early intervention on issues of concern. Combined with the fact that the story highlights a promising new clean technology and a situation in which a supplier is being proactive rather than reactive to these issues, it is an exciting convergence and a hopeful indicator of current trends.

COMPANY INFORMATION

Applied Materials is the world's largest supplier of wafer fabrication systems and services to the global semiconductor industry. In 1998 revenues were $4 billion, and the company employed 12,000 people in fourteen countries. Corporate headquarters are in Santa Clara, California, USA; research and development and manufacturing centers are located in the United States, Israel, Europe and Japan; and technology centers are located in South Korea and Taiwan.

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Industry Standards for SCEM

Hewlett-Packard

THE CHALLENGE

Work With Industry Peers to Standardize Requirements

Other themes in this case study:
- Supply base environmental performance management
- Environmental requirements at the purchasing phase

Hewlett Packard (HP) sets high standards for its suppliers' environmental performance. But it recognizes the burden that long, detailed environmental questionnaires place on suppliers. The trend among environment- and risk-conscious companies to require suppliers to fill out long questionnaires and provide various forms of documentation has been onerous and expensive to suppliers, many of whom have had to fill out similar questionnaires for multiple customers. The inefficiency of this repetitive workload taxed suppliers, the supplier-customer relationship, and the common-sense notion of minimizing repetition in work (which is, of course, a concern when asking a supplier to deliver value.)

The solution to the problem seemed to be the adoption of common tools—a standardization of supplier questionnaires that could be used by a number of firms to minimize the amount of duplicate work a supplier would be required to perform. Developing this solution is the subject of this case study, in particular, the standards developed by the Pacific Industry and Business Association (PIBA) and Computer Industry and Quality Conference (CIQC), the latter a network of U.S. computer system producers. Hewlett Packard's experience, related here, is in developing the standard and applying it effectively.

The process of developing a standard questionnaire involves discussion of the use and implementation of the standard in procurement. A discrepancy, however, can occur between the objectives of environmental (E) and health and safety (HS) groups, which may want to ask detailed technical questions related to environmental performance, and the objectives of procurement groups, which want to ask a few critical process-related questions regarding environmental management.

Procurement at HP has worked with both the procurement and environmental groups that take part in the PIBA and CIQC fora to shape a supply-base questionnaire that is business and procurement focused and addresses important environmental issues.

THE SOLUTION

A number of companies that were already part of the Pacific Industry and Business Association (PIBA), including HP, came together in 1995 and, in recognition of the problem of duplicate questionnaires discussed above, established a Supplier Management Forum. Together, the participants drafted a set of environmental practice questionnaires to help companies reduce business risks and enhance supplier relationships. Based on the PIBA questionnaires, CIQC developed its first environmental practice standard (CIQC STD 0014) in October 1996 as a

common tool for gathering supplier environmental practice information and for optimizing the transfer of environmental performance information between purchasers and suppliers.

Discussing the reasons underlying the standardization movement, Hsia Choong, HP program manager of supply chain environmental programs for procurement of environmentally responsible materials, noted that a proliferation of customer queries on environmental performance has burdened suppliers. "Part of the reason we are involved in this initiative is for positive supplier relationships," says Choong, "We are a supplier ourselves, so we understand the difficulty. Part of our motivation is also to standardize it in such a way that the process is easier for our suppliers and for our worldwide procurement organizations for supplier environmental performance management."

PIBA Supplier Forum Mission Statement

In an effort to optimize the transfer of environmental, health, and safety performance expectations and data between purchasers and their supplier base, model tools and guidelines will be developed and made available to PIBA to enhance supplier relationships, reduce business risks and liabilities, and support long-term business growth.

Computer Industry and Quality Conference

- CIQC is a computer system producers' network organized to promote a common focus and continuous improvement in electronic component quality and the practices used to purchase and deliver these products.
- Total electronic components and semiconductor devices purchased by CIQC member companies exceed $36 billion annually, not including contract manufacturing.
- Member companies include Apple, Celestica, Compaq, Digital, HP, IBM, Lucent Technologies, Silicon Graphics/Cray Research, and Sun Microsystems.

A number of considerations figured prominently in the CIQC Environmental Committee's efforts to draft the standard:

- The group chose to focus on environmental practices at supplier companies, rather than on environmental characteristics of suppliers' products. The group's members believed that by addressing the suppliers' manufacturing environmental practices, the questionnaire could be used across a variety of industrial sectors that might represent the range of suppliers to electronics companies.
- Because so many electronics suppliers are international, the questionnaire was constructed to be useful across international boundaries and relatively easy to translate. For this reason, the questionnaire did not address specific legal requirements or laws and regulations that are country specific.
- A few important environmental issues were intentionally withheld from the questionnaires, because many companies already had systems in place to address these issues—namely ozone-depleting substances and the supplier's obligation to comply with legal requirements.
- Information in the questionnaire was not designed to satisfy international or domestic regulatory requirements. Rather, the questions chosen reflected the experience and judgment of participating environmental and purchasing managers in a selection of items representing current thinking on development of environmental management systems and processes to ensure legal compliance.

The questionnaire consists of two main parts and was designed to be completed in two hours or less by an environmental manager. A modular approach was taken so that the questionnaire could serve several purposes and to allow for ease of use by companies that wished to use only a portion of the questionnaire. Part I of the questionnaire gauges continual improvement and compliance assurance. Part II is for risk assessment contains additional questions used with critical suppliers, high-volume suppliers, or suppliers whose processes have major environmental aspects. The documents are recommended as particularly useful if used in conjunction with supplier reviews.

SUPPLIER ENVIRONMENTAL PERFORMANCE REVIEW QUESTIONNAIRE

PART I: Continuous Improvement and Compliance Assurance

1. Does the company/facility have a written environmental policy statement? If "yes," please attach a copy. Does the policy statement include a commitment to continuous improvement of environmental performance?

2. Does the facility have written environmental performance objectives/targets and implementation plans to reduce cost or risk? Please describe three significant environmental performance objectives/targets, performance plans, and measures for the next 12 months.

   (Examples of cost-reducing or risk-reducing environmental performance improvements may include: waste minimization, pollution prevention, source reduction including recycling and reuse targets, energy use, water consumption, packaging programs incorporating targets for reduction, reuse and recycled content, and enhanced training. These examples are not meant to exclude other types of programs, which you may be implementing.)

3. Is a management representative assigned responsibility for facilitating compliance with environmental regulations? If "yes," please give name and title.

4. Does the facility have a system to track environmental laws and regulations that apply to the operations of the facility? If "yes," is there a system for communicating this information and training to the appropriate personnel?

5. Are periodic environmental regulatory compliance audits of the facility's operations conducted?

6. Does the company have documented processes to implement corrective action plans for nonconformance to environmental laws and regulations?

7. Does the company have a documented supplier environmental program that ensures conformance of its suppliers to legal requirements?

   Note: This questionnaire does not address two important issues, that is, the elimination of ozone-depleting substances, and the supplier's obligation to comply with applicable legal requirements. Most companies already have systems in place (contracts, standards, bid specifications, and so on) that address these issues. Users of this supplier review questionnaire may want to consider incorporating relevant questions here to address their needs if not otherwise addressed in their system.

PART II: Risk assessment

1. Environmental permits, chemical registration and compliance status

   1.1 Is the facility required to have any types of environmental permits or registrations? Please check those that apply:
   - ☐ Industrial wastewater discharge
   - ☐ Hazardous waste storage
   - ☐ Hazardous waste treatment
   - ☐ Hazardous materials use/storage
   - ☐ Air emissions
   - ☐ Storage tanks
   - ☐ Radioactive materials
   - ☐ Other (please list)

   1.2 Does the facility monitor its operations, emissions, or discharges to check compliance with permit requirements? Do regulatory agencies regularly monitor and/or inspect the facility? Is the facility in compliance?

   1.3 Has the company obtained all necessary chemical registrations and submitted all necessary notifications for substances imported, exported, or used at the facility?

   (Examples include but are not limited to the United States Toxic Substances Control Act [TSCA], European Inventory of Existing Commercial Substances/European List of Notified Commercial Substances [EINECS/ELINCS], and Canadian Domestic Substances Lists.)

2. Hazardous waste management

   2.1 Does the facility generate hazardous waste? If "no," go to question 3.

   2.2 Are hazardous wastes that are stored, treated, or disposed of on site managed in properly designed facilities that will prevent future environmental impacts?

   2.3 Are off-site transporters and treatment, storage, or disposal facilities properly licensed?

3. Industrial wastewater and air emissions management

   3.1 Does the facility treat its industrial wastewater prior to discharge? Please describe.

   3.2 Is the facility required to control its industrial emissions? If "yes," does the facility have air emission control equipment installed? Please describe.

4. Environmental release potential

   4.1 Does the facility use chemicals that, if released accidentally, could create a business interruption?

   (Examples include but are not limited to high volume chemicals, either pressurized gases or liquids that are flammable, highly toxic, or radioactive.)

   4.2 Does the facility have written emergency response plans in case of a release to the environment?

(Examples include but are not limited to training, drills, chemical hazard communication, hazard identification, audits of high-risk areas, mutual aid relations, emergency response, and disaster recovery equipment.)

5. Company environmental standards

5.1 Does the company have minimum company environmental standards that apply to the facility's operations regardless of the country in which the facility is located? If "yes," please describe.

6. Business interruption potential

6.1 Is the company/facility aware of any chemicals used in the facility's manufacturing processes whose availability is currently restricted or scheduled to be restricted in the future due to environmental requirements (e.g., CFCs)? Please list chemicals that apply. If yes, does the company/facility have written plans to eliminate these chemicals or otherwise accommodate their reduced availability?[11]

Once the standard is written, the core question for the members of the group is how it is used and how it is integrated into existing SCEM programs. This is primarily an issue for individuals to deal with at their own firms, however. At Hewlett-Packard, the company has a particularly well-defined set of supplier environmental expectations (see box) and the CIQC standard has been integrated as one of a number of expectations. Product environmental specifications, for example, are not addressed in the standard, but HP has a separate procedure and requirement for ensuring that its expectations for product environmental expectations are met.

By already adopting CIQC 0014 as a companywide standard, HP has demonstrated leadership within CIQC. Many of the other member companies are still working on the question of how the standard will be applied internally or else have implemented the standard in certain departments but not all.

HP's statement to suppliers indicates the level of expectations that it sets for its suppliers' environmental management.

Important as statements of expectations are, ultimately the adoption of standards and statements of expectations are meaningless unless they can be used effectively by procurement. Purchasing is the critical juncture between suppliers and the environmental expectations established by the company. For environmental priorities to be effectively implemented, procurement needs good tools, and strong communication needs to exist among departments. At HP, the company has been working to bring together purchasing process realities and environmental ideals.

The first way this happened was the official addition in 1993 of environmental concerns to the list of criteria on which suppliers would be judged in the procurement process. Carl Snyder, executive director of procurement at HP, describes this transition in the company's environmental

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Note: There is now a guidance document that accompanies the standard and offers explanations of most of the questions, which is meant to clarify the questions and make the standard easier for suppliers to manage.

procurement brochure. "For many years HP Procurement evaluated and favored those suppliers that best met our needs in the areas of technology, quality, responsiveness, delivery, and cost (TQRDC). In 1993 we added an "E" for environmental performance. As we look forward, we hope that each HP supplier will join with us in working toward protecting the environmental quality of our communities and our world." The procurement process involves TQREDC-E reviews, which are opportunities to talk to suppliers about standard 0014 and their responses, particularly to part one, the seven questions on environmental management.

These discussions are also good opportunities for discourse on environmental management, but effective implementation of environmental criteria in purchasing is still difficult. The tools need to be usable for procurement staff, which is why Hsia Choong has had an ongoing role in the PIBA and CIQC groups trying to introduce the procurement perspective into the drafting of the standard. Without procurement involvement at the drafting stage, she notes, groups of environmental staff have a tendency to write standards that are too technically dense, too long, or too complex for individuals with purchasing backgrounds to use effectively. She has been part of a movement to make the standards relatively short and simple, without neglecting the most important aspects of environmental management and risk assessment.

The standard that has been developed does adequately meet the needs of procurement departments, Choong believes. HP deals with the complications of enforcing environmental expectations largely by giving the responsibility for progress to the supplier. In their meetings with suppliers, HP asks suppliers to identify and outline their own opportunities and goals for improvement in environmental performance. At the next meeting, HP then reviews the progress made against the mutually agreed goals and what is left to be done. But the purchasing groups do not adopt responsibility for overseeing the changes. Noting the complications involved in the supply chain in today's global marketplace, Choong says, "The procurement chain is getting very complex and is worldwide. It's impossible for us to know everything about our suppliers or about their environmental practices. We can't constantly be in charge of making sure that they comply; however, we do want to be sure that the processes are in place at the suppliers' facilities, and the suppliers are accepting responsibility for their own environmental practices."

HP Statement of Expectations for Suppliers

We want our product material suppliers to act as responsible corporate citizens and take a positive, proactive stance regarding environmental issues. We ask that they pursue a policy of continuous improvement in this area and be forthright about sharing relevant information with us. At a minimum, we ask that they do the following:

- Develop and adhere to an environmental improvement policy.
- Create an environmental policy implementation plan with defined metrics.
- Eliminate ozone-depleting substances from their manufacturing processes.
- Complete the HP Supplier Environmental Performance Review Questionnaire (CIQC STD 0014).
- Ensure that all parts, components, materials, and products supplied to HP comply with HP's General Specification for Environment Dwg. No A-5951-1745-1.

THE RESULTS

HP has achieved several notable successes with regard to SCEM. The first is that they have eased the burden on suppliers by cooperating with other companies in PIBA and CIQC. By using the CIQC standard throughout the company, they have established a level of uniformity that is uncommon and indicates a trend toward standardization of supplier questionnaires. In the long run, as more companies adopt supplier questionnaires, these standards will be an important means of alleviating suppliers' workloads, building awareness, and focusing on compliance and continuous improvement.

It is not easy to meet the needs of everyone involved in the purchasing function. HP has established environmental expectations and determined that responsibility for compliance lies with the supplier in an effort to deal with these challenges. At the point of purchasing, the interests of suppliers, procurement and environmental organizations come together, and each group has different objectives, knowledge areas, and process systems. Achieving a clear outcome with these differences can be difficult; for one group to be successful, the needs of all three groups must be met. To moderate the issues of environmentally responsible procurement effectively, HP has established procedures that are mindful of differing needs and abilities. They have worked with others to see that the CIQC standard considers the needs of procurement staff as well as be helpful for suppliers. And they have established environmental expectations, while making it the responsibility of suppliers to meet them. By doing these things, HP provides one model of how the complex issue of environmentally responsible procurement can be addressed.

COMPANY INFORMATION

Founded in 1939, HP manufactures a variety of computer and imaging products, test and measurement products, and electronic, chemical, and medical products. Revenues in 1998 were $47 billion. Ranked forty-seventh in the Global 500, the company employs 124,600 people worldwide and has sales and support offices and distributorships in 120 countries.

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The Benefits of Partnership

United Technologies Corporation

THE CHALLENGE

In 1996 United Technologies Corporation (UTC) revised its EHS policy, including the requirement to "Make safety and environmental considerations priorities in new product development and investment decisions and in our dealing with contractors and suppliers" (emphasis added). Although UTC had previously dealt with contractor EHS issues through its contractor standard practice document, an extensive review of EHS requirements, and criteria for evaluating contractors, the company had not formally ventured into the area of merging EHS standards and supplier standards. This new focus turned out to be especially challenging.

Promote Exchange of Information and Ideas

Other themes in this case study:
- Environmental conditions at the purchasing phase
- Inform suppliers of corporate environmental concerns

For similar case studies, see:
Intel Corporation

The following year, UTC began to look along its supply chain and saw a nearly unmanageable number of suppliers—more than 150,000. In a company, at the time, with approximately 175,000 employees, the situation seemed out of hand. Not only did the high number of suppliers appear hopelessly inefficient, but it made the prospects for a sustained supply-chain partnership effort all but impossible. It was evident that something needed to change.

The convergence of the issues of SCEM and procurement policies created an opportunity to look comprehensively at the role of purchasing. Although the circumstances that brought about the new approach—the change in the EHS policy and the new look at procurement—were unrelated, their repercussions justified an integrated approach. Shortly, a third factor—a shared services analysis—would create additional incentives to rationalizing suppliers.

It would seem an insurmountable task to address the complex issue of supplier chain environmental management (SC[E]M) with such a high number of suppliers. Many companies might respond by declaring the effort impossible and give up. UTC did not. Their story involves a dual effort to make wise business decisions and promote sound environmental measures when dealing with suppliers. Their experience explores the overlap between the two concerns and raises several important questions, including: How can a large job, such as instituting SCEM strategies, be best approached? What are the rewards of attacking the issue, both for the company and for the suppliers? What are the relationships between business and environmental concerns when dealing with supply chain issues? And what makes SCEM successful?

THE SOLUTION

Shortly after the company realized that its supply chain was unmanageably large, it launched a strategic sourcing initiative. Reversing the long-standing policy of decentralized purchasing, the

program had ambitious goals: to cut the number of suppliers on which UTC depended dramatically with the intention of rationalizing the supplier base to approximately 10 percent of 1997 levels. Analyzing UTC's procurement policy, it concluded that this required a more organized and focused sourcing policy.

Led by a Strategic Sourcing initiative, UTC formed cross-divisional commodity teams to source for a larger portion of UTC's needs. The teams' focus was on sourcing for those goods and services that were most in need of centralized purchasing and were currently used significantly by different operating units with high strategic value. As of April 1999, EHS is represented on each team and the EHS representative has an opportunity to identify and manage EHS risks at a number of key phases. She or he is able to influence the language and scoring of both the requests for information and the requests for proposals and participate in any site visits that occur and ultimately in the final selection process. The goal of EHS involvement is to advise on potential EHS risks and identify EHS opportunities at both supplier and UTC sites where better EHS management may benefit both parties by controlling costs. The program is intended to bring order to the process of procurement, not only by achieving a sensible number of suppliers but also by implementing procedures that ensure comprehensive and efficient supplier assessment.

With such large changes under way in terms of how the company thought about procurement issues, it seemed to be a prime time to address the EHS mandate to prioritize environmental

UTC Puts Supply Managers Through Tough Basic Training

Article reprinted in part with permission from *Purchasing Magazine*, April 23, 1998

There's a big change brewing at United Technologies Corporation. The Hartford Conn.-based multinational is making major changes in supply management at its Carrier, UT Automotive, Otis Elevator, Pratt & Whitney, Hamilton Standard, and Sikorsky divisions.

UTC's chairman and CEO George David has identified integrated supply chain management (SCM) as a superhighway to long-term corporate competitiveness, and he has empowered Kent Brittan, vice president of supply management, to integrate sourcing activities across the six major divisions and to make SCM a core competency for the corporation. The battle call: "Supply chains—not companies—compete."

For corporate procurement at UTC, this represents a major departure from history. Until recently, the group had approached supply chain integration through cross-divisional purchasing councils. But while the councils were very effective at leveraging information and knowledge among the supply units, they continued to operate within a highly decentralized procurement structure (meaning they could create corporate supply agreements but couldn't always deliver volume to suppliers). The councils were also focused mainly on nonproduction aspects of supply, for example, MRO, energy, capital equipment, and travel.

Now this is changing. David, for one, suspects that the company is leavinging money on the table by failing to act as a unified whole. Noting that UTC spends well more than $10 billion per year with suppliers, Sam Farney, senior manager of education and training for corporate purchasing, says, "We wanted to see what could happen if we began to integrate our supply chain management efforts at the corporate level and to extend our efforts to include production purchasing."

considerations in dealing with suppliers. UTC's enhanced "greening the supply chain" initiative was, at least partially, a result of this convergence. A number of observations have fueled and informed UTC's program:

- *Partnership to meet environmental goals.* Having established ambitious EHS goals involving reductions in the company's emissions levels, waste generation, energy and water use, and safety incidents, UTC recognized that it could not meet its targets on its own. No matter how environmentally conscious UTC's operations were, the goals would not be met if the company inherited a legacy of dirty production and unsafe and energy-intensive technologies from its suppliers. This was particularly true because approximately $14 billion of UTC's $24.5 billion in sales was from purchased products or services. UTC's emphasis on meeting its own goals required the company to involve suppliers; communicate about environmental, health, and safety strategies; and enhance efforts to incorporate EHS criteria into purchasing decisions.

- *Evolving supplier relationships.* UTC has recognized a progression in the maturity and sophistication of the dialogue that has taken place between buyers and suppliers concerning EHS issues. Such concerns may not be recognized at all in the less advanced stages, but they will be incorporated (primarily on the basis of risk) as both buyers and suppliers begin to take EHS issues into account. At the more sophisticated stage of interaction, both parties are forward thinking, concerned about EHS impact, and willing to work in partnership to achieve EHS results.

- *Improving business performance through greening the supply chain.* A focus of UTC's program has been using SCEM and business performance to complement one another. The recognition that SCEM can result in lower costs is a key incentive, and over time the company has found that programs that do not advance both business and environmental goals are unlikely to be attractive or sustainable. The basic business goal of avoiding risk leads immediately to establishing regulatory compliance as an important standard for environmental performance.

Asian Environmental Supplier Outreach Program (AESOP)

> **"Through much experience, UTC and US-AEP have learned that manufacturing that considers environmental impacts can result in significant savings in cost and efficiency. Also, cleaner production can significantly reduce the risk of regulatory enforcement."**
>
> —UTC report

In 1998 UTC had an exciting opportunity to address the benefits of good environmental practices through the Asian Environmental Supplier Outreach Program (AESOP), which is now an ongoing project. The 1998 program was a joint venture between UTC, US-AEP, and UTC's suppliers. It emphasized a shared commitment to sound EHS management in Asia and was a pilot to test the impact of a structured assessment process for manufacturing efficiency, operating costs, and environmental impacts.

UTC and US-AEP joined in the partnership, because each had an interest in demonstrating environmental commitment, sharing expertise with Asian suppliers, and exploring means of outreach. Leslie Carothers, UTC vice-president for EHS, addresses the opportunity of events such as the

AESOP program: "In developing countries, improving environmental performance of suppliers will require large-scale sharing of technology and know-how. Although governments can be a catalyst for this activity, most of the resources and opportunities are in the business sector."

The AESOP pilot took place in Malaysia in June 1998 and involved a small, representative sample of Malaysian suppliers. The eleven-day event entailed conferences, site visits, debriefing and feedback opportunities, and report production. The opening and closing conferences took place at UTC facilities in Penang, Bangi, and Klang, Malaysia, where representatives of each supplier had an opportunity to tour and see the EHS measures implemented at the UTC sites. This framework set the tone of the event as an opportunity to exchange information and advances, rather than conduct an audit of the suppliers involved. Eight days of site visits to the suppliers followed the opening conference. At each site, the AESOP team:

- Toured the facility with site management
- Had an opportunity to informally discuss general impressions and opportunities
- Held a brainstorming session with the site participants over potential EHS risks and opportunities
- Formed a list of observations and recommendations on process improvements to reduce costs and risks and to promote environmentally sensitive operations.

Following the site visits, the AESOP team had a day to brainstorm and review notes and prepared a confidential final report. The team also had an opportunity to prepare short reports specific to each site visited.

> **"Importantly, the highest priority for the suppliers was improvements that would cut costs along with reducing waste and energy use."**
>
> —Leslie Carothers, vice-president for EHS, UTC

The pilot ended with a closing conference; exit briefings with each supplier, providing an opportunity for questions and discussion as well as distribution and discussion of the short reports; and distribution of the team's program report. The specific contents of the report and site visits are confidential, but a number of observations and approaches highlighted the event:

- Consistently emphasized were the financial benefits of environmental performance. Presentations on environmental and financial benefits of improved pollution prevention projects were part of the UTC site tours and conferences, and the AESOP team also took pollution prevention case studies with them on the supplier site visits. Significantly, during the brainstorming and exit briefing sessions, cost and benefit factors were explicitly discussed with site management whenever new project ideas were introduced.
- The suppliers involved exhibited a variety of EHS awareness and compliance postures. Some suppliers had no exposure to EHS issues, but most had at least some awareness and had some EHS programs and goals in place. Existing programs required varying degrees of attention, but the team found that all suppliers were eager to improve their respective EHS performance.

- "Greening the supply chain" is not a one-way monologue. Many of the suppliers, after gaining greater detail on UTC's EHS goals and programs, had specific suggestions on how use of their products could improve UTC's EHS performance.

- Stand-alone EHS assessments do not replace a comprehensive program, but significant opportunities exist to incorporate EHS issues into current supplier assessment and development programs, such as quality assessments that may already be in place.

The event was considered an unqualified success. "All participants involved benefited from the discourse and used the event as an opportunity to advance both financial and environmental performance," reported Nicholas Shufro, manager of regulatory affairs and policy planning for EHS, in a post-AESOP summary. Furthermore, "suppliers demonstrated real willingness to adopt the recommendations of the AESOP team and have committed to implementation of a variety of measures." For the hosts, AESOP was a useful approach because it allowed UTC and US-AEP to work on a smaller scale, while assessing the likely success of extension to similar programs in the future. UTC had a valuable opportunity to work directly with an important group of suppliers and demonstrate its commitment to EHS considerations. Perhaps most important, it provided a manageable project that would help UTC design a focused program.

Following the event, the AESOP team felt that it had learned a great deal and was in a position to offer potentially valuable advice to companies interested in expanding their own SCEM efforts:

- It is helpful to start with some type of pilot and begin to understand the magnitude of issues rather than decide supplier initiatives are too complicated.

- A stand-alone EHS assessment of suppliers will not be a sustainable program. Assessment activities need to be integrated with existing supplier programs, such as purchasing and quality programs. Few companies have the EHS staff to conduct supplier assessments apart from ongoing programs.

- Make sure to work with the purchasing organizations so that they understand the company's concerns and understand where opportunities may exist.

- To green the supply chain, one must constantly emphasize the business benefits of doing specific EHS projects or programs. Projects that do not consider the financial costs and benefits will not succeed.

- Suppliers will often surprise you with new ideas and opportunities. Greening the supply chain is not a one-way street, and any customer working with its suppliers should listen to suppliers' ideas.

"Helping performance of suppliers is paramount for getting success—both financial performance and EHS performance."

—Nicholas Shufro

THE RESULTS

At the time of writing, UTC has had less than a year to digest the lessons of the AESOP experience and is preparing to further the evolution of the Greening the Supply Chain initiative. EHS staff are currently at work on a statement to suppliers, which is expected to redefine the supplier relationship in the context of UTC's EHS expectations. The statement will be distributed to suppliers as a means of alerting them to UTC's expectations, but for key suppliers it will mean more. It will establish a "higher bar" of EHS standards to be met by suppliers who want to achieve long-term relationships with UTC, and it will, therefore, establish a framework for increased vigilance and closer long-term relationships. This launch will represent a significant step in an evolving SCEM program and demonstrates the continual progression that companies are making toward careful examination of these issues.

A few anecdotes illustrate the success of UTC's effort to green the supply chain. As a direct result of the AESOP pilot, a number of positive and mutually beneficial partnerships were established. One of the suppliers involved with the pilot was a small, relatively sophisticated firm with no previous EHS expertise and no internal EHS program in place. Immediately following the site visit on his premises, the supplier voiced an interest in being a "Little Brother" to the UTC unit for which he was a supplier. His frank request to establish information exchange and participate in EHS training at the UTC Malaysian facility was more than a perfect way for him to enrich his own EHS background. For the firm using his services, it also provided a sense of security to know that he was implementing EHS measures, enhancing the supplier relationship.

The AESOP team achieved another tangible outcome at the site of a larger supplier. One of the energy specialists made a simple, yet highly effective suggestion. The supplier was preparing to install a new piece of equipment—a sludge-drying machine—and the AESOP team member recommended installing it in the vicinity of a furnace. This simple recommendation, involving no additional costs, saved an estimated 15 to 20 percent in energy costs. The supplier implemented the suggestion, and, as a result, UTC's supply chain was not only greener, but more cost-efficient.

The success of the AESOP pilot, demonstrated in these stories, was experienced universally among the participants. Julie Haines, managing director of the Clean Technology and Environmental Management Program of US-AEP, comments on the factors that facilitated the program's achievements: "The UTC/US-AEP AESOP partnership really worked, primarily for one reason—everyone involved won. Both UTC and their suppliers won by building a stronger relationship centered on improving efficiency and jointly improving their environmental performance. The host government and surrounding communities got cleaner industries. And, finally, US-AEP catalyzed an innovative program that proves government and industry can successfully work together as agents of positive change for long-term sustainable development."

Another story illustrates the point that greening the supply chain is not a one-way street but a two-way dialogue leading to improvements for both sides. At a UTC facility in the United States, a logistics supplier noticed that six chemicals were being stored in a single crib, despite the fact that each chemical had its own recertification schedule, toxicity rating, inventory management, material safety data sheets (MSDSs), and manifesting and disposal costs. The supplier's observations led to an analysis of the use of chemicals at the UTC site, which generated EHS benefits, process improvements, and cost savings.

More broadly, the results of UTC's SCEM efforts, particularly with respect to their returns to business performance, are positive, yet difficult to quantify. Leslie Carothers notes just that fact: "While there is a growing recognition that advanced environmental management can save money, the evidence is usually anecdotal. The business benefits are certainly less clear to purchasing staff than the contribution of, say, product quality programs to the value offered by a supplier. Consequently, it has been difficult to sell EHS performance as an important way to differentiate among suppliers based on cost and quality criteria alone." Yet, UTC's efforts demonstrate that cost and quality are affected by EHS performance, even if other factors remain important motivations behind the drive to improve EHS. And, as more companies expand their SCEM programs, a great deal of attention is likely to be given to measuring the rewards of that effort. UTC has helped to define where others should begin the process.

COMPANY INFORMATION

United Technologies Corporation provides a broad range of high-technology products and support services to customers in the aerospace and building industries worldwide. In 1997 UTC had revenues of $24.7 billion, employed 180,100 people, and was 130th in the Global 500. UTC's best-known products include Pratt & Whitney aircraft engines, Otis elevators and escalators, Carrier heating and air conditioning systems, Sikorsky helicopters, and Hamilton Standard aerospace systems. The corporation also supplies equipment and services to the U.S. space program.

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Conclusion

This report has provided background for understanding the development of SCEM. The first two chapters chronicled the major types of environmentally related supplier initiatives (ERSIs) that companies are using. This was followed by case studies, which identified best practice examples of how companies are implementing these ERSIs.

What are the implications of SCEM for the Asian electronics industry? American firms included in this report's case studies have generally started their SCEM efforts with local (U.S.) suppliers. This experience is, however, already being exported to Asia, and more will be in the future. UTC's case study showcases an Asian supplier outreach pilot; HP and Xerox have global SCEM programs in place; and AMD's Bangkok facility performs waste audits. The Asian programs already in place indicate great potential for widespread extension of SCEM in the region. SCEM training programs, interactive experiences like UTC's, and supplier requirement programs would mutually benefit the firms involved.

This conclusion will identify ten emerging themes in SCEM suggested by the case studies. These include challenges and opportunities for all firms—customers and suppliers—in the electronics sector.

1. Companies experience external and internal pressures for SCEM.

External forces driving SCEM include regulatory threats, consumer pressure, investors, and commercial customers. Among the companies represented in this report, European take-back regulation is a particularly important driver. It has helped companies to see the issue of product responsibility in a new way and prompted companies to work proactively to demonstrate that voluntary, rather than regulatory, measures will achieve the best outcome. Advocacy groups—NGOs and shareholders—are also becoming increasingly interested in SCEM and are working harder to encourage companies to implement SCEM programs. Internal pressures include risk management, eco-efficiency, life-cycle analyses, environmental management systems (EMS), internal benefits, corporate image, and concern for environmental impact. Individually, many of these issues are important; cumulatively, they are an important driver for change.

2. Customer firms are applying SCEM by forming cross-functional procurement teams and by seconding environmental staff to design and procurement departments.

Several companies included in the report meet supply chain management needs by using cross-functional design and/ or procurement teams. With the shift beyond SCM to SCEM, EHS staff are being included on these teams to ensure that the company's environmental needs are met.

The implementation of SCEM depends in many cases on the ability of environmental staff to influence procurement decisions. In most organizations, the design and procurement departments are more powerful than the EHS department. The relationship and power differential between environmental and other departments will significantly influence the impact that SCEM programs will have. The case studies in this report reveal that environmental objectives are consistently favored when effective mechanisms bring procurement and environmental staff together, when risk is sufficient to lend environmental staff credibility in purchasing decisions, or

when the company has made environmental considerations a high priority or has made a strong commitment to SCEM programs.

3. DFE constitutes a fundamental shift in the supplier/customer relationship.

The design stage is the place in the life cycle of a product that has the most potential to shape the product itself and the processes that are used to create it. As long as companies continue to emphasize the development of green products and reduction of downstream risks and wastes, DFE will gain importance. For suppliers, this trend is likely to result in increasingly common environmental product specifications and the opportunity to work with companies on developing products that use cleaner production processes and materials.

Suppliers are also being asked to collaborate on finding solutions to environmental problems. This represents both an opportunity and an obligation for suppliers. Suppliers who demonstrate skill and ingenuity in their involvement with environmental solutions will likely receive customer loyalty. They will also save effort and expense for their customers by eliminating problems early in the supply chain. On the other hand, suppliers unable to provide solutions may not receive the same benefits.

4. SCEM proposes a new model for the relationship between companies and their suppliers.

The importance of customer-supplier partnerships was most directly illustrated in the case studies on promoting the exchange of information and ideas—that is, UTC, Intel, and Xerox—but it is an aspect of nearly all the case studies. These partnerships represent a shift from the old business model of communicating with suppliers primarily through purchase orders to one of shared problem solving. In its most advanced form, the supplier is encouraged to become a consultant to the customer. Developments in process and production methods are not just coming from requirements along the supply chain, they are also evolving as suppliers and firms cooperate and anticipate one another's environmental and business needs. The development of a DFE data base by EORM in conjunction with Quantum Corporation, Texas Instruments, and Lucent Technologies, shows that innovative and cleaner processes and technologies can emerge out of these partnerships as firms and suppliers recognize the potential for mutual benefit and environmental gains. These provide models of entrepreneurship that do not preclude developing country suppliers.

In the new model of business, the supplier is a strategic partner for the customer in dealing with all aspects of production from design to waste management. The case studies in this report give examples of ways in which suppliers are going beyond merely providing products, services, and materials to actively meeting the needs of companies and participating in forming solutions. In the long term, successful suppliers are likely to be those who anticipate customers' needs—including EHS needs—and provide solutions. Suppliers who actively collaborate in the design, production, and disposal phases are likely to add value to the process—for themselves and for the customer. The case studies also demonstrate a number of examples in which suppliers have proactively made suggestions on environmental improvements to their customers.

5. The implementation of SCEM is still in its infancy.

The use of audits, questionnaires, and product specifications is central to SCEM and was evidenced in most of the case studies. Firms are now refining these processes and making them

more effective and user friendly for both company and supplier. This process involves developing effective mechanisms for use of audits and questionnaires, as in the AMD case study; bringing together the needs of procurement and EHS departments, as in the HP case study; collaborating as customers to produce a single supplier standard for common suppliers, as in the Intel case study; and reducing the burden on suppliers through developing industry standards, as in the HP example.

At present, ERSIs are not being used in a systematic way. This is likely to change as firms mature in their use of SCEM and see opportunities for adding value and rationalizing costs. Suppliers are likely to see more examples of firms in a sector coming together to meet their SCEM needs. Sematech, PIBA/CIQC, and Quantum provide examples of this trend. Suppliers should feel capable of taking an active role in the SCEM process. Firms are still in the process of formulating their programs, and suppliers should not feel discouraged from making contact with their customers. In the case of supplier questionnaires, for example, it may be useful for suppliers to speak with firms to find out which information is most important, and how it is used.

6. The trend is to reduce the number of tier 1 suppliers and lengthen the supply chain.

Rationalization of the supplier base, evidenced in statistical surveys and in the case studies, is becoming a trend. Although this may not necessarily mean that many supplier companies lose business, some will. Niche providers and specialist providers will be best insulated. The real impact of the reduction in the number of suppliers may be to lengthen, rather than shorten the supply chain. In the electronics industry, many of the parts required in production are niche or highly specialized products. These will still have a market, but not necessarily with multinational customers. Global companies will reduce the number of tier I suppliers, but this may simply reorganize the supplier structure so that their enduring tier I suppliers contract with old tier I suppliers, making them tier II suppliers, and so forth. This shift will restructure supplier relationships but may not mean a loss in business for smaller suppliers.

7. SCEM can be a means of environmental risk management.

A primary concern of SCEM practitioners is risk management. This is a shared concern in SCM: "just-in-time" management offsets expensive processes such as storage of inventory to suppliers. Risk management was emphasized by both EHS professionals and procurement officers in the course of interviews for this report. Companies, concerned about inheriting risk from their suppliers, are trying to manage the risk issues of the supply chain. SCEM programs, the concentration of suppliers, and the lengthening of the supply chain will mean that financial and environmental risk is pushed back down the supply chain, onto suppliers. Inventive SCEM programs, however, will help suppliers minimize their own risk as well.

8. The benefits of SCEM may be uneven.

SCEM has the potential to benefit both suppliers and customers. Among suppliers in developing countries, however, concern exists on whether the benefits to suppliers of SCEM will be evenly distributed. In the semiconductor sector, for example, companies in developed countries often export the lower-tech, labor-intensive phases of production to developing countries. These segments of the supply chain may not have the same opportunities to benefit from SCEM initiatives as those associated with the design phase, for example. This suggests that in some segments of the semiconductor industry, suppliers may face environmental requirements without

receiving the benefits of collaboration. This may or may not be applicable elsewhere in the electronics sector, and suppliers may often be able to participate actively in shaping SCEM programs.

9. The marketplace will start to reward environmentally sound products and processes.

Savvy suppliers and regions will recognize the competitive advantage that green products and processes are likely to present in coming years and will position themselves accordingly. As more companies begin to implement sophisticated, comprehensive SCEM programs, it will be a key advantage to suppliers to have clean technologies already in place. Companies that take steps now to begin the process of greening their operations—eliminating or minimizing hazardous material use, favoring cleaner technology, adopting DFE processes, and minimizing environmental risks—will find that they are well positioned to answer rising concerns about environmental management.

10. SCEM complements "just-in-time" management at many points.

Many of the issues in SCEM have already been rehearsed with "just-in-time" management—the increased importance of customer-supplier partnerships, reduction in the number of suppliers, integration of suppliers at the design stage, and pushing risk downstream onto suppliers. The implication of this is that it is not an entirely new aspect in the customer-supplier relationship, but a strategic one and likely to endure.

The strategic and environmental advantages of SCEM ensure that it is a major issue—a different business model—for the next decade and beyond. SCEM may prove to be the most effective way that global firms can spread clean technologies and promote global voluntary environmental management. Companies have the power to effect enormous changes in the environmental performance of their suppliers worldwide without intervention or regulatory involvement. Governments, bilateral organizations like US-AEP, and multilateral aid agencies may also play a complementary and supportive role.

Aid agencies could support SCEM in several ways. They could provide a better understanding of upcoming changes in U.S. and multinational firms' expectations. Studies such as this is one way to assist in this area. Aid agencies could provide access to relevant environmental measuring technologies and/ or lists of restricted or potentially restricted production processes and products. The case studies in this report identify several potential sources among international firms for such lists. They could devise ways to integrate U.S. environmental rules that place obligations on firms—such as TRI reporting, with Asian country environmental rules and with business practice. They could help to protect developing country businesses by providing education in the relevant technical aspects of U.S. rules and practices. They could provide training in environmental management systems and SCEM management systems for Asian managers and institutions. Public/private partnerships like these, and partnerships between suppliers and firms, have tremendous potential to generate positive outcomes for suppliers, for customers, and for the environment.

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