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Environmental supply chain management integration into the purchase of finished electrical products

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Environmental Supply Chain Management: Integration into the Purchase of Finished Electrical Products

by

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Dedication

This thesis is the culmination of many long hours of research and preparation ending several years of graduate course study. This work would not be possible except for the patience, understanding, and support of my wife and two children who put their lives in the background so I could pursue this master's degree. I owe them an untold debt of sincere gratitude.

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Abstract

Representatives from the electronics equipment industry were surveyed and selected companies were interviewed to determine the current level of environmental supply chain integration into the purchase of finished electrical products. Based on the information gathered, a summary of best practices was defined which included insights into effective buyer/supplier relationships and establishing environmental product requirements.

As electronic equipment manufacturers change from a vertically integrated marketing structure to one of a horizontal supply chain, there is an increasing need to outsource manufacturing of or to procure finished products made by another supplier and subsequently branded by the buying manufacturer. The manufacturer's environmental supply chain management system must now include environmental requirements for finished products. This extension of the supply chain follows the same precedence set by the extension of the quality management systems to suppliers. Consistent with quality provisions in supply contracts, environmental requirements form another key contract element.

The ability of a buyer to influence suppliers to meet these requirements will be dependent on the buyer/supplier relationship. It is easier to influence strategic partnerships in which the buyer/supplier share common goals. Common environmental requirements are focused on restricting certain materials in the construction of the finished product. Additional environmental requirements, including those necessary to achieve environmental labeling standards or corporate objectives, are then defined unique to the product being marketed.

Key Words

environmental purchasing, environmental supply chain management, finished product procurement, green procurement, OEM products, supplier partnering, supplier requirements, supplier specifications, supply chain management

1.0 Introduction

1.1 Description of the topic

As electronics industries move towards a business model that focuses more on core competencies and less on the vertical integration of their product lines, it is necessary to outsource products to other manufacturers. Companies may still provide a total solution to meet a customer's needs, however this solution is likely to involve a combination of products that the company uniquely manufactures as well as products that the company obtains directly from other suppliers (i.e., the procurement of finished goods from another supplier).

This outsourcing strategy provides many business challenges to a company. One of these challenges will be how the company broadens its environmental management system to include the supply chain associated with the procurement of these finished goods. Based on this challenge, this thesis attempts to answer the following questions:

(1) To what extent do environmental requirements for the procurement of finished products follow quality requirements for the same products?

(2) What amount of influence do purchasers perceive they have when dealing with large and small OEM suppliers?

(3) What environmental criteria for OEM products are important to leading electronic manufacturers?

1.2 Rationale and significance

Like the implementation of quality aspects into the supply chain as part of a manufacturer's Total Quality Management (TQM) system, manufacturers, particularly electrical equipment manufacturers, are being driven to expand the scope of their environmental responsibility to encompass their supply chain. According to various studies, like the 1998 Focus Study by the Center for Advanced Purchasing Studies (Carter and Narasimhan 5) and the 1999 Clean Technology Environmental Management Program of the U.S.-Asia Environmental Partnership (Krut and Karasin 3-5), environmental supply chain management (ESCM) is still in its infancy. Applying ESCM to the procurement of finished goods is even less well defined. This research will elaborate on the present state of this ill-defined situation.

1.3. Theoretical framework

The framework for this research stems from two different aspects.

First aspect – Quality requirements for finished product procurement

As part of the quality revolution in the United States (1980s and 1990s), companies had to extend their quality requirements to include products from suppliers. Total Quality Management (TQM), ISO 9000 Quality Management System certification, Malcolm Baldrige Award, and the Deming Prize were the terms manufacturers, particularly automobile and electronics manufacturers, grew to know as they tried to compete in a global market. Managing supplier relationships, through supplier partnering, therefore became an important strategic part of the purchasing function. Partnerships were developed according to various driving forces, one of which is quality – forming a partnership to meet the quality needs of the ultimate customer. Quality specifications are driven by a level of supplier ownership and measurement which include safety and environmental goals (Stimson 2). A 1998 Focus Study by the Center for Advanced Purchasing Studies evaluated leading-edge practices and methodologies used in environmental supply chain management (ESCM). This study identified the increasing role of purchasing in ESCM and the use of supplier environmental performance during the selection process. Three lessons were of particular interest:

(1) To achieve the buyer's short time-to-market objective, suppliers must adhere to quality and environmental standards.
(2) Experience from past Total Quality Management continuous improvement activities can be applied to increase the environmental efficiency and effectiveness of a company.
(3) Program success is dependent on the integral alignment of the supplier's environmental capability and the buyer's environmental goals.
(Carter and Narasimhan 1-3)

Second aspect – Environmental guidelines for procurement

"Green purchasing" guidelines are being established to assist purchasing agents in the selection of environmentally considerate products. The United States Environmental Protection Agency (EPA) has developed guidance on "Environmentally Preferable Purchasing" (http://www.epa.gov/opptintr/epp) as well as "A Practical Guide for Materials Managers and Supply Chain Managers to Reduce Costs and Improve

Environmental Performance" (http://www.epa.gov/oppintr/acctg). The World Business Council for Sustainable Development has developed a Suppliers Self-Evaluation Checklist to assist suppliers and buyers improve their competitiveness and environmental efficiency (UK 1). See Appendix A for a copy of this checklist. These guidelines and checklists are useful in identifying environmental characteristics that could be used in a finished goods procurement effort.

1.4 Statement of problem

The extension of a manufacturer's environmental management system to encompass environmental supply chain management is providing an opportunity for purchasing agents to draw upon their past quality practices and to use this experience as they integrate environmental aspects into their procurement activities. How then are manufacturers, and in particular electrical equipment manufacturers, actually incorporating environmental criteria into their purchasing operations?

As Carter and Narasimhan indicate from their 1998 Focus Study, there is no common application of using environmental information for supplier evaluations among leading-edge companies (5). This research explores the current practices that are being used by electronic manufacturers to integrate environmental criteria into their procurement activities for their strategic finished products.

1.5 Interesting aspects

The ability of a purchaser to influence the environmental requirements of a supplier is dependent on the relationship they share. Part of the Purchasing/Supplier Quality Management System (PSQM) involves the linking of the supplier with the vision, mission and objectives of the buying company with the goal of meeting the needs of the ultimate customer. Richard Fernandez (49) states that

> "Suppliers with the strongest links of ties to the plans and objectives of the organization, and whose own organization is in alignment with the same, will inevitably provide products and services that better meet the overall needs of the organization."

According to Lascelles and Dale's research of 300 United Kingdom suppliers, a buyer's influence on its suppliers is directly related to the buyer's purchasing power and that, in general, the supplier's quality assurance program was more effective when the buyer's purchasing power was greatest (91). Without sufficient volume however, a buyer's purchasing power is contingent on their ability to project future sales growth (Buddress 3).

Buyer-supplier exchanges can be broken down into four basic categories each requiring a greater level of buyer and supplier resources. Araujo, Dubois and Gadde describe supplier-buyer relationships in the following four ways.

(1) Standardized Interface: Suppler does not need to understand the buyer's criteria and likewise, the buyer doesn't need to understand the supplier's operation.
(2) Specified Interface: Supplier needs certain requirements from a buyer to manufacture and produce a customized part to meet the buyer's design characteristics.
(3) Translation Interface: Buyer provides information regarding the functional end-use properties of the product and the supplier must translate these into a product offering.
(4) Joint Learning Interface: Supplier and buyer share knowledge about the end-user and supplier operations and jointly develop the product specifications which optimize productivity.

(Araujo et al. 4)

The greater the extent of the partnering, the more resources that will be required by the buyer and supplier. A focus on the interface, rather than the products being exchanged, provides a unique perspective on the relationship. The relationship management emphasis shifts from one of maintaining current product transactions to that of evaluating of the supplier's capabilities and value that they add to the entire supply chain. Buyers need a variety of interface relationships since the capabilities and needs of each supplier/buyer relationship are so diverse. The resource consuming interactive interface provides more inherent value (opportunities for productivity improvements and innovation) but this must be balanced against the resource demands and strategic importance. This interface does not always guarantee a "win-win" situation for each partner (Araujo et al. 2).

Another supplier/buyer model is provided by Stimson. In this model, suppliers are placed into various categories depending on their relative risk, supply cost, volume, or complexity. A four-quadrant matrix provides a pictorial breakdown of the categories, see Figure 1.1 (14)[1].

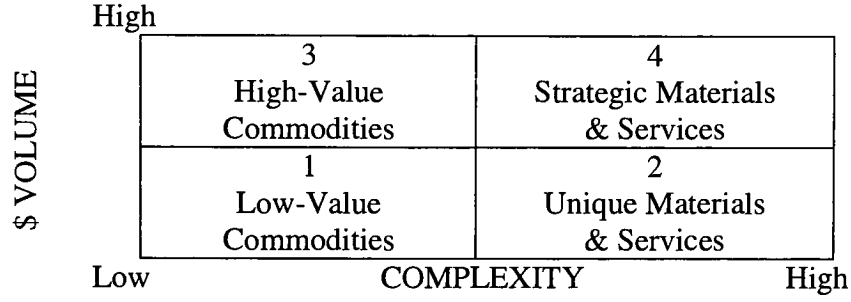


Figure 1.1 Matrix of Commodity Complexity versus Dollar Volume (Stimson 1998)

Rosen, Bercovitz, and Beckman describe five buyer/supplier relationships based on five contractual governance structures.

(1) Classical Contracts: short-term, arms length, spot market contracts
(2) Neo-classic Contracts: specifies a role for a third party to assist with conflict resolution and performance evaluation
(3) Relational Contracting: the framework for the exchange is established by a contract but the details of the relationship are continually agreed upon by both parties committed to a long-term association
(4) Joint Venture: (not specifically defined by the paper authors, but understood to mean a common relationship where both parties participate equally)
(5) Unitary Governance: the vertical integration of both parties into a common corporate structure.
(Rosen et al. 7-8)

The ability of the purchaser to influence the environmental criteria for supplied products will therefore be contingent on the relationship established with that supplier and the amount of power the buyer has in the relationship. Araujo et al., Rosen et al., and Stimson provide models that separate suppliers into various categories. Stimson separates suppliers according to tactical and strategic aspects. Araujo et al. separates

[1]Stimson does not specifically define "complexity". It is expected to mean the relative complexity of the commodity or service being procured.

suppliers according to their relational interfaces with the buyer. Rosen et al. separates suppliers according to their contractual governance structures. All of these models provide a common continuum of buyer/supplier relationships. At the low end are those suppliers that provide commodities (low or high-value), have simplistic interfaces (standard or specified interfaces), or operate under classical contracts. At the high end are those suppliers that provide strategic products (materials or services), have greater interactions (translational or joint learning interfaces), or operate under relational contracts. Joint ventures and unitary governance structures are not considered by the author to be within the context of this research. Environmental supply chain management programs, when they exist within these continuums, have typically manifested themselves in the form of supplier surveys, supplier performance audits or the development of green purchasing guidelines. This thesis focuses on the environmental purchasing efforts at the strategic, translational or joint learning interface level where a buyer is securing a finished product from an OEM supplier for subsequent resale under the buyer's brand name.

1.6 Delimitations and limitations of the work

As part of this study, surveys and in-depth interviews were conducted with representative electrical manufacturers. This study was limited to the responsiveness of those surveyed and interviewed to share information in a timely and non-proprietary manner. In addition, the survey portion of this study was bounded by a certain reasonable number of electrical equipment manufacturers. At the beginning of this research project, it was expected that twenty to thirty electronic equipment manufacturers in the United States would respond. In fact, only fourteen responded, four of which had questions and did not return the survey information. Attempts were made to survey or interview select manufacturers (one or two) outside of the United States. One multinational company provided a response from their operations located in Germany. In depth interviews were conducted with four participants.

1.7 Definition of terms

The following definitions apply throughout this paper. Since many of these definitions are evolving in the environmental vernacular, the author has derived the meanings of each term based on an evolving consensus from a variety of different sources and personal experiences.

Blue Angel: A German environmental labeling program that recognizes products for their environmental design characteristics as measured against defined standards. For electronic equipment, like copiers or printers, these standards include such conditions as the level of emissions from the product, end-of-life management plan of the product, the use of certain restricted materials, and product safety.

DFE: Design for Environment. A design discipline applied to new product development in order to improve the environmental characteristics of the product.

Ecolabel: A label applied to a product indicating that a certain level of environmental performance has been achieved as measured against defined standards. This is sometimes also termed environmental labeling.

EH&S: Environmental, Health and Safety organization within a company.

Energy Star: A voluntary environmental labeling program managed by the United States Environmental Protection Agency that recognizes certain classifications of products as having a low energy consumption when the product is not in use.

Environmentally preferable: products that have a lesser or reduced effect on human health and the environment when compared with competing products. This is also referred to as green purchasing.

EOL: End-of-Life. Product end-of-life aspects pertain to the destination of the product at the end of its useful life. This destination might include a strip and salvage operation for

reclaim parts, a conversion of the product into another product, a recycling of the material components, a conversion to energy in a furnace, or a more traditional disposal in a solid waste landfill or incinerator.

Finished goods/products: those items provided by a supplier to a purchaser that already meet the customer requirements and do not require additional value added by the purchasing organization. These goods are branded by the supplier according to the purchaser's specifications.

Green purchasing: see environmentally preferable.

Green purchasing guidelines: a list of environmental criteria that is considered to be relevant when an individual or organization is contemplating the purchase of a product.

OEM: Original Equipment Manufacturer. The supplier is responsible for the manufacturing of the product branded for a specific buyer. The level of design involvement by the buyer is typically limited.

Supply chain: the delivery system that provides the product or service valued by an end user or final customer. This delivery system includes the upstream operations that enable the product or service to be provided including distribution, manufacturing, processing and raw material suppliers.

Supplier partnering: the integrated strategic relationship between a supplier and a buyer in which the supplier's goals are aligned with the buyer's goals in order to provide valuable products to the end customer.

TCO99: A Swedish environmental labeling program that recognizes monitors for their ergonomic design and low-level electromagnetic emissions.

Total Quality Management (TQM): an organization-wide philosophy led by top management to change and improve quality practices within the organization.

2.0 Background

Manufacturers will continue to see internal and external drivers requiring them to extend their environmental management program beyond the factory walls to include their supply chains. These drivers, with the exception of regulatory drivers, are not unlike the quality drivers in the 1980s and 1990s – customers expecting higher quality levels, off-shore competition with lower cost quality programs, attainment of quality awards to bolster corporate image, ISO 9000 Quality Management System certifications, investors and shareholders making decisions based on overall quality performance, etc. Today, substitute the word "environmental" for "quality" and the drivers for supply chain management take on a new dimension.

This new dimension has spawned the concept of environmental supply chain management (ESCM). As manufacturers become more aware of their Extended Producer Responsibility (EPR) (United States EPA EPR 1), they are beginning to realize the need to extend their environmental considerations to include supplied raw materials, parts, subassemblies, and finished products. For electronic equipment manufacturers, this awareness has been catalyzed by the emerging European take-back regulations (Krut and Karasin 3-4). Figure 1 shows the interrelationship between the upstream supply chain and its potential effect on the end-of-life disposal of the product.

Environmental responsibility for end-of-life management, as characterized by the European take back regulations, would require the importer or manufacturer to be responsible for the appropriate management of the product after its final use. This responsibility would then be cascaded up the supply chain as indicated in Figure 2.1. It would be the responsibility of the manufacturer to work with its suppliers to eliminate certain substances of concern (e.g., heavy metals found in the raw materials or components) in order to reduce the end-of-life management cost or comply with regulatory restrictions.

With this growing responsibility, purchasing agents must determine how they will expand their relationships with both tactical and strategic suppliers or partners. Tactical partners are transaction-related and not strategic to the buyer's business success. An example of a tactical partner would be a supplier of commodity resistors or capacitors. A purchaser can decide to buy these electrical components from supplier X, Y, or Z.

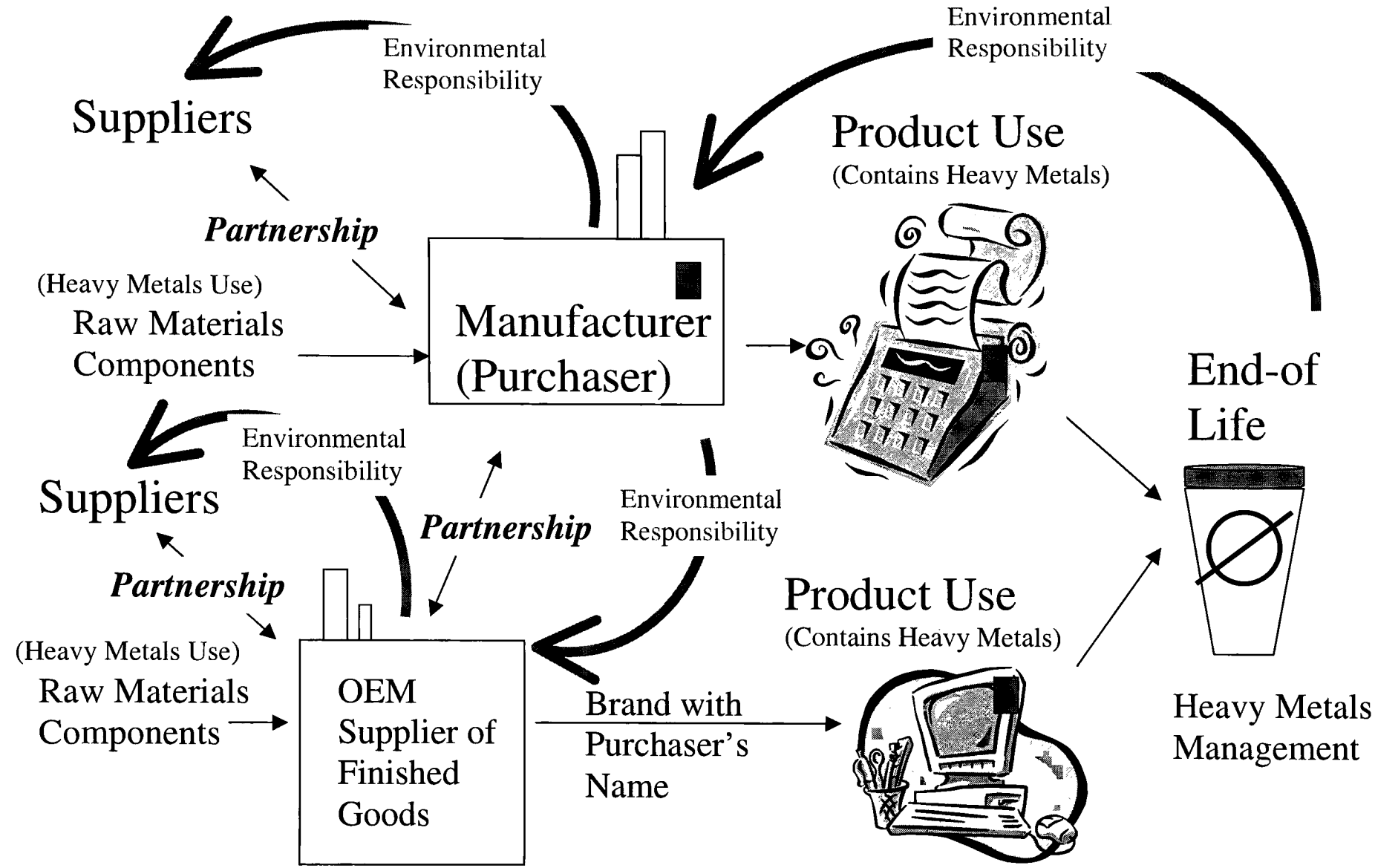


Figure 2.1 Use of Heavy Metals in Supply Chain affects Product End-Of-Life Management

Each supplier provides similar components, there are no strategic reasons to choose one supplier over another. Conversely, strategic supplier partners are those that uniquely help companies meet customer needs. These suppliers offer a product or service that cannot be easily obtained through another supplier thus enabling the purchasing company to obtain revenue for the sale of a product or "achieve the imperatives of a business" (Stimson 11). In support of strategic partnering, relationship management requires appropriate supplier/buyer resources aligned to common goals in order to make the relationship effective. ESCM creates a new model for the supplier/buyer relationship changing the old model of communication through purchase orders to one of shared problem solving (Krut and Karasin 5-6).

Most current supplier environmental efforts are focused on independent certification of a supplier's environmental management system (supplier audits and selection) and/or on the restriction of environmentally unfriendly substances from raw materials, parts and components. In some cases, the purchaser will encourage their suppliers, like IBM (Gabriel 226), or require their suppliers, like Toyota (Toyota asks 1), to become registered to the ISO 14001 Environmental Management Systems standard. There is, generally however, no unique focus on environmental criteria as applied to finished goods procurement.

3.0 Review of the literature

This material is broken down into general categories in which general conclusions are drawn from a review of literary resources (bulletized). Additional individual notes are provided as specific points of interest.

3.1 Buyer-supplier partnering

There appears to be a general understanding that there is a stratification of the various types of suppliers relating to the type of offering provided to the buyer. Off-the-shelf commodities do not necessitate the need for formal partnering. Partnering is important however in those areas in which there is a high level of strategic business importance. Strategic partnering involves a greater commitment by both parties as they enter into a longer-term business relationship.

- Partnerships are developed according to various driving forces one of which is quality – forming a partnership to meet the quality needs of the ultimate customer. Quality specifications are driven by a level of supplier ownership and measurement which includes safety and environmental goals (Stimson 2).

- Partners are distinguished as either tactical or strategic. Tactical partners are transaction-related and not strategic to the buyer's businesses success. Strategic supplier partners are those that help companies "achieve the imperatives of a business." (Stimson 11)

- Suppliers can be placed into various categories depending on their relative risk, supply cost, volume, or complexity. A four-quadrant matrix provides a sample breakdown of the categories (reference Figure 1.1).

Stimson does not specifically define "complexity". It is expected to mean the relative complexity of the commodity or service being procured.

- Araujo, Dubois and Gadde describe supplier-buyer relationships in 4 ways.
  1) Standardized Interface: Suppler does not need to understand the buyer's criteria and likewise, the buyer doesn't need to understand the supplier's operation. (similar to a Stimson quadrant 1 supplier)
  2) Specified Interface: Supplier needs certain requirements from a buyer to manufacture and produce a customized part to meet the buyer's design characteristics. (could be similar to a Stimson quadrant 2 supplier)

3) Translation Interface: Buyer provides information regarding the functional end-use properties of the product and the supplier must translate these into a product offering.
4) Joint Learning Interface: Supplier and buyer share knowledge about the end-user and supplier operations and jointly develop the product specifications which optimize productivity.

(Araujo et al. 4)

- Carter and Narasimhan stipulate that increases in the quality of environmental inputs will create a greater level of environmental supply chain management. In addition, the higher level of supply chain uncertainty, the greater the level of suppler/buyer integration (4-5)

It is expected that the higher level of supply chain uncertainty will warrant the buyer to increase the level of interaction with the supplier in order to sufficiently monitor and manage the risk associated with this uncertainty.

- Partnering focuses on the alignment of the key suppliers and the buyer on best total cost for the end customer, not just on the best price for the supplier and the buyer independently. The individual supplier selection is one of a strategic importance based on mutual open-mindedness and trust with a cross-sharing of visions, missions, goals and tactics between the partners (Armstrong 4)

- Exchanges can be classified by five different contractual governance structures.
  (1) Classical Contracts: short-term, arms length, spot market contracts
  (2) Neo-classic Contracts: specifies a role for a third party to assist with conflict resolution and performance evaluation
  (3) Relational Contracting: the framework for the exchange is established by a contract but the details of the relationship are continually agreed upon by both parties committed to a long-term association
  (4) Joint Venture: (not specifically defined by the paper authors, but understood to mean a common relationship where both parties participate equally)
  (5) Unitary Governance: the vertical integration of both parties into a common corporate structure.

  (Rosen et al. 7-8)

Rosen's Classical Contracts are defined in a somewhat similar manner to Stimson's tactical partners or Araujo's standardized interface for the procurement of commodities. Likewise, Rosen's Relational Contracting is defined in a similar manner to Stimson's strategic partners or Araujo's translational or joint interfaces. These three sources provide a stratification of suppliers from a low end, non-strategic commodity supplier level to a high end, strategic relationship supplier level.

3.2 Business and environmental benefits of partnering

Partnering has proven benefits to reduce costs and reduce the supplier/buyer overall risk. Life cycle cost analysis is one key way to determine the benefit associated with environmental partnering.

- Asea Brown Boveri (ABB) an electrical engineering plant in Canada, and Cominco a mining and metals producer have realized the benefits of aligned corporate goals and strategic partnering. They have been able to reduce transaction and engineering costs. To quantify this success, they are developing business process efficiency measures and life cycle product cost measures to demonstrate the value of the partnership (Maccoby 3)

- A project team under EPA's Common Sense Initiative studied the automotive manufacturing sector with regards to "Life Cycle Management/Supplier Partnerships." The goal of this project was to test whether or not a supplier partnership could lead to better life cycle management decisions and subsequently reduce the environmental burden of the product. One question considered in this project was "How are design criteria such as durability, program timing, and risk (e.g., new technology), cost, safety, etc. considered in a life cycle management (LCM) partnership?" They concluded that, although some design criteria are set by standards (e.g., automobile safety standards), most other design criteria can only be optimized by evaluating the entire life cycle costs. In addition, early communication in the design phase of the partnership may lead to better LCM decisions (United States EPA CSI 6)

3.3 Relationship building

In support of strategic partnering, relationship management requires appropriate supplier/buyer resources aligned to common goals in order to make the relationship effective. The emerging role of supply chain environmental management is not unlike that which presently exists within the quality provisions of the supplier/buyer relationship. There were no specific references to suppliers of finished goods, although this could be expected in the higher-level strategic relationships.

- Close relationships with key "tier 1" suppliers for the Boeing's Commercial Airplane Group are being fostered through the creation of a "Boeing City" in which key suppliers would be located within 30 miles of six fabrication and airplane assembly sites. Of the almost two dozen purchasing goals, there is an

emphasis on the creation of clear "partnership-style" relationships and on building strategic alliances with key suppliers (Stundza 1)

- Buyer-Supplier exchanges can be broken down into four basic models each requiring a greater level of buyer and supplier resources. The greater the extent of the partnering, the more resources that will be required by the buyer and supplier. A focus on the interface, rather than the products being exchanged, provides a unique perspective on the relationship. The relationship management emphasis shifts from one of maintaining current product transactions to that of evaluating of the supplier's capabilities and value that they add to the entire supply chain.

  Buyers need a variety of interface relationships since the capabilities and needs of the suppler/buyer partnership are so diverse. The resource consuming interactive interface provides more inherent value (opportunities for productivity improvements and innovation) but this must be balanced against the resource demands and strategic importance. This interface does not always guarantee a "win-win" situation for each partner (Araujo et al. 2)

- Ingersall-Rand used a program developed by the Small Business Development Center for Enterprise Excellence (University of Texas at Arlington) to improve their relationship with 14 key suppliers. Both Ingersall-Rand and their suppliers saw benefits from this improved customer-driven process. Shane Lein, buyer for Ingersall-Rand remarks "You can't have success if you don't have common goals and values." (Weddle and Priest 2)

- The environmental supply chain management (ESCM) creates a new model for the supplier/buyer relationship changing the old model of communication through purchase orders to one of shared problem solving. However, as ESCM is seen as complementing the "just-in-time" (JIT) quality management practice (supplier partnerships, faster delivery times, reduced number of suppliers, pushing risk further into the supply chain, supplier design integration) the new ESCM relationship is not unlike the strategic supplier/customer quality relationship known to purchasing (Krut and Karasin 5-6).

- Computer manufacturers have typically changed their purchasing strategy from one of short-term, limited communication contracts to one of long-term customized relationships (relational contracting) with a smaller number of suppliers. These long-term relationships provide for a greater interaction on product design, scheduling, cost structures and are conducive for joint efforts regarding environmental management (Beckman et al. 19).

3.4 Buyer influence

Strong linkages between the supplier's quality expectations with that of the buyer's are important when both are striving to provide value to the end-customer. The

influence that a buyer has over a supplier to aligning quality expectations is based on the buyer's purchasing power, or the buyer's potential purchasing power. There is a potential downside of over-powering a supplier, particularly a small supplier, with ever increasing demands. In this area, the environmental influence is likely to follow the same model as its quality predecessor.

- Part of the Purchasing/Supplier Quality Management System (PQMS) involves the linking of the supplier with the vision, mission and objectives of the buying company with the goal of meeting the needs of the ultimate customer. Richard Fernandez (49) states that

  > "Suppliers with the strongest links of ties to the plans and objectives of the organization, and whose own organization is in alignment with the same, will inevitably provide products and services that better meet the overall needs of the organization."

- According to Lascelles and Dale's research of 300 United Kingdom suppliers, a buyer's influence on its suppliers directly related to the buyer's purchasing power and that in general, the supplier's quality assurance program was more effective when the buyer's purchasing power was greatest (91).

- Based on the quality experiences of Frank Armstrong, Avon Automotive Americas Inc., the biggest challenge in the supplier/buyer relationship with regards to the implementation of a quality management system (like QS 9000) in the supply chain is "trying to convince them (suppliers) that we are doing it for their own good." (Suzik 5).

- Without sufficient volume, a buyer's purchasing power is contingent on their ability to project future sales growth (Buddress 3)

- Wayne Tollefsen, Special Projects Manager for Omron Automotive Electronics, replies to the increasing quality management requirements of the automotive buyers in this way

  > "I know what needs to be done to make improvements so that we can withstand the next level of cost reduction negotiations. Every year the customers demand anywhere from 5% to 15% cost reduction. Where's it going to come from? Every time I turn around, I'm being asked to fulfill more requirements, which takes money, resources, and time." (Chase 2)

- Over the years, large manufacturers like General Motors, CNH Global and Deere & Co. have increasingly made supplier requirements more stringent particularly with regards to delivery time, quality levels, and cost. This has created an overwhelming burden for small suppliers. Some small manufacturers with limited resources and finances are forced to sell their businesses to larger firms or competitors. For example, Haban Manufacturing Co. did not have enough human

resources to comply with a 90-page supplier quality requirements manual used by Murray Inc., the lawn and garden equipment manufacturer (Gallun 1)

- Stanley Engineered Components (SEC), a small supplier of oven door latches to Whirlpool had to respond to the new TQM quality requirements placed upon them by Whirlpool if they wanted to continue to do business with the large appliance manufacturer. Whirlpool represented a significant business opportunity for SEC. In 1993, Whirlpool was requiring their suppliers to become partners with them in a new TQM related arrangement. SEC had to change its business philosophy in order to adopt the new TQM principles and to change from being just another supplier to being a concerned business partner. To do this SEC began considering all of the aspects of the final product, not just the aspects associated to SEC-supplied components. Whirlpool required greater than 10 x (ten times) quality improvements, five percent cost productivity improvements per year, and world-class, JIT delivery logistics.

  SEC cascaded these requirements onto their suppliers. After two years of improvement activities, SEC was able to meet the stringent demands. By demonstrating TQM principles in this newly transformed company, SEC was also able to gain additional business from General Electric. Between 1993 and 1997, SEC's sales to Whirlpool increased by one-hundred and twenty-five percent, with a productivity gain of seventy-six percent, and an increase in sales to other customers by 25% (Roethlein 71-81).

Although this represents a perspective from a component supplier, it does demonstrate the effect that a large manufacturer had influencing a smaller manufacturer to change to a Total Quality Management System. This had many benefits to the supplier and the buyer. Although it was painful for SEC, in the end they were a much more valued supplier to their customers.

3.5 Corporate drivers

Buyers will continue to see internal and external drivers that will require them to extend their environmental management program beyond its factory walls to include their suppliers. These drivers, with the exception of regulatory drivers, are probably not unlike the quality drivers in the 1980s and 1990s – customers expecting higher quality levels, off-shore competition, attainment of quality awards to bolster corporate image, ISO 9000 certifications, investors, shareholders, etc.

- The emerging awareness of Extended Producer Responsibility (EPR) captures several existing strategies including eco-efficiency, design for environment, product stewardship, and supply chain management. (United States EPA EPR 1)

- Companies seeking to benefit from the registration to ISO 14001 Environmental Management System should consider how it will reduce the risk of negative supplier activities which in turn reflect on its own internal environmental management system (Cooper 2)

- The research conducted by the Center for Advanced Purchasing Studies found that environmental supply chain management is driven by four forces: governments, suppliers, customers, and competitors (Carter and Narasimhan 4).

- External forces and internal forces are driving electronic companies to develop supply chain environmental management programs. External forces include regulations (in particular the European take-back regulation), customers, and advocacy groups (i.e., non-government organizations, investors, and shareholders). Internal forces include corporate image, risk management, company benefits, and social concerns (Krut and Karasin 3-4).

- AMP, Incorporated internalized requests from customers (OEMs) regarding targeted substances and is surveying their suppliers to better understand and answer requests (Brennan 341)

- Computer manufacturers provided a wide variety response with regards to the drivers for their environmental supply chain initiatives. Some computer manufacturers, began supplier programs in response to corporate design for environment initiatives (ten to twenty years ago), others in response to regulatory provisions (e.g., the Montreal Protocol phase out of chloroflurocarbons), and others in response to increasing customer inquiries. These drivers were also being communicated to their first tier suppliers but very little of this information ever reached second or third tier suppliers who are typically overwhelmed with local regulatory emissions and waste management pressures as well as liability pressures (Beckman et al. 12-17).

3.6 Previous studies

Early 1990s studies focusing on the integration of quality provisions into the purchasing process did not include specific environmental criteria for suppliers. Later studies (1998-2000) of the purchasing process have recognized the importance of including environmental considerations. This recognition and adoption of supply chain environmental management systems is very much in its infancy. Leading companies are using supplier surveys and supplier audits to better understand and make more

knowledgeable business decisions regarding suppliers. As these studies have been conducted, Motorola, Intel, Xerox, IBM, Hewlett-Packard, Quantum, Chrysler, General Motors and Honda appear to be the common leading companies from which quality and/or environmental information was gathered.

Beckman, et al.'s, studies provide an interesting perspective on how environmental pressures are being felt by manufacturers, first tier suppliers and second tier suppliers. These studies are closely related to the topic at hand, verifying the need for more research. The use of interviewing to conduct these studies provides supporting material for the use of this method to gain additional knowledge specific to finished product environmental specifications as part of this thesis.

For the next phase of supplier survey and interviewing, these companies represent potential candidates. The automotive experience may or may not be directly related to the electrical equipment focus of the thesis. The opportunity to brand an OEM product is quite limited in the automotive sector since they manufacture most of their own automobiles. However, that industry is in the forefront of environmental stewardship and is facing the same driving forces (including the European End-of-Life Vehicle Directive).

- In 1993, James F. Cali authored "TQM for Purchasing Management" in which he briefly described what 28 well respected companies were doing to integrate quality practices into their purchasing operations. These 28 companies included

Apple	Harley-Davidson	Navistar International
Bell & Howell	Haworth	NCR
Black & Decker	Honda	Outboard Marine
Briggs & Stratton	IBM-Rochester	Raytheon Small Missile Division
Caterpillar	ITT Defense	Thiokol
Chrysler	Kurt Manufacturing	Toyota
Corning	McDonnell Aircraft	Westinghouse
Cummins Engine	Morton & Co.	Xerox
Ford	Motorola	Yale Materials Handling

  Cali defines a model for implementing Total Quality Management (TQM) in purchasing but none of the benchmark companies are cited for any environmental considerations as part of their purchasing strategies (43-59).

- In 1995, Ricardo R. Fernandez authored "Total Quality in Purchasing and Supplier Management" which described the relationship of the Purchasing/Supplier Quality Management System (PSQMS) to the Total Quality

Management System (TQSM). The book places an emphasis on quality tools and the use of quality awards to improve supplier performance. A description of various types of supplier certification process used at the following companies is provided.

Chrysler	Florida Power & Light	Ford
General Motors	Motorola	

Florida Power & Light was a previous winner of The Deming Prize, a prestigious quality award originating in Japan, and Motorola was a previous winner of the Malcolm Baldrige National Quality Award, a U.S. quality award granted by the National Institute of Standards (132-135).

The book does not specifically discuss supplier certifications based on environmental criteria, however, there is at least one reference to environment in the appendix case study of Michigan Consolidated Gas Company as part of the Supplier Evaluation Audit (277).

"Is there evidence of good housekeeping and safe practices/environment?"

Neither The Deming Prize nor the Malcolm Baldrige Award previously had specific criteria for environmental performance, although The Deming Prize did list "environment" in a comprehensive listing of various measured "results".

"Substantive results in quality, services, delivery, time, cost, profits, safety, environment, etc." (Fernandez 39).

Since 1995 however, the Deming Prize criteria and the Malcolm Baldrige Award criteria have been updated to include environmental aspects including the following sections

Deming Prize

section 2.4 Relationship to ISO 9000 and ISO 14000

"When ISO 9000 and ISO 14000 are implemented, the consistency between TQM and these systems are assured and executed." ("Deming" 4)

section 4.4 Environmental Management

"An environmental management system is established. Considering the effects of the company's operations to its communities and environment, it actively addresses the issues such as ISO 14000, LCA (Life Cycle Assessment), and eco-marks. Recognizing the importance of the global environment, the company addresses the environmental issues and problems enthusiastically." ("Deming" 6)

section 10.3 Social Relations

> "As a good corporate citizen, the company maintains its management transparency and fairness. Its concerns for co-existence with local communities, contribution to society, and environmental issues are well thought out and carried out to achieve favorable results." ("Deming" 8)

Malcolm Baldrige Award
section 1.2 Public Responsibility and Citizenship

> "Protection of health, safety, and the environment includes your organization's operations, as well as the life cycles of your products and services. Also, organizations should emphasize resource conservation and waste reduction at the source." (United States Dept. of Commerce 3)

section 6.1 Product and Service Processes

> "You should consider the key requirements for your products and services. Factors that might need to be considered in design include safety, long-term performance, environmental impact, "green" manufacturing, ..." (United States Dept. of Commerce 41)

- A 1998 Focus Study by the Center for Advanced Purchasing Studies evaluated leading-edge practices and methodologies used in environmental supply chain management (ESCM). Fourteen firms were selected for case-studies including

3M Corporation	Eli Lilly	Novartis
Daimler Benz, AG	Grundfos	Novo Nordisk
Dekra Umwelt GmbH	Hoechst AG	Oscorna
DENSO Manufacturing. Michigan, Inc	Honda of America Manufacturing	Sidler GmbH and Co.
		Whirlpool

Thirty-four key lessons were recorded as part of this study. Most of these lessons dealt with the buyer's environmental management program, the increasing role of purchasing in ESCM, the use of supplier environmental performance during the selection process. Three lessons were of particular interest are as follows

(1) To achieve the buyer's short time-to-market objective, suppliers must adhere to quality and environmental standards.
(2) Experience from past Total Quality Management continuous improvement activities can be applied to increase the environmental efficiency and effectiveness of a company.
(3) Program success is dependent on the integral alignment of the supplier's environmental capability and the buyer's environmental goals.

(Carter and Narasimhan 1-3)

The research project concluded that environmental supply chain management is still in a beginning stage and that there is no common application of using environmental information for supplier evaluations among leading-edge companies. (Carter and Narasimhan 5)

- In 1999, the Clean Technology Environmental Management Program of the U.S.-Asia Environmental Partnership sanctioned a study of seven firms to identify major environmental issues related to the purchasing within the electronics industry. Their report, entitled "Supply Chain Environmental Management: Lessons from Leaders in the Electronics Industry", engaged the following companies (Krut and Karasin 1):

Advanced Micro Devices	Intel Corp.	Xerox Corp.
Applied Materials	Quantum Corp.	
Hewlett-Packard	United Technologies Corp.	

This report outlined the common environmental supply chain management (ESCM) tools commonly used and ten emerging themes representing challenges and opportunities with one of the conclusions identifying the fact that the actual implementation of ESCM is still in its infancy. The initial use of supplier audits, questionnaires, and environmental product specifications, all core pieces of an effective ESCM, are now being refined making them more user-friendly and effective (Krut and Karasin 3-5). A collection of environmentally related supplier initiatives was documented and is provided in Appendix B.

The initiatives identified are similar to those found within the context of the literature search – supplier questionnaires, supplier selection criteria, supplier audits to monitor performance, exchange of information, etc. Two particularly relevant tools defined in the study were (1) build environmental criteria into supplier contract conditions and (2) build environmental considerations into design. It appears that the "criteria" are centered around restricting certain substances in component supplies. These criteria include life cycle considerations for hazardous raw materials, reduced energy consumption during manufacture and use, and minimizing end-of-life impacts (recycling, reuse). None of these approaches explicitly define efforts to deal with finished good suppliers.

- In the late 1990s Beckman et al., conducted a two year study of environmental supply chain management of manufacturers and suppliers in the computer industry. They used exploratory case interviews to obtain information from environmental and/or procurement managers at nineteen companies. These companies ranged from component suppliers (semiconductor fabricators), to

assemblers (circuit board), to end-product manufacturers (computer manufacturers). In addition, they rounded their study with interviews from members of the Semiconductor Equipment and Materials International (SEMI) trade association and California Environmental Associates an associated consulting firm. Companies studied include the following

Media/Head Disk Assembly
Read-Rite Corporation
Anonymous Media Supplier*

Disk Drive Manufacturers
Anonymous Disk Drive Manufacturer*
Quantum Corporation
Western Digital

Networking Products
3Com Corporation
BayNetworks, Inc. (now part of Nortel)

Printed Circuit Board Assemblers
Solectron, Corp.

Semiconductor Equipment Suppliers
Silicon Valley Group, Inc.
Ion Systems

Semiconductor Fabricators
Intel Corporation
SGS-Thomson

Computer Manufacturers
IBM
Hewlett-Packard Company
Motorola
DEC (now part of Compaq)
Sun Microsystems, Inc.
Anonymous Computer Manufacturer*
Silicon Graphics, Inc.

* Companies who participated but wanted to remain anonymous

Computer manufacturers and first tier suppliers were feeling the pressure to integrate environmental aspects into their supply chain. Intel, a supplier to HP, for instance, describes communicating with HP on environmental issues to better understand and position Intel to be a valuable partner to HP. Most companies studied had general environmental clauses in their corporate umbrella contracts with suppliers (i.e., supplier agrees to comply with applicable laws and regulations). Individual product environmental specifications, if identified at all, were left to the individual project teams and included as an attachment to the contract. Computer manufacturers typically integrated environmental aspects into their existing supplier performance measuring criteria. Standardized supplier surveys, such as the one developed by the Computer Industry Quality Conference (CIQC), have been in use by leading computer manufacturers since 1996. These surveys help to heighten environmental communications and initiate actions towards common buyer/seller expectations.

The study concludes that there is a broad spectrum of approaches to dealing with environmental purchasing requirements and that relational contracting, emphasizing collaboration, is a critical characteristic to ensuring environmental performance of suppliers. The authors note that there is still more work to be done to document the implementation of environmental aspects in to the supply chain. (Beckman et.al. 1-27)

- In 1999, Rosen, Bercovitz, and Beckman conducted a study to analyze the relationships between manufacturers in the computer industry and their suppliers

from the perspective of transaction cost economics (TCE). The TCE perspective provides a conceptual method of describing the way purchasers are managing economic risks associated with their programs to improve supplier environmental performance. They focused on a vertical sector of the computer industry supply chain comprised of three parts (1) the manufacturer that sold computers directly to the end user, (2) suppliers of the disk-drive subassembly, and (3) suppliers of semiconductor equipment or fabricators in the sub-supply chain. Their study involved phone interviews with environmental and/or procurement managers in 15 different companies including the following:

Media/Head Disk Assembly
Read-Rite Corporation
Anonymous Media Supplier*

Disk Drive Manufacturers
Anonymous Disk Drive Manufacturer*
Quantum Corporation
Western Digital

Semiconductor Equipment Suppliers
Silicon Valley Group, Inc.
Ion Systems

Semiconductor Fabricators
Intel Corporation
SGS-Thomson

Computer Manufacturers
IBM
Hewlett-Packard Company
DEC (now part of Compaq)
Sun Microsystems, Inc.
Anonymous Computer Manufacturer*
Silicon Graphics, Inc.

* Companies who participated but wanted to remain anonymous

In addition, they rounded their study by interviewing staff members at the Semiconductor Equipment and Materials International (SEMI) trade association and the California Environmental Associates consulting firm. This firm has been active in the Pacific Industry and Business Association (PIBA) trade organization that has helped to develop industry standards relating to ESCM.

TCE is an economic theory based on two main assumptions (1) parties in a transaction seek to minimize the cost of the transaction including both the actual costs of the goods or services as well as the relationship costs (legal, administrative, data gathering, negotiating, monitoring, enforcement), and (2) both buyers and suppliers are self-interested economic actors that may work to maximize their individual profits by resorting to such tactics as false promises or secretly cutting corners.

The study concluded that there were two types of ESCM programs in use. One program focused on the supplier's environmental management system, the other program focused on environmental product design or DFE (elimination of hazardous chemicals, use of recycled materials, etc.). The level of buyer/supplier involvement was highly correlated with how buyers structured their relations with their suppliers. Buyers with the least active supplier involvement required little of their suppliers and operated mainly within the classical contracting, arms length relationship. Those buyers with more active ESCM programs were using

relational and neo-classic contracting methods as well as classical contracting to structure their supplier program.

Buyers were categorized according to their involvement with supplier DFE involvement – minimally, some, and actively and with their supplier environmental management system (EMS) involvement – minimally, moderate and significant. Those with "some" or "moderate" involvement were starting to ask their suppliers to go beyond compliance and to consider such items "gray lists" of materials to avoid. In addition, they were sending questionnaires to their suppliers asking them about their EMS and conducting site visits. Buyers that were "actively" or "significantly" involved with suppliers were requiring them to meet the buyer's environmental goals, and were working with them to meet eco-labeling requirements (U.S. EPA Energy Star, German Blue Angel) and take-back requirements. In addition, they had formal programs to monitor and improve supplier EMS practices favoring those that were environmentally progressive.

These advanced buyers relied extensively on relational contracts with their suppliers and communicated requirements in advance of their actual implementation. Communications through a more flexible relationship rather than through a conventional classic contract allows the buyer to make trade-offs between a supplier's environmental weak performance and the supplier's strong performance in other areas. (Rosen et al. 3-20)

This study, although based on a very small slice of the electronics industry, does provide a unique perspective based on an economical risk model, transaction costs economics, TCE. Using this model, the study suggests that the more a supplier has to invest in unique environmental technology to meet the customer's environmental goals, the better it will be for the buyer to use long-term, neoclassic and relational contracting arrangements. This confirms the need for strategic partnering in order to meet the environmental goals of the buyer and ultimately the needs of the end customer.

- In 2000, the Center for Advanced Purchasing Studies published an evaluation of "Purchasing's Contribution to the Socially Responsible Management Supply Chain." As part of this report, they interviewed 26 managers from purchasing, transportation, and warehousing from manufacturing and service organizations. A complete listing of companies is not provided in the report, however, the following firms were identified (Carter and Jennings 2):

Coca-Cola	General Mills	Reynolds Metal Co.
The Dial Corporation	Honda of America	Toro Purchasing Co.
F&G Life	McNeil Consumer Products Co.	The Valspar Corp.

Based on these interview, eight environmental activities were identified for purchasing's involvement in socially responsible management (Carter and Jennings 19).

(1) Ensuring that supplier processes and products are environmentally sound
(2) Sourcing from environmentally sound suppliers
(3) Purchasing recyclable and reusable packaging and containers
(4) Using life cycle analysis
(5) Participating in design for reuse and recycling
(6) Identifying and sourcing non-hazardous alternatives
(7) Ensuing proper labeling, documentation and packaging of hazardous materials
(8) Reducing packaging materials

3.7 Green procurement guidelines

General environmental procurement checklists are not specific enough for direct OEM use, although they could be tailored with some limitations, to be a valuable starting point for considering important environmental aspects. There is a great deal of literature regarding "green procurement" of some product types (e.g., recycled paper, Energy Star office products) specifically for state or federal purchasing agents. Nagel does provide a comparison of "Green Procurement" and "Environmental Supply Chain Management" approaches. He concludes that the environmental supply chain management approach leads to a higher level of sustainable development.

- The World Business Council for Sustainable Development has developed a Suppliers Self-Evaluation Checklist to assist suppliers and buyers improve their competitiveness and environmental efficiency (UK 1-2) See Appendix A for a copy of this checklist.

- EPA has published guidance on "Environmentally Preferable Products" that includes Appendix B: Environmental Attributes. These attributes include natural resource use human health and ecological stressors, hazard factors associated with materials, and positive attributes. The listing of attributes is provided to help Executive agencies in their environmental assessment of services and products consider for purchase. See Appendix C for a listing of these attributes. (United States EPA's Final 2-5)

- EPA has published "The Lean and Green Supply Chain: A Practical Guide for Materials Managers and Supply Chain Managers to Reduce Cost and Improve Environmental Performance". This document demonstrates, through the use of examples, supply chain improvements in the areas of purchasing, materials

handling, storage, materials recovery, disposition, and product take back. It also provides environmental cost and benefit categories for these six areas. Finally, this guide defines a four step decision making framework that includes (1) the identification of potential environmental costs, (2) the determination of improvement opportunities, (3) the calculation of benefits for opportunities, and (4) the decision to implement and monitor a course of action. (United States EPA The Lean 10)

This is a general guidance document not specific to raw materials or finished products.

- M.H. Nagel, a faculty member of Industrial Design from the Delft University of Technology compares the approach of Green Procurement to the approach of Environmental Supply Chain Management as used in the electronics and telecommunications industry along a continuum of sustainable development. Stating that there is no clear definition of "green procurement" in the electronics industry, Nagel characterizes green procurement as a series of short action-driven activities driven by mostly external regulatory drivers in which the supplier has to meet a set of component or product related environmental requirements. In contrast, environmental supply chain management is a long-term business strategy directed program triggered by internal leadership drivers that are based on the integration of environmental quality requirements from the customer to the supplier. Nagel concludes that the environmental supply chain management approach leads to a higher level of sustainable development. These two approaches are contrasted in the following table (220-224).

Table 3.1 Comparison of Green Procurement Approach Compared to Environmental Supply Chain approach

Green Procurement Approach	Environmental Supply Chain Management Approach
Action-driven program against environmental criteria or a survey to assess supplier performance	Strategy-driven program with the integration of environmental quality from a business perspective
External direct drivers from legislation, customer requirements, or competition	No external drivers, internally driven by vision and leadership
Reactive, short-term	Proactive, long-term
Can trigger environmental technology innovations	Focused to trigger environmental technology innovations
Cost Avoidance, minimizing competitive and regulatory risks	Cost Effective, coupling material and energy into a total cost of ownership model
Creates environmental awareness from the bottom up (i.e., supplier relationship into the business operations)	Creates environmental awareness from the top down (i.e., a business imperative to working with suppliers)
Mostly concerned with material content of components and products	Mostly concerned with material content of components and products as well as the production processes

3.8 Today's supplier efforts

Most current supplier environmental efforts are focused on independent ISO 14001 certification of the supplier base and/or on the restriction of environmentally unfriendly substances from raw materials, parts and components. There is no particular focus on the environmental criteria for finished goods (although a higher-level finished good could be considered as simply a very large complex component).

For more than 5 years, The Institute of Electrical and Electronic Engineers, Inc (IEEE) has held annual international symposiums on electronics and the environment. These symposiums cover a broad range of environmental topics relevant to the electronics industry including the following topics: improvements in manufacturing methods, implementation of design for environment and life cycle assessment tools, disassembly and end-of-life disposal strategies, environmental management systems, and environmental supply chain management. The only paper that alludes to environmental requirements for finished products is IBM's paper presented last year entitled "Environmental Conscious Products Integration into the Supply Chain: an IBM

Perspective." Environmental requirements are "being prepared for basic engineering materials (plastics, metals, paints, inks, lubricants, etc.) and complete OEM products." (Gabriel et.al. 228).

- Johnson Controls, Inc. has implemented a yearly "Supplier Performance Awards" program that recognizes key suppliers on three levels, gold, silver, and bronze for their performance in four areas: quality commercial, material and logistics, and service and engineering support. They are currently registering their manufacturing sites to ISO 14001 and are encouraging suppliers to implement environmental management systems as well. In addition to the four award areas, in 2000, the company developed criteria to evaluate suppliers based on their commitment to the environment. ("Johnson" 2)

- Saturn has entered into partnership with its suppliers, the state of Tennessee the U.S. Environmental Protection Agency and the University of Tennessee to improve the environmental performance of Saturn and its suppliers based on relevant issues identified in ISO 14001 environmental management standard. ("Saturn" 1)

- Toyota is, as part of their Supplier Environmental Program, is requiring 500 suppliers to conform with its list of 450 banned chemicals and to become ISO 14001 certified by the beginning of 2004. ("Toyota asks" 1)

- Toyota's supplier requirements are specified in their "Green Supplier Guidelines: Leadership in Environmental Performance" brochure. These guidelines extend Toyota's environmental program to its business relationships and partnerships that it manages with 500 parts, materials, and component suppliers. ("Toyota Issues" 1)

- Toyota is requiring its 500 North American suppliers to complete one or more of the three initiatives (1) obtain ISO 14001 certification by year end 2003, (2) comply with its regularly updated list of approximately 450 banned substances, and (3) develop procedures to ensure compliance to applicable state, federal, and international hazardous materials transportation requirements. (Toyota 1-2)

- Over the last several years, IBM has significantly changed its procurement business model from one of a decentralized tactical organization supplying all components and raw materials to IBM manufacturing facilities to a matrixed strategic organization supplying parts, subassemblies and entire products to IBM. Environmental supply chain integration is focused on supplier assessments (permits, compliance history, on-site evaluations) and on encouraging suppliers to align or register their environmental management systems to ISO 14001. The latest process improvements in this area has been focused on the development of separate engineering specification documents for:
  raw materials (plastics, metals, paints, lubricants, inks, etc.)

- components, parts, and simple subassemblies
  complete finished products

The table below identifies the contents of a typical engineering specification. In addition to these requirements, IBM also is developing OEM specifications that include functional environmental requirements in such areas as energy efficiency, acoustic output, electromagnetic fields, and chemical emissions (Gabriel, et al. 226-228)

Table 3.2 IBM Contents of Engineering Specifications (Gabriel, et al. 2000)

Materials not permitted in IBM purchased products, parts, and assemblies
Materials not permitted in plastic parts
Materials not permitted in paints, and plastic coloring agents
Materials not permitted to be used in manufacturing of IBM purchased products, parts, and assemblies
Requirements for product protective packaging
Requirements for coding of plastic parts
Additional requirements for batteries battery content restrictions product design and labeling requirements for batteries requirements for rechargeable lead acid batteries requirements for nickel metal hydride batteries requirements for nickel cadmium batteries

This is the only literature reference that specifically identifies the need for environmental specifications for OEM purchased electrical products. Since these OEM specifications were not yet developed at the time this article was printed (May 2000), no information was provided regarding how these were used in supplier relationships.

- In the fall of 1996, the Computer Industry Quality Conference (CIQC), a U.S. based network of computer system producers, published the first common tool for obtaining supplier environmental information. This standard, CIQC STD 0014, was developed by the following member companies:

Apple	Hewlett-Packard	Silicon Graphics/Cray Computer
Compaq	IBM	Sun Microsystems
Digital (now part of Compaq)	Lucent	

The standard focused on environmental performance of the supplier, not on the specific product offerings. It was developed to provide a common format for

evaluating suppliers common to the computer industry. The standard consists of two parts, Part 1 an assessment of the supplier's continuous improvement and compliance efforts and Part 2 a risk assessment of the supplier's environmental management system ("Hewlett-Packard 1). The complete standard is found in Appendix D.

This standard can be applied to the purchase of OEM products, however, it is not product specific to the product that is being procured.

- An eco-design questionnaire for suppliers to the electronics industry has been developed by Delft University of Technology. This questionnaire, entitled "Supplier's Sustainability Self-audit", is provided in a user-friendly software package. A software demo can be downloaded from the following website: http://www.io.tudelft.nl/research/dfs/ecoquest.htm. This software enables a supplier to perform an environmental self-audit after completing a series of questions. The questions are broken down into two sections Part A consists of 25 questions focused on product design, materials, energy consumption, distribution, packaging, durability and end-of-life disposal. Part B consists of 10 questions focusing on the suppliers environmental management system. A graphical spider plot evaluation is produced based on eight measures with improvement opportunities identified. These measures include (Brink, et.al. 131-132):

New concept development	Low-impact materials
Material use	Production techniques
Distribution systems	Impact during use
Initial lifetime	End-of-life system

Although this software is identified as a supplier tool for the electronics industry, it is severely lacking in specific details regarding material and design details for individual parts. As such, it is not a sufficient tool for suppliers to assess the environmental sensitivity of their product offerings.

- Motorola has developed an eighteen page "Ecodesign Criteria Substance List" providing suppliers with environmental performance requirements for many materials. This list has a reporting threshold limit identified for most materials, beyond which suppliers are expected to report if they are contained in a suppliers' components and products (Motorola 1).

- Sun Microsystems has integrated environmental requirements into their existing "ScoreCard" used to assess their top forty suppliers every quarter. This ScoreCard contains four performance measures including (1) quality, (2) delivery, flexibility, and lead-time, (3) product and process technology, and (4) support. Environmental requirements have been included as part of the questions

surrounding product and process technology. At the time of this publication in 1997, Sun Microsystems was considering using the CIQC questionnaire to identify industry leaders, industry average performers and industry followers (Craig 283-284).

- The Electronic Industries Alliance (EIA), a trade association of U.S. electronic equipment manufacturers, has progressed a twenty-two page draft "Material Declaration Guide" that provides industry consensus on the types and on the threshold quantities of materials to be reported by a supplier. The declaration is divided into three sections (1) prohibited materials: materials subject to a regulatory ban or a voluntary industry prohibition, (2) restricted materials: materials that are prohibited only in certain applications (e.g., cadmium in dyes, pigments, paints, enamels, plastic stabilizers in electric cables), and (3) materials of interest: materials that the electronics industry would like to track for end-of-life management or other reasons (Evans "Re: Concall" 1).

EIA has combined restricted material lists from several manufacturers (IBM, Kodak, Motorola, HP, Xerox, IBM, etc.) in an effort to arrive at a common industry guideline that can be used in supplier relationships. These lists are most commonly applied in non-strategic, tactical, buyer/supplier relationships. They may be useful in strategic relationships as starting point from which to build other environmental requirements.

4.0 Methodology

4.1 Description and rationale

Three methodologies were utilized during the research. These include (1) a literature review considering relatively new concept of environmental supply chain management, (2) a qualitative survey approach with scalable answers used to sample existing environmental supply chain management practices in the electronic industry, and (3) a qualitative interviewing approach selected from leading-edge survey participants from which a set of best practices are defined. Each method is described in additional detail below.

4.1.1 Literature Review

This method was used to investigate new or relatively new approaches with potential advantages over existing approaches. The use of environmental criteria in the purchasing of raw materials and components for electronic equipment manufacture is relatively new, however, the use of environmental criteria in the purchasing of finished products (i.e., products supplied by one company specifically for the branding and sale by another) is even less understood. A literature review was used to explore documentation of existing practices in use including, but not limited to, the electronics industry. There may be some potential lessons that can be learned from other industries – in particular the automotive industry.

4.1.2 Survey

A survey questionnaire was used to augment the literature search and to evaluate the practices of electronic manufacturers. The questionnaire was pre-tested to obtain user feedback on its format and clarity. Minor modifications were made to the survey as a result of the feedback received. Due to time constraints, the number of final survey participants was limited, although a representative cross section of industry was attempted. The survey was limited to US companies, including multinational companies. The responses to the survey enabled a landscape to be created with regard to the range of activities currently in use or planned.

4.1.3 Interviews

In-depth interviews were conducted with a few key survey respondents to better understand and characterize leading-edge practices. These interviews were telephone interviews. Results of the interviews were used to identify best practices and additional opportunities for improvement.

The interview questions were structured in such a manner as to be asked in the same order for each participant, delving into areas that may provide additional insights as necessary.

Taken together, the literature review, survey and interviews were used to triangulate the conclusions drawn to answers the research questions.

4.2. Data collection and management

Data collection for the literature review was conducted via traditional research methods including an analysis of relevant published literature found in books, journals, magazines, papers and websites. This information was abstracted and categorized in order to form conclusions according to each category. The categorization was done according to common themes derived from the literature reviews.

Data collection for the survey was done in a series of phases. The first phase was to identify from electronic trade associations manufacturers that could potentially be surveyed. The population of electronic manufacturers was deliberately framed by the population of companies participating in these trade associations. These participating companies generally represent the leading companies in the industry. According to the scope of this study, trade associations were selected from the United States including the Electronics Industries Alliance (EIA) and the Information Technology Industry Council (ITI). In addition, opportunities to survey European based electronic manufacturers were pursued through the American Electronics Association, Europe (AEA-Europe) and ECMA (formerly known as the European Computer Manufacturers Association) trade associations. As expected, this survey group of companies was much smaller in size than their U.S. counterparts. As such, a

direct valid comparison of European practices compared to U.S. practices is not possible. See Appendix E for a description of each of these trade associations.

These trade associations were selected based on the author's knowledge of environmental activities within each association. An alternative approach would have been to pursue survey participants through a purchasing related trade association like the National Association of Purchasing Management (NAPM). NAPM members are involved in industries that are much broader than just electronics manufacturers. It was therefore determined by the author that this approach would be less likely to provide results in a reasonable timeframe.

The second phase was to create a sample survey using filtering questions (Trochim 3) and pre-test ("Writing" 7) this on two companies so that survey comments could be collected and refinements could be made prior to full survey distribution in phase three.

The third phase was a single stage sampling exercise in which those companies that could potentially participate were contacted with a letter and an attached survey. The introductory letter is provided in Appendix F and the survey is provided in Appendix G. To reduce the cost and time of this survey, the survey was conducted by e-mail. This means allowed efficient forwarding within a given company for appropriate participant direction, review and comments. Participants were encouraged to return the survey with a promise of confidentiality (Hossein 4) and of receiving the final survey aggregated results.

Based on the author's experience with manufacturing quality systems, the general rule of thumb requires a minimum of thirty data points from which to draw meaningful process conclusions. In addition, the author's past experience participating in the development of regulatory advocacy programs sponsored by these trade associations has demonstrated that twenty to thirty companies typically rally around a common issue. Given the minimum sampling needed to assess the quality of a process and given the likelihood of obtaining a certain level of trade association participation, attempts were made to achieve a minimum sample size of 30 survey participants.

The fourth phase was to follow-up with prospective participants via a reminder e-mail memo two weeks after the defined response date. This memo included the attached survey.

The returned surveys were screened for relevance and those companies producing answers in which they are actively using environmental supply chain management approaches with their suppliers of finished products were purposefully identified (Creswell 148). A reasonable selection of the best four electronic manufacturers was contacted to arrange for in-depth interviews. These qualitative interviews were conducted using open-ended questions according to predetermined interview protocol (Creswell 153) as defined in the Interview Guide found in Appendix H. To minimize costs, and in line with general limits for interview tolerance, interviews were conducted over the telephone expecting to last approximately 30 to 40 minutes ('Writing" 2). Written notes were taken during the interview.

4.3 Analysis and evaluation

Survey data is reported by the percent of respondents and non-respondents. Qualitative survey results were tallied according to individual questions. Most questions are designed according to a modified Guttman or cumulative scale approach (Trochim 1). Answers were arranged in a progression such that choices progressively identify companies with a better overall management system. For example:

Question: Select one of the following statements that best reflects your company

__ none or minimal experience related to the question

__ more experience related to the question

__ most experience related to the question

In addition, for each question a "none of the above" choice was provided in an effort to encourage the participants to answer the rest of the questionnaire. Additional investigation into the reason a participant choose a "none of the above" answer may provide opportunities for further research beyond the scope of this particular project.

Two questions were structured as filtering or contingency questions that lead directly to subsequent questions for those participants that have more experience on a particular topic (Trochim 3).

Tallied responses were compared against generalizations found in the literature search to determine the association between survey results and the literature conclusions. Those participants with the greatest cumulative experience across all questions were identified for in-depth interviews.

The range and commonality of responses was documented for each interview question. Major themes, dependent on the range disparity, were identified from the interview responses. If the range disparity is large for a question, one common major theme may not be readily apparent. In this case, there may be no major theme, or conversely, there may be more than one major theme identified. Based on these themes, a set of best practices was documented. These best practices were compared to the literature search to determine the association between the best practices and the literature conclusions.

4.4 Summary

The methodological literature review was used to define the current published practices used by corporations to integrate environmental requirements into the supply chain for the purchase of finished products. Surveys were e-mailed to electronic equipment manufacturers to collect and subsequently tally responses. Those participants that rate highest on the survey were identified for in-depth interviewing. Best practices were derived from the interviews. Survey and interview results were compared to the literature conclusions. Supporting or divergent aspects of this comparison are documented.

5.0 Survey results and discussion

5.1 Survey delivery and responses

As described in the Section 4.2. Data collection and management, the survey process was conducted in four phases. In phase one, trade associations were contacted to determine the best means in which the survey could be delivered to association members. Three means were used:

(1) EIA decided to send the survey out on behalf of the author to its appropriate members

(2) ITI members could be sent the survey by the author via a committee list-serve available to the author

(3) Selected AEA-Europe and ECMA members could be sent the survey by the author's European colleague

In phase two, a sample survey was created and pre-tested on one electronics company (Calkins 1) and one industry consultant (Christensen 1-5). As part of the pre-test phase, neither survey was completed by either of these two sources, although both provided feedback on the survey questionnaire. Based on their comments, minor modifications were made to the survey. The final survey is provided in Appendix G.

In phase three, the survey was sent via e-mail to trade association members as described above. The survey to EIA members was sent directly from EIA to seventeen participating companies of EIA's Environmental Issues Council with responses returned directly from survey participants to the author (Evans "Fwd: Industry" 1). The survey to ITI members was sent directly from the author to fourteen participating companies members of ITI's Product Life Cycle Environmental Management Committee, Technical Committee 1 via the committee's list-serve distribution list (Kelsey "Industry" 1). In addition, personal e-mails were graciously sent from Greg Batts, to nine member companies in AEA-Europe and ECMA (Batts 1). Their responses were returned to Mr. Batts and subsequently forwarded to the author. Potential survey participants were given a specified time frame in which to respond, approximately two weeks after the first request. The same time frame was used for follow-up requests, and personal memos.

After the first requests were sent out, seven replies were received. Based on this relatively low response rate, a second follow-up memo was sent out to ITI members. A reminder to return the survey was published in EIA's weekly "Inside Skinny Report" publication (Linnell 3). After this follow-up activity, four additional surveys were returned. Finally, e-mails were sent from the author to six additional electronic companies with whom the author has familiarity (Kelsey "Response" 1). This resulted in an additional five survey responses. All together a total of sixteen replies were received.

The returned surveys were screened for relevance and compiled to maintain the confidentiality of the results. Aggregated results, therefore, are not based on specific company names. Two replies received were questioning the way in which the survey information would be published or whether the results would be available to participants. The author immediately responded to each of these replies reassuring the participants about the confidential nature in which the data would be published or made available. In both cases, a response to the actual survey was not returned. A third reply questioned the manner in which the survey was conducted and indicated that it was directed to the wrong individuals. A fourth reply indicated that the individual contacted was not directly involved in the purchasing activity of the company. The replies from these four companies, identified as Company N1 through N4, are summarized in Table 5.1.

Table 5.1: Replies Received Other than the Returned Survey

Company	Company N1	Company N2	Company N3	Company N4
Title	(not provided)	Senior Engineer (EH&S)	(not provided)	(not provided)
Response Time	Within 1 week of First Request	Within 1 week of First Request	Within 1 week of Follow-up Letter	Within 1 week of Personal Memo
How contacted	EIA	EIA	ITI	ITI & personal memo
Reply	Had Questions: "...not publishing individual responses – correct? Will each participating company receive a copy of the results and the final thesis or report? Other than a master's thesis, how else will the information be used?"	Had Question: "Will the results/thesis be available to participants?"	Stated: "All of the survey should be performed through ITI and they would then strip off the proprietary information. You are asking the wrong people. The information is only available from other functions within the company... guessing would reduce the accuracy of the survey."	Stated: "Purchasing handled on a local basis, especially for manufacturing sites which is where this would be most relevant. In my position, I have no involvement with this... most of our DFE activities are in Japan."

Two companies completed the survey, but stopped at Question #3 as directed in the survey since their company procured no finished products produced by another manufacturer. One company was a small consumer electronics manufacturer and the other company was a manufacturer of radar devices. The survey responses from these two companies, are identified as Company NA1 and NA2 are summarized in Table 5.2.

Table 5.2 Data From Companies With No Finished Products Procured

Company	Company NA1	Company NA2
Title	Manager (EH&S)	Senior Engineer (EH&S)
Response Time	Within 1 week of First Request	Within 1 week of First Request
How contacted	EIA	EIA
Questions		
1. Industry Sector	Consumer Electronics	Other Electronics
2. Number of Employees	1K-10K	10K-50K
3. % Finished Products procured	None	None

Eight companies returned surveys with responses to all ten questions. In one instance, a survey response was returned by two separate individuals in the same multinational company – one from Europe, one from the United States. The responses from these two individuals were fairly consistent and, therefore, these were combined into a single company response. The data from these eight companies, identified as Company A through H is provided in Table 5.3.

Table 5.3 Completed Survey Responses

Company	Company A	Company B	Company C	Company D (aggregate info from 2 sources)
Title	Manager (EH&S)	Senior Engineer (EH&S)	Director (EH&S)	Senior Engineer (EH&S) Product Manager
Response Time	Within 1 week of Personal Memo	Within 1 week of Follow-up Letter	Within 1 week of Follow-up Letter	Within 1 week of First Request
How contacted	Personal memo	EIA	EIA	ITI ECMA
Questions				
1. Industry Sector	Office Equipment	Telecommunications	Other Electronics	Consumer Electronics, Office Equipment
2. Number of Employees	50K-100K	>100K	10K-50K	>100K
3. % Finished Products procured	5%-10% "and growing"	>50%	>50%	10%-50%
4. Relative Supplier Size	Most Smaller	Smaller & Larger	Most Smaller	Most Smaller
5.a) Small supplier quality influence	Works jointly	Works jointly	Supplier Loss of Business	Rely on Supplier Quality, Works Jointly
b) Large supplier quality influence	Not applicable	Works jointly	Supplier Loss of Business	Not applicable
6. Quality requirements for finished products	Part of Engineering Product Specs	Part of Engineering Product Specs	Part of Engineering Product Specs	Part of Engineering Product Specs
7. Environmental Management System	Proactively influences new products	Proactively influences new products	Developed, Not integrated into commercialization (See Note b)	Proactively influences new products
8. Integration of environmental requirements into purchasing	Integrated into purchasing of finished products	Integrated into purchasing of finished products	Integrated into purchasing of finished products (See Note c)	Integrated into purchasing of finished products
9. Types of env. requirements				
Without certain materials	Yes	Yes	See Note b	Yes
With recycled content	No	Yes	No	Yes
Low standby energy	Yes	Yes	No	Yes
Easy disassembly	No	Yes	No	Yes
Reconditioned or remanufactured	No	Yes	No	No
Shared EOL responsibility	No	Yes	No	No
Other Attributes	None	None	None	See Note d
10. Additional Comments	None	See Note a	None	See Note e

Table 5.3 (continued) Completed Survey Responses

Company	Company E	Company F	Company G	Company H
Title	Manager (EH&S)	Manager (EH&S)	Director (EH&S)	Engineer (EH&S)
Response Time	Within 1 week of First Request	Within 1 week of Personal Memo	Within 1 week of Personal Memo	Within 1 week of Personal Memo
How contacted	EIA	EIA & personal memo	ITI & personal memo	ITI & personal memo
Questions				
1. Industry Sector	Other Electronics	Consumer Electronics, Office Equipment	Office Equipment	Other Electronics
2. Number of Employees	10K-50K	>100K	50K-100K	10K-50K
3. % Finished Products procured	10%-25%	>50%	25%-50%	10%-25%
4. Relative Supplier Size	Most Smaller	Smaller & Larger	Most Smaller	Most Larger
5.a) Small supplier quality influence	Works jointly	Supplier Loss of Business	Supplier Loss of Business	Supplier Loss of Business
b) Large supplier quality influence	Not applicable	Supplier Loss of Business	Supplier Loss of Business	Supplier Loss of Business
6. Quality requirements for finished products	Separate attachment in supply agreement	Separate attachment in supply agreement	Part of Engineering Product Specs & Separate attachment in supply agreement	All apply, No single method is used
7. Environmental Management System	Proactively influences new products	Proactively influences new products	Proactively influences new products	Proactively influences new products
8. Integration of environmental requirements into purchasing	Integrated into purchasing of finished products	Integrated into purchasing of finished products	Integrated into purchasing of finished products	Integrated into purchasing of finished products
9. Types of env. requirements				
Without certain materials	Yes	Yes	Yes	Yes
With recycled content	No	No	Yes	No
Low standby energy	No	Yes	Yes	Yes
Easy disassembly	No	No	Yes	No
Reconditioned or remanufactured	No	No	Yes	No
Shared EOL responsibility	Yes	No	No	No
Other Attributes	None	See Note f	See Note g	Yes (none listed)
10. Additional Comments	Provided EH&S Policy	None	None	None

Survey Data Notes:

a) Company B: Do not expect much from reconditioning or remanufacturing of products in the telecom industry because technological innovations are leading.
b) Company C: Our designs incorporate customer and country requirements related to use of hazardous substances but not necessarily "design for environment".
c) Company C: We request compliance history for products that are likely to use chemicals in their manufacturing. We also request info on the supplier's environmental management system.
d) Company D: Powder coatings, avoidance of the use of conductive coatings, marking/coding of plastic parts, fewer kinds of plastic resins in a given machine.
e) Company D: Evaluation and ratings of products for the DFE.
f) Company F: Blue Angel ecolabel for some products. Items not checked above vary by product type as to whether included in supply requirements.
g) Company G: Some supplier environmental criteria will apply to any supplier (i.e., use of CFCs in manufacturing process), while others are product specific DFE requirements which may vary from each type of product depending on product category and market/customer requirements.

The reply rate from the survey, including all replies, was 16 out of 45 or approximately 36%. Excluding the companies that did not return a survey, the response rate was approximately 27%. For those responding with a completed survey, not including the one duplicate company response, the final response rate was 18%. A breakdown of returned survey replies and responses is provided in Table 5.4.

Table 5.4 Summary of Returned Surveys

	#	Potential Number of Usable Surveys	Potential Response Rate
Total surveys sent to companies	45	45	
Number of total replies	16	16	36%
Number of replies from two different individuals in the same company	2	14	31%
Number of companies replying but not returning surveys	4	10	22%
Number of companies returning surveys, but not procuring finished products (i.e., stopping at survey question 3)	2	8	18%
Final number of completed surveys returned	8	8	18%

5.2 Survey Analysis

There are general, cross-company, and individual company conclusions that can be drawn as a result of the survey responses. Despite the 18% response rate, drawing statistically meaningful conclusions about the electronics industry from only eight representative industry responses is not possible[2]. As described in the Methodology section, section 4.2 Data collection and management, thirty data points are typically required to draw statistically meaningful conclusions. The data can however, be used to draw conclusions with respect to those companies that responded without implying that those conclusions hold true across the entire electronics industry. As described in section 4.2 Data collection and management, the survey results are likely to be positively biased towards those companies that wanted to share their results. It is believed, by the author, that those companies that responded did so because they had relevant supply chain activity on which they could base their answers.

From a general perspective, all the companies that intended to reply or provide a completed survey, did so within one week of receiving the initial request, follow-up letter or personal memo. In all cases, the individuals that responded to the survey, were part of the company's Environmental, Health and Safety organization and were aware of the procurement activities within their respective companies. There was no evidence that the survey was directed within a company to individuals directly associated with the company's purchasing function (although during the subsequent interviewing, Company F did reveal that the procurement organization was consulted on certain questions). One reply, from Company N4, indicated that the survey should be directed to other functions within the company, however, there was no evidence that this individual redirected the request to any other function.

From a cross-company perspective, each of the ten questions were analyzed to determine whether any specific commonalities exists. These commonalities are summarized in Table 5.5. A choice of "none of the above" was offered on survey

[2] The 1999 "Supply Chain Environmental Management: Lessons from Leaders in the Electronics Industry" report from Krut and Karasin draws conclusions from seven companies studied, two of which also responded to the survey sent out by the author.

questions 4, 5, 6, 7, and 8. None of the respondents selected this choice and any of the questions.

Table 5.5 Cross-company Commonalities and Statistics

<table>
<tr><th>Questions</th><th>Commonalities</th><th>Statistics</th></tr>
<tr><td>1. Industry Sector</td><td>All companies are part of the electronics industry</td><td>
<table>
<tr><th>Industry Sector</th><th colspan="5"># Companies</th></tr>
<tr><td></td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>Office Equipment (a)</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Other Electronics</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Consumer Electronics (a)</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Telecommunications</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Industrial Equipment</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Medical Devices</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
</td></tr>
<tr><td>2. Number of Employees</td><td>All companies had greater than 10K employees</td><td>
<table>
<tr><th>Number of Employees</th><th colspan="5"># Companies</th></tr>
<tr><td></td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>>100K</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>50K to 100K</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>10K to 50K</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>1K to 10K</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>0.1K to 1K</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
</td></tr>
<tr><td>3. % Finished Products procured</td><td>Most companies had at least 25% of their products procured as finished products. Company A reported that their % was “growing”.</td><td>
<table>
<tr><th>% Finished Product procured</th><th colspan="5"># Companies</th></tr>
<tr><td></td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>>50%</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>25% to 50%</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>10% to 25% (b)</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>5% to 10% (c)</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>0% to 5%</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
</td></tr>
<tr><td>4. Relative Supplier Size</td><td>Most companies procured finished products from smaller suppliers</td><td>
<table>
<tr><th>Supplier Size</th><th colspan="5"># Companies</th></tr>
<tr><td></td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>Most Larger</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Larger and Smaller</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Most Smaller</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
</td></tr>
</table>

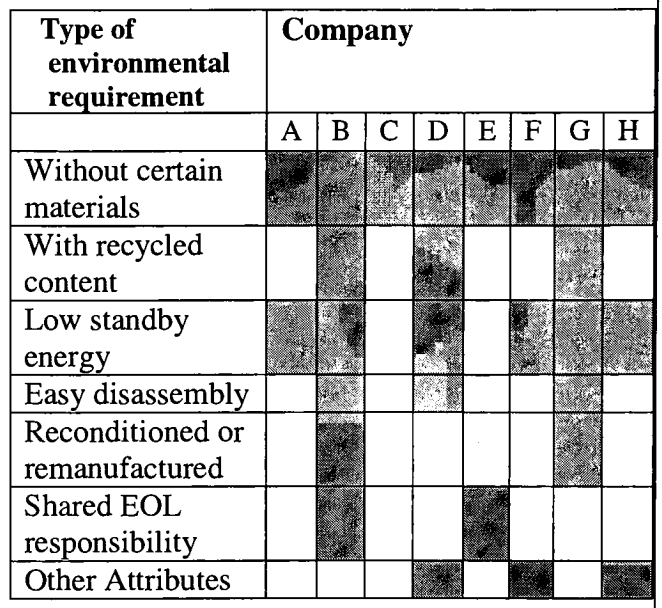
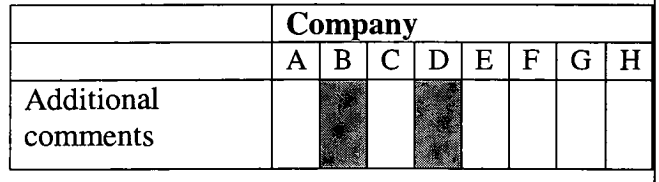
Table 5.5 Cross-company Commonalities and Statistics (continued)

<table>
<tr>
<td>5.a) Small supplier quality influence</td>
<td>All companies responded to this question regarding their influence on smaller suppliers. Companies either worked jointly with their suppliers or withdrew their business.</td>
<td>
<table>
<tr><th>Supplier Size</th><th colspan="5"># Companies</th></tr>
<tr><td></td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>Loss of Business</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Rely on Supplier's Quality Program (d)</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Works Jointly (d)</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
</td>
</tr>
<tr>
<td>b) Large supplier quality influence</td>
<td>Although most of the suppliers are smaller for the majority of the companies, even those few larger suppliers are subject to a withdrawal of business</td>
<td>
<table>
<tr><th>Supplier Size</th><th colspan="5"># Companies</th></tr>
<tr><td></td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>Loss of Business</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Rely on Supplier's Quality Program (d)</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Works Jointly</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Not applicable since company responded to 5a)</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
</td>
</tr>
<tr>
<td>6. Quality requirements for finished products</td>
<td>Most companies included quality requirements for finished products in the engineering product specifications. Companies G and H used one or all methods.</td>
<td>
<table>
<tr><th>Quality requirements for finished products</th><th colspan="6"># Companies</th></tr>
<tr><td></td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td></tr>
<tr><td>Separate attachment in supply agreement (e)</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Part of engineering product specifications</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Not specified (f)</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
</td>
</tr>
</table>

Table 5.5 Cross-company Commonalities and Statistics (continued)

<table>
<tr>
<td>7. Environmental Management System</td>
<td>All companies have developed environmental management systems. All but one company is using that system to proactively influence new product designs</td>
<td>
<table>
<tr><th>Company's Environmental Management System</th><th colspan="8"># Companies</th></tr>
<tr><td></td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td></tr>
<tr><td>Developed and proactively influences new products</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Developed but not influencing new products</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Development just beginning</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
</td>
</tr>
<tr>
<td>8. Integration of environmental requirements into purchasing</td>
<td>All companies have integrated environmental requirements into their procurement of finished products</td>
<td>
<table>
<tr><th>Company's integration of environmental requirements into purchasing</th><th colspan="8"># Companies</th></tr>
<tr><td></td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td></tr>
<tr><td>Integrated into purchasing of finished products</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Integrated into the purchasing of commodities</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Not yet integrated</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
</td>
</tr>
</table>

Table 5.5 Cross-company Commonalities and Statistics (continued)

9. Types of environmental requirements	Companies that have integrated environmental management systems into the development of new products (all respondents except one), all have finished product requirements pertaining to the use of certain materials. Low standby power modes were also required by 75% of companies.	
10. Additional Comments	Company B and Company D provided additional comments pertaining to reconditioning and to plastic part requirements, respectively.	

Notes

a) Two companies stated that they produced both Consumer Electronics and Office Equipment.
b) Two responses from one multinational company, Company D, were counted. One response was 10% to 25%, one was 25% to 50%.
c) Company A indicated that their 5% to10% rate of finished product procurement was growing.
d) Two responses from one multinational company, Company D, were counted. One response was the reliance on the supplier's quality management program, one was works jointly with suppliers.
e) Company G and responded that quality requirements are included in the product specifications and/or as a separate attachment to the supply agreement
f) Company H responded that quality requirements were either not required, included in the engineering product specifications or included as a separate attachment. No single method was used.

Each company, except one, Company C, had an environmental management system that was developed and proactively influenced the design of new products. This influence was further demonstrated in the types of environmental requirements identified as typically included in the procurement of finished products. All companies had quality requirements that were used in the procurement of finished products either as part of the product engineering specifications or as a separate attachment in the supply agreement. In addition, all companies had integrated environmental requirements into the procurement of finished products. The survey responses support the literature review, section 3.3 Relationship building, in which environmental supply chain management was not unlike the supplier/customer quality relationship known to purchasing (Krut and Karasin 5-6).

The selection of potential in-depth interviewees was made, based on the survey responses. A brief analysis of each company is provided below, based on responses to questions #4, #5, #9 and #10. Since responses to questions #6, #7, and #8 were relatively the same across all the companies, these questions were not used as differentiators in determining interview candidates.

Company A: The percentage of finished products being procured is increasing beyond 10%. Most finished products suppliers are smaller than Company A and as such, they work jointly to define quality requirements. Environmental requirements exist for the types of materials used in a product and low power energy. Relative to other companies, it appears that the Company A does not have as much experience with regards to relationships with finished product suppliers. This company was not selected for further interviewing.

Company B: The percentage of finished products being procured is greater than 50%. Finished products suppliers are both larger and smaller than Company A. Quality requirements, for large and small suppliers, are developed by working jointly with the supplier. Environmental requirements exist for six product features. Company B was also identified under the procurement activities within the literature review. Based on this fact, the company's large percentage of finished product procurement, and its work with large and small suppliers, Company B was selected for further interviewing.

Company C: The percentage of finished products being procured is greater than 50%. Finished products suppliers are mostly smaller than Company C. Both large and small suppliers risk losing business if they can not meet the quality requirements of this company. They do ask suppliers about their compliance history and their environmental management system, however, Company C's environmental management system has not yet been integrated into the design of new products. There are no environmental requirements for finished products. This company appears to be in the early implementations stage of their environmental management system, therefore, it was not selected for further interviewing.

Company D: The percentage of finished products being procured is between 10% and 50%. Most finished products suppliers are smaller than Company D and as such, they work jointly to define quality requirements and/or for those suppliers that are unique strategic partners, they rely on the suppliers quality management system. Several environmental requirements exist for procured finished products including other attributes beyond those identified in the survey. This company had been referenced in the literature reviews for their quality, procurement, and environmental systems. Because of these complimentary factors, Company D was selected for further interviewing.

Company E: The percentage of finished products being procured is between 10% and 25%, slightly lower than other companies selected for interviewing. Most finished products suppliers are smaller than Company E and as such, they work jointly to define quality requirements. Environmental requirements exist for the types of materials used in a product and shared end-of-life responsibility. Relative to other companies, it appears that the Company E does not have as much experience with regards to relationships with finished product suppliers nor the range of environmental requirements integrated into the purchase of finished goods. Although not specifically requested, this company did provide a copy of their EHS Policy. This company was not selected for further interviewing.

Company F: The amount of finished products being procured is greater than 50%. Finished goods suppliers are both larger and smaller than Company F and they risk losing business if the quality requirements are not met. Although only two of the seven environmental requirements were identified on the survey as being integrated into the

procurement of finished products, the additional attribute of ecolabling was considered important for some products. This company had been referenced in the literature reviews for their quality, procurement, and environmental systems. Because of these complimentary factors, Company F was selected for further interviewing.

Company G: The percentage of finished products being procured is between 25% and 50%. Most finished products suppliers are smaller than Company G. Both large and small suppliers risk losing business if they cannot meet the quality requirements of this company. Quality requirements are specified in either as part of the engineering product specifications or as a separate attachment to the supply agreement. Six environmental requirements were identified on the survey as being integrated into the procurement of finished products. This company had been referenced in at least one of the literature reviews for their environmental systems. Because of these complimentary factors, Company G was selected for further interviewing.

Company H: The percentage of finished products being procured is between 10% and 25%, slightly lower than other companies selected for interviewing. Most finished products suppliers are larger than Company H. Both large and small suppliers risk losing business if they cannot meet the quality requirements of this company. No single method of defining the quality requirements was used, however, depending on the supplier, any one method could be selected – quality requirements not specified, quality requirements part of engineering product specifications, or quality requirements provided in a separate attachment to the supply agreement. Relative to other companies, it appears that the Company H does not have as much experience with regards to relationships with finished product suppliers nor the range of environmental requirements integrated into the purchase of finished goods. This company was not selected for further interviewing.

5.1 Interpretation of Results

Quality requirements for the procurement of finished products were used by all of the companies responding to the survey. For the most part, companies either (1) worked jointly with their finished goods suppliers to define expected quality requirements that matched the supplier's manufacturing system and the company's customer needs or (2) developed an expectation with their suppliers regarding the supplier's responsibility and

their potential loss of business if the supplier failed to meet the quality requirements. These results suggest that companies have extended their quality management systems to include the procurement of finished products. The joint working relationship identified by half of the companies could be compared to the "joint learning experience" described by Araujo et al. (4) and to the "relational contracting" described by Rosen et al (7-8) in which the buyer/supplier jointly develop quality requirements to meet customer needs.

The fact that half of the companies will withdraw business from larger or smaller suppliers if quality requirements are not met demonstrates how important it is for the supplier to link their objectives with the buyer's goals. As prescribed by Fernandez, in order for the supplier to be successful, this linkage needs to be made (49).

All companies integrated quality requirements into the procurement of finished products through the use of engineering product specifications or through the use of a separate attachment to the supply agreement. Likewise, all companies responded that they had integrated environmental requirements into their procurement of finished products. All but one company had a developed environmental management system that proactively influenced new product designs. These results suggest that companies have extended their existing environmental management systems to include the procurement of finished products. As Krut and Karasin depicted, the new environmental supply chain management relationship is not unlike the strategic supplier/customer quality relationship known to purchasing. One of the environmentally related supplier initiatives identified by Krut and Karasin was to build environmental criteria into supplier contract conditions (5-6). The survey results indicate that this is indeed happening in the procurement of finished products.

According to the survey results, restrictions of certain materials were identified as minimum environmental requirements when procuring finished products. This minimum requirement is similar to those efforts already implemented by various companies dealing with commodity suppliers (i.e., those suppliers that provide components or materials to a buyer, but not a finished product as defined in the context of this thesis). This green procurement approach that restricts the use of certain materials matches those described by Nagel (200-224), Gabriel et al. (228), and Evans ("Re: Concall" 1). Other environmental requirements identified in the survey varied among respondents and

included the use of recycled content, low standby energy, ease of disassembly, and other non-specific design-for-environment (DFE) criteria. The Rosen, Bercovitz, and Beckman study concluded that the focus on the supplier's environmental product design is one type of ESCM program in use today. The DFE criteria identified by most respondents in the survey suggests that that this approach is being used. The other type of ESCM program Rosen et al. defines is one that focuses on the supplier's environmental management system (3-20). One survey respondent, Company C, used this approach when dealing with their finished product suppliers.

Although not directly asked in the survey, three respondents did indicate that regulatory (e.g., CFC-bans), market (e.g., Blue Angel ecolabel), and customer requirements drove the environmental requirements used in the procurement of finished products. These are not unlike the forces described by Kurt and Karasin (3-4), Beckman et al. (12-17), and Carter and Narasimhan (4).

The survey results confirmed the information provided in the literature review. Companies, motivated by corporate drivers, appear to be leveraging their quality management experiences into the extension of their environmental management systems when procuring finished products. Buying influence is applied to larger and smaller suppliers as part of the buyer's TQM system. Environmental criteria for finished products vary across respondents, however all require suppliers to restrict the use of certain materials. Additional design-for-environment requirements are being applied depending on the individual product category to meet customer needs.

6.0 Interview Results and Discussion

6.1 Interview Delivery and Responses

As described in Section 4.2 Data Collection and management, four companies were selected for in-depth interviewing. These companies were selected based on their responses to survey questions and on their inclusion in any of the studies analyzed as part of the literature review described in Section 3.0. Companies B, D, F, and G were selected and contacted to arrange for these interviews. The interviews were conducted by using the speaker function on the telephone with written responses recorded by the author during the interview. The Interview Guide provided in Appendix H was used. Since this was a guide, and the interview process is a dynamic interaction, not all questions received the same amount of probing. Each interview lasted between 40 and 50 minutes, 10 minutes more than initially planned. Responses to the interview questions are summarized in Table 6.1. To maintain confidentiality of the respondents, no product specific information or company specific information is provided.

Table 6.1 Responses to Interview Questions

Interview Questions	Company B	Company D
Types of finished products	• Multi-switch service system: 16 circuit boards, 10,000 components, 5000 component suppliers	• Personal computers, printers, servers
Supplier Relationship	• Nothing unique for any one supplier, no single product targeted as "environmentally friendly" • Apply 3 part approach to all suppliers o Material content of components (current focus) o Environmental Management System (1997: 70% suppliers had no Env. Policy, 50% now) o Total Environmental Cost (future state) (price break for suppliers with high env. performance)	• Strategic relationships and, for contract manufacturing, partnerships • Need to be reasonable with regards to what can be delivered by suppliers
Ability to influence the supplier's quality requirements	• Supplier quality awareness tracks the supplier's environmental quality efforts	• Quality conscious suppliers tend to have greater environmental awareness
Ability to influence the supplier's environmental design requirements	• Create supplier awareness of environmental issues • Future state: use supplier's environmental performance to determine pricing incentives. • Designers, customers and suppliers are becoming more and more environmentally aware	• Work with suppliers to help select materials • Meet minimum buyer requirements or buy finished products based on supplier requirements
Typical environmental requirements for finished products	• Main focus, currently, is on eliminating heavy metals across all suppliers (lead, hexavalent chromium, mercury, cadmium) driven by European and Japanese regulatory/competitive pressures	• Energy Star required for applicable products, material requirements /restrictions, coding of plastic parts
Integration of environmental requirements into the procurement of finished products	• Supplier contracts include six key requirements o Pricing, Quality, Delivery, Service, Technology, and (now) Environmental Quality • Final product declarations for energy use, env. hazardous substances, mass/weight, recyclability, and recycled material content can also be drivers for environmental requirements	• Supplier Contracts include 5 key criteria o Performance, Long-term reliability, Cost, Safety, Environment
Supplier Obstacles to meeting requirements	• Next 10 years research of new materials will have to include environmental concepts	• Recycled resins not available in Far East, need to be reasonable with regards to requirements
Other Comments	• Rely on suppliers to start DFE activities within their own control/community to minimize waste (e.g., solid waste, emissions) • List of "hazardous materials" not well defined nor understood by suppliers	• Reasonable environmental expectations are good engineering practices and demonstrates good corporate citizenship

Table 6.1 Responses to Interview Questions (continued)

Interview Questions	Company F	Company G
Types of finished products	• Personal computers, laptops, scanners, printers	• Printers, monitors, and some personal computers,
Supplier Relationship	• Strategic relationships and partnerships (shifted from buyer design & manufacture to strategic buyer design and supplier manufacturing)	• Strategic relationships and business partners • Jointly develop product roadmaps and product planning • Outsourcing is now model – have greater risk with less control over manufacturing
Ability to influence the supplier's quality requirements	• Performance and quality specifications are always provided to the supplier • A range of general performance specifications to individual supplier specifications are used	• The better the supplier's quality plans, the higher environmental awareness of supplier • Greater influence with business partners
Ability to influence the supplier's environmental design requirements	• Influence will vary depending on product • Size of business or potential future business helps to influence suppliers • Greater influence with strategic partners – they share goals Less influence with commodity-type suppliers (example: Company F wanted cover design to be made from plastic material with metal inside cover. Larger supplier served several manufacturer's and already had a process to spray a metal coat onto plastic covers. More costly to have unique process for Company F. Eventually, the supplier did convert manufacturing to serve Company F and other manufacturers)	• Easier to get environmental requirements integrated when buyer is larger part of supplier's business • Some larger suppliers are flexible knowing that there is a potential for increased future business • Early involvement with finished product suppliers identifies environmental requirements • Have paid premium for certain environmental packaging requirements to meet corporate standards (no bleach, recycled content in corrugated board) as well as for monitor ecolabeling (e.g., TCO99)
Typical environmental requirements for finished products	• Range of requirements from restricted material specifications to ecolabeling (e.g., Energy Star, Blue Angel) written into specifications	• Common industry specifications including restricted materials and ecolabeling (e.g., TCO99) • Ease of disassembly – aids service, upgrading, and refurbishment
Integration of environmental requirements into the procurement of finished products	• DFE requirements identified as "musts" and "wants". Marking of plastic parts and common screw types are examples "musts". Other environmental requirements include material restrictions, Energy Star, and ecolabeling.	• Try to stay with "off-the-shelf" requirements (e.g., common color and flame retarded plastics) • Basic environmental requirements applied to all finished product suppliers, unique product specific requirements also specified
Supplier Obstacles to meeting requirements	• More difficult and costly to require a larger supplier to change manufacturing process/design	• Balancing act between cost economy of scale versus environmental requirements
Other Comments		• Review supplier's environmental roadmaps

6.2 Interview Analysis

There are cross-company and individual company conclusions that can be drawn as a result of the interviews. Since the cross-company conclusions lend themselves directly to subsequent interpretations, they are covered in Section 6.3. Individual company profiles are provided below.

Company B: Company B has a somewhat unique perspective to their dealings with their finished goods suppliers. In general, they treat all of their suppliers the same with a focus on a limited set of material restrictions (i.e., heavy metals). Since "hazardous materials" are not well defined, their experience has shown that suppliers are struggling to respond to a common list of restricted "hazardous materials". Therefore, their main focus is only on the heavy metal subset of restricted materials. "Environmental quality" has been added to the contractual requirements of pricing, quality, delivery, service and technology. In the future, the supplier's environmental performance will be factored into the total environmental cost model for a product. The better a supplier's environmental performance, the better the purchase price will be for the product.

Company D: Company D also includes environment as one of the five key supplier contract criteria, the others being performance, long-term reliability, cost and product safety. Their approach to finished product suppliers is one of mutual cooperation intended to define reasonable material requirements. For example, requiring a certain percentage of post consumer recycled plastics to produce a new part is not reasonable in the Far East because of the lack of post consumer recycled plastics in that region. Requirements for Energy Star compliance, for restricted materials and for the marking of plastic parts with their resin codes for potential recycling are other environmental requirements specified for finished products.

Company F: Company F uses a range of environmental requirements, from a list of restricted materials to specific product specifications, depending on the type of finished product being procured. As their business structure shifted from central design and manufacturing to one of targeted design and increased supplier manufacturing, their supplier relationships became more strategic and contained a higher level of partnering. They are better able to influence environmental design requirements with strategic

partners that shared common goals. It is more difficult for Company F to secure specific environmental product requirements from larger suppliers that supplied commodity-type finished goods to many different companies. Unique environmental requirements result in changes to the supplier's manufacturing process and in higher cost products. In these instances, Company F continues to place a high priority on its environmental requirements that helped in the eventual conversion of the supplier's manufacturing process. The size of potential future business with the supplier also helps to influence the supplier.

Company G: Company G approaches finished product procurement in a manner quite similar to Company F. Strategic relationships and business partners are of greater importance as outsourcing of manufacturing has increased. In these relationships Company G and the supplier jointly develop product roadmaps and product plans. Integration of environmental requirements can be accomplished more readily when the company is a larger share of the supplier's business. Larger suppliers are flexible when there is a potential for increased business. Environmental requirements are defined during early involvement with the suppliers. Although Company G relies on common industry environmental requirements (e.g., restricted materials, common plastics), there are occasions where the company will pay a premium for certain environmental requirements until these requirements become more of a de facto standard in the industry. When it is too costly for a supplier to meet certain environmental requirements, Company G will review the supplier's environmental roadmap to determine when the environmental requirements could be met. There is always a balancing act between cost economies of scale and meeting environmental requirements.

6.3 Interpretation of Results

The results of the interviews provide common themes from which best practices are be extracted. In some cases, more than one theme was derived. These alternative themes are also provided. The following themes resulted from the interview

1. Forming strategic partnerships, alternatively: treating all suppliers the same
2. Including quality and environmental requirements in supply contracts
3. Reasonable, balanced expectations for suppliers

4. Use strategic partnerships and the potential for future business to influence supplier's environmental design requirements
5. Environmental requirements based, as a minimum, on certain restricted materials, alternatively: the lists would be focused on only four heavy metals
6. Additional product environmental requirements specified, as necessary, to meet business objectives, alternatively: rely on supplier to start DFE activities within their span of control/community
7. Move towards a state of supplier pricing incentives rewarding greater environmental performance of the supplier

Theme 1: Three of the four companies interviewed had strategic relationships and business partnerships that support the outsourcing model prevalent in electronic equipment manufacturers. These relationships are similar to the "relational contracting" described by Rosen et al. (7-8), the "joint-learning interface" described by Araujo et al. (4), or the "strategic partners" described by Stimson (11). Increased risk due to outsourcing requires these higher-level buyer/supplier interaction models consistent with the stipulations of Carter and Narasimhan (4-5). The Beckman et al. study of the computer industry, conducted in the late 1990's, concluded that relational contracting emphasizing collaboration was a critical characteristic to ensuring the environmental performance of suppliers (1-27). The thesis survey results and interview results confirm that this conclusion is still valid for most participating electronic equipment manufacturers.

Company B, however, approached all suppliers equally with out designating any special buyer/supplier relationship but rather requiring all suppliers to follow their objectives of eliminating certain heavy metals (lead, mercury, cadmium, hexavalent chromium). The behavior of this particular company more closely follows the "specified interface" relationship described by Araujo et al. (4) in which the supplier only needs certain requirements in order to manufacture the part to meet the buyer's design characteristic.

Themes 2 and 3: In general all companies recognized the direct correlation between the level of a supplier's quality program and the supplier's level of environmental

awareness. Quality requirements and environmental requirements were two key elements in supplier contracts. In the survey, Company B and Company D indicated that they worked jointly with their suppliers to achieve quality requirements. In the interview, Company D also worked with suppliers to obtain reasonable environmental expectations.

Theme 4: Company F and Company G responded to the survey that suppliers would lose business if they couldn't meet the quality requirements. From an environmental requirements standpoint, both companies find it easier to influence strategic partners and find it possible to influence larger suppliers when there is a potential to increase the supplier's business. This confirms the Lascelles and Dale research in which they concluded that the ability of a buyer to influence the supplier is directly related to the buyer's purchasing power (91). Without this purchasing power, as confirmed by Buddress, the buyer has to rely on their ability to project future business in order to influence supplier requirements (3).

Themes 5 and 6: The use of restricted materials is a common focal point of environmental requirements for all companies in the survey and in the interviews. Additional individual product requirements were also specified, except for Company B, to meet business objectives. These individual product requirements enabled ecolabeling certifications (Energy Star, Blue Angel, TCO99) of the company's products. As described by Rosen et al., buyers with relational contracting arrangements with their suppliers had a more active environmental supply chain management program focused on environmental product design features (4).

In contrast, Company B learned by experience that suppliers were often confused by long restricted "hazardous" materials listings. In addition, since the suppliers in turn relied on their own suppliers (i.e., second tier suppliers), it was difficult to understand what materials were definitely restricted in the final product. This is was particularly true with smaller suppliers and is similar to Gallun's (1) and Chase's (2) reports where smaller (automotive) suppliers were overwhelmed with responding to large volumes of quality requirements.

Company B's focus on a subset of restricted materials (i.e., selected heavy metals) is driven by emerging European and Japanese regulatory and competitive pressures, irregardless of the environmental science behind such restrictions. Carter and

Narasimhan (4), Krut and Karasin (3-4), and Beckman et al. (12-17) identify regulatory and competitive drivers force companies to develop environmental supply chain management (ESCM) programs. In this case, the ESCM program is expanded to cover finished product procurement activities.

Theme 7: Company B envisioned a future ESCM state in which the supplier's positive environmental performance would be rewarded with price incentives from the buyer. Beckman et al. alludes to the fact that long-term relationships provide for a greater interaction regarding cost structures and joint efforts regarding environmental management (19).

Based on the literature, survey responses and interview results, a set of "best practices" are summarized and provided in Table 6.2.

Table 6.2 Summary of Best Practices

1	Foster strategic relationships with key finished product suppliers. Use those relationships to share product plans in early product development to influence environmental design criteria that meet the ultimate customer's needs.
2	Form partnerships with larger suppliers. Rely on the long-term partnership to increase future business subsequently help to direct environmental design improvements
3	Work jointly with suppliers and be reasonable with them to determine cost effective environmental product requirements. Specify environmental requirements that are commonly used within industry and identify unique, higher cost environmental requirements, as necessary, to meet your business objectives.
4	As a minimum, define a set of restricted materials that suppliers are not to use in their product design and mark plastic parts with the resin type. Define additional requirements particular to the product being marketed (e.g., ecolabel certifications).
5	In addition to other typical elements in supply contracts (product performance, costs, delivery, quality), integrate environmental requirements as another element in the procurement of finished products. Document environmental requirements as part of the engineering product specifications or as a separate contract attachment.

A future best practice would be to financially reward suppliers for their improved environmental performance. Some companies, like Johnson Controls, Inc. (2), have environmental reward programs for their suppliers, but a total cost of ownership model, as described by Nagel (220-224), has not yet been implemented for suppliers of commodities or finished products.

7.0 Conclusions and Recommendations

7.1 Conclusions

Since the number of survey respondents was lower than initially expected, a statistical analysis of the data is not possible (i.e., a minimum number of 30 samples is typically required to draw statistical conclusions). Qualitative insights into the ESCM activities of electronic equipment manufacturers, however, are possible. It is believed that some surveyed companies did not respond to the survey because they perceive that they do not procure finished products. For example, AMP, Incorporated (acquired by Tyco International Ltd. in 1999) provides electronic components to the electronics industry, but the author does not believe that they provide branded products for any particular purchaser. Survey data was therefore, automatically biased towards those electronic equipment manufacturers that supply or purchase finished products (Creswell 120). In addition, as expected, the number of companies participating was not a truly random sample of the total companies that comprise the trade association membership. Survey respondents will be positively biased towards those companies that want to share their programs and/or those companies that are motivated to receive the survey results.

Given the intent to identify leading practices, these biases are viewed positively in two ways. First, since trade associations are made up of leading companies, survey responses will be from those manufacturers that are leading the industry and are likely to have the specific ESCM programs applicable to the procurement of finished products. Second, those companies that don't purchase finished products were not relevant to this study so their responses could not be used to identify subsequent in-depth interviews or best practices. For example, two companies that do not procure finished products responded with an incomplete survey and were therefore not included in the final survey data. Final survey respondents and those interviewed represented the leading companies in the industry. In addition, those selected for interviews were leading companies that had been identified in the thesis literature review as having participated in past quality/environmental surveys.

Experiences learned from the past implementation of quality principles are applied in the procurement of environmentally preferable products. Manufacturers are extending their environmental management system to include environmental supply chain

management. From a finished product procurement standpoint, this extension is formed through various supplier-partnering relationships and results in environmental requirements in supply agreements (material restrictions, DFE ecolabeling, etc.) and to a lesser extent, reviews of supplier environmental management systems. This extension is particularly significant in the electrical equipment industry that is currently being faced with emerging Extended Producer Responsibility laws embodied in material restriction regulations and European take back directives.

The ESCM relationship between the buyer/supplier and the purchasing power of the buyer are factors in the creation of environmental criteria for supplied products. These relationships span a spectrum characterized in similar ways by Araujo, et al. (4), Stimson (14), and Rosen et al. (7-8). At the high end of the spectrum are those suppliers that have strategic partnering relationships. The thesis surveys and interviews confirmed that these buyer/supplier relationships were most important when procuring finished products that met environmental design requirements.

Within the strategic buyer/supplier relationship, buyers were able to easily influence the environmental requirements of suppliers since both were working towards common goals. For other supplier partners, larger and smaller, the buyer had little purchasing leverage and their ability to influence the environmental requirements was based on the promise of increased future business with the supplier. As predicted, this influence model parallels, the quality provisions that have previously been studied by Lascelles and Dale (91), Roethlein (71-81) and Buddress (3).

Past ESCM studies by Carter and Narasimhan (1-3), Krut and Karasin (3-5), and Carter and Jennings (2), as well as green procurement guidelines by the World Business Council for Sustainable Development (UK 1-2) and the United States Environmental Protection Agency (2-5, defined ESCM activities involving the purchasing organization on a broad scale, but not specific to the procurement of finished products. To some limited extent, the computer industry study performed by Beckman et al. found that individual product environmental specifications, if defined at all, were included as an attachment to the supply contract (1-27). The IEEE paper, presented by Gabriel et al., indicated that IBM was in the process of completing environmental requirements for OEM products (228). This thesis confirms the fact that electronic equipment

manufacturers are integrating environmental requirements into their supply contracts for finished products. In addition, this thesis research defines a set of best practices that can be used to help guide procurement activities in this area.

Within the supply chain, environmental design criteria for finished products procured by a manufacturer must be considered. Based on the surveys and interview responses, the minimum environmental requirement for dealing with OEM suppliers is a listing of restricted materials that cannot be used in the product and the marking of plastic parts with the resin type. The identification of what materials to restrict can be found in material lists promulgated by trade associations, like the Electronics Industries Alliance supported by many of the companies surveyed, or unique to a manufacturer, like the four heavy metals defined by Company B. EIA is working with other trade associations in Europe, European Information and Communications Technology Industry Association (EICTA) and in Japan, Japan Electronics and Information Technology Association (JEITA) to develop a harmonized list of common restricted materials (Evans EIA 1-2). The latest EIA listing and gap analysis comparison with lists from other trade associations is provided in Appendix I. In addition to the material listing and marking of plastic parts according to international standards (ISO 11469: 2000 "Plastics -- Generic identification and marking of plastics products"), additional environmental requirements specific to a finished product are defined in the supply contract.

These additional requirements may include packaging requirements (non-bleached, recycled content), or other ecolabeling requirements as defined in voluntary standards (e.g., Energy Star, Blue Angel). These additional environmental requirements are specific to individual products. For example, there are ten different printer specification tables that define the Energy Star requirements for a variety of printers (United States EPA Energy 1-3). These tables are provided in Appendix J. Additional environmental requirements for printers producing prints at a rate of less than or equal to 25 pages per minute, are defined in the German Blue Angel standard for printers, RAL-UZ 85 (Germany 1-7). This standard is found in Appendix K. Product performance requirements in this standard include

- Avoidance of coatings, composites, glues
- Reduction in the number and types of plastics

- Restricted use of certain plastic flame retardants
- Marking of plastic parts
- Emission levels for noise, dust, ozone, styrene
- Toner and cartridge requirements
- Product safety and electromagnetic compatibility
- Energy requirements harmonized with the Energy Star requirements

Individual product environmental requirements, therefore, start with a listing of restricted materials and the marking of plastic parts. Additional environmental requirements are then tailored for specific products and intended markets. OEM specifications can be created from common industry lists of restricted materials with additional environmental requirements selected from various ecolabeling standards or company unique requirements. To be successful in meeting these specifications there needs to be early communication within the framework of a strategic buyer/supplier partnership. Through this partnership an acceptable balance of these specifications with other purchasing criteria (e.g., cost, delivery, quality) will be attained.

7.2 Recommendations

Based on the author's experience in preparing this thesis, there are several recommendations that could improve results or advance knowledge in this area. These recommendations are focused in three areas (1) the survey process (2) the interview process, and (3) areas for further research.

Survey Process: Since the number of survey respondents was less than expected, the sample size should be increased in order to apply a quantitative statistical analysis. This could be done by reducing the sensitivity of potential respondents to the manner in which the data would be collected, used, and shared. The use of a third party, like a trade association, would be one way to reduce concerns about proprietary information. The usefulness of the sanitized data would have to be carefully considered since that would severely limit the comparison by the researcher to the literature review. Advanced notice that the survey was coming and distribution to a broader audience within the industry would help to increase potential responses.

All responses to the survey occurred within one week of contact. Therefore, the two week response time could be replaced by a one week response date in order to speed up the survey cycle time.

Surveys through other trade associations in the Asia-Pacific and Latin America region as well as a more intense survey effort in Europe could provide insights into best practices in other parts of the world.

Interview Process: To aid in the recording of the responses, a tape recorder could be used to capture the discussion and notes taken later. This approach would have to be approved by the interviewee prior to the interview.

Because of the amount of discussion necessary to obtain the data, future studies should allow for 40-50 minute interviews rather than 30-40 minutes initially expected in this thesis.

Company A was not interviewed, but could be a potential candidate for further study. Since their percentage of finished procurement is increasing, they may be using unique ways to deal with this demand. Company E was not interviewed, but could be a potential candidate for further study based on their joint work with suppliers on quality requirements on and a shared EOL responsibility. Additional probing could reveal some unique aspects associated with the shared EOL responsibility.

To capture a broad perspective of industry experiences, an interview with industry consultants could augment or verify company findings. These consultants may consist of trade association managers, purchasing or environmental consultants, or authors in the ESCM field.

Areas for further research: There are many areas that could be considered for further research. First, the same process could be used to obtain results from the purchasing function within the buying company. This perspective could provide insight into the priority of environmental requirements valued by the purchasing professionals, as opposed to that obtained from the EH&S professionals.[1]

Second, the perspective of the OEM supplier could be studied to determine what drivers and values are important to them in the buyer/supplier partnership. In addition, a

[1] The EH&S professional in Company F did review the survey response with the purchasing department prior to returning the survey.

study of supplier preparedness to meet the buyer's environmental requirements could be studied. Over time, as identified in the interviews, common suppliers in the industry adopt a set of de facto environmental standards based on their experience with similar requests from several different buyers. This study could be focused on the average amount of elapsed time required before a certain environmental requirement becomes a de facto standard (e.g., Energy Star certified monitors, elimination of CFCs or PCBs). This could be useful when dealing with new suppliers or suppliers established in developing countries.

Third, research to determine if OEM suppliers in any particular region or cultural setting would be more proactive or receptive to meeting the environmental requirements could be studied. For instance, suppliers in Europe, where ecolabeling is the most prevalent, could be compared to suppliers in Japan where there are closer buyer/supplier relationships. This analysis could be useful as part of the supplier selection process.

Fourth, end-of-life product management, an area of study only briefly reviewed as one of the product environmental criteria defined in the survey, could be pursued in greater detail to define the specific buyer/supplier expectations regarding extended producer responsibility for products at the end of their useful life. Company E indicated, in their survey response, that they have requirements for shared EOL responsibility with their OEM suppliers. What are these requirements? Certainly, the elimination of restricted materials and the marking of plastic parts help to minimize the buyer's EOL product management cost. However, there are other EOL aspects that could also be considered. Do companies expect OEM suppliers to take back products at EOL and remanufacture them for subsequent resale or strip them for salvageable service parts? What logistics are involved in returning products from the end-customer to the OEM supplier? Are companies preparing to cascade the responsibility and cost associated with EOL product management to OEM suppliers in such a manner as to encourage the supplier to improve the environmental design of the product? How are OEM suppliers preparing for EOL management requests? In some cases an OEM supplier, like a company that manufacturers monitors for instance, may already have an EOL product management structure in place that the buyer could utilize. In other cases, the supplier

may be too small or too removed from the end-customer in which case, establishing an EOL management program would be a significant burden.

These four areas are a just few suggested for further research. Because ESCM is still in its infancy, this field of research has many opportunities to expand the present knowledge base.

Bibliography

Araujo, Luis, Anna Dubois and Lars-Erik Gadde. "Managing Interfaces with Suppliers." Industrial Marketing Management September 1999: 12. Lexis/Nexis Academic Universe. 31 December 2000.

Armstrong, Frank E. "QS-9000 Drives Automotive Supplier Development." *Quality Digest* November 2000: 7. Available: http://www.qualitydigest.com/nov00/html/qs9000.html. 18 December 2000.

Arsham, Hossein. "Questionnaire Design, Statistical Data Analysis and Management of Surveys." University of Baltimore. Available: http://ubmail.ubalt.edu/~harsham/stat-data/opre330Surveys.htm. 26 January 2001.

Batts, Greg. Packaging and Equipment EOL Manager, Kodak Ltd. "Supply Chain Survey." E-mail to selected AEA-Europe members. 30 May 2001.

Beckman, Sara L., Christine Rosen, and Janet Bercovitz. "Environmentally Sound Supply Chain Management: Implementation in the Computer Industry." n.p. Haas School of Business, U of California: Berkeley 2000.

Brennan, Douglas F. "Implementing Product Stewardship in a Component Manufacturer." Proceedings of the 1999 IEEE International Symposium on Electronics and the Environment. May 1999. Danvers: The Institute of Electrical and Electronics Engineers, Inc., 1999.

Brink, Suzanne, Jan Carel Diehl and Ab Stevels. "Eco-Quest, An Ecodesign Self Audit Tool For Suppliers of The Electronics Industry." Proceedings of the 1998 IEEE International Symposium on Electronics and the Environment. May 1998. Danvers: The Institute of Electrical and Electronics Engineers, Inc., 1998.

Budress, Les and Alan Raedels. "Essential tools of supply chain management." Hospital Material Management Quarterly, Rockville, Aug. 2000.

Cali, James F. TQM for Purchasing Management, New York: McGraw-Hill, 1993.

Calkins, Patricia. Manager EH&S Product Support, Xerox Corporation. E-mail to author. 2 May 2001.

Carter, Craig R., and Marianne M. Jennings. "Purchasing's Contribution to the Socially Responsible Management of the Supply Chain." Center for Advanced Purchasing Studies 2000. Available: www.capsresearch.org/ReportPDFs/PSRA11.pdf. 7 January 2001.

Carter, Joseph R. and Ram Narasimhan. "Environmental Supply Chain Management." Center for Advanced Purchasing Studies 1998. Available: http://www.capsresearch.org/ReportHTMs/environmental.html. 6 January 2001.

Chase, Nancy. "QS-9000 Third Edition: Clarity at What Cost?" Quality Online January 1999: 6. Available: http://qualitymag.com/articles/1999/jan99/0199f6.html. 18 December 2000.

Christensen, Troy. EHS Consultant, Environmental and Occupational Risk Management. E-mail to the author. 7 May 2001.

Cooper, Laura. "Global Practices: ISO 14000 sets environmental standards." Puget Sound Business Journal (Seattle) 23 March 1998. Available: http://www.bizjournals.com/seattle/stories/1998/03/23/focus7.html. 18 December 2000.

Craig, Erin. "Integrating Environmental Considerations Into Supplier Management Processes at Sun Microsystems, Inc." Proceedings of the 1997 IEEE International Symposium on Electronics and the Environment. May 1997. Danvers: The Institute of Electrical and Electronics Engineers, Inc., 1997.

Creswell, John W. Research Design Qualitative & Quantitative Approaches. Thousand Oaks: SAGE Publications, Inc., 1994.

"Deming Prize Criteria and Accompanying Viewpoints." 5 October 2000. Clemson U. Available: http://deming.eng.clemson.edu/pub/den/deming_prize_2000.pdf. 21 February 2001.

Evans, Holly. "Fwd: Industry survey regarding environmental relations with OEM Suppliers." E-mail to EIA/EIC members. 18 May 2001.

Evans, Holly. "Re: Concall to finalize EIA material declaration guide." E-mail to the author. 22 December 2000.

Evans, Holly. "EIA Concall to Harmonize EIA/EICTA/JETA Material Declaration Guides." E-mail to author. 1 November 2001.

Fernandez, Ricardo R. Total Quality in Purchasing and Supplier Management. Delray Beach: St. Lucie Press, 1995.

Gabriel, Joseph, Mary Jacques, J. Ray Kirby, T. Mann, and Dewey Pitts. "ECP Integration into the Supply Chain: an IBM Perspective." Proceedings of the 2000 IEEE International Symposium on Electronics and the Environment. May 2000. Danvers: The Institute of Electrical and Electronics Engineers, Inc., 2000.

Gallun, Alby. "Life gets tougher for little guys supplying Deere, CNH." The Business Journal of Milwaukee 6 March 2000. Available: http://www.bizjournals.com/milwaukee/stories/2000/03/06/focus2.html. 18 December 2000.

Germany. Federal Environmental Agency. RAL-UZ 85: Printers, Basic Criteria. Berlin. February 2001. Available: http://213.198.61.142/blauer/e-prod/uz/085-ef.htm. 14 November 2001.

Glaser, Barney G. and Anselm L. Strauss. The Discovery of Grounded Theory: Strategies for Qualitative Research. New York: Aldine Publishing Company, 1967.

"Hewlett-Packard: Industry Standards for SCEM." SCEM Report: Case Studies: Hewlett-Packard. Available: http://www.usaep.org/scem/case6.htm. 7 February 2001.

"Johnson Controls Announces 1999 Supplier Performance Award Winners; Company recognizes the contributions of its suppliers." PR Newswire 8 December 1999:2. Lexis/Nexis Academic Universe. 31 December 2000.

Kelsey, Cavan. "Industry survey regarding environmental relations with OEM suppliers." E-mail to ITI TC1 members. 17 May 2001.

Kelsey, Cavan. "Response to Survey." E-mail to selected electronic companies. 19 September 2001.

Krut, Riva and Leslie Karasin. "Supply Chain Environmental Management: Lessons from Leaders in the Electronics Industry." October 1999. United States-Asia Environmental Partnership. Available: www.usaep.org/scem/report.htm. 7 January 2001.

Lascelles, D.M. and B.G. Dale. "The Buyer-Supplier Relationship in Total Quality Management." Journal of Purchasing and Materials Management. Vol 25, No. 2, Summer 1989.

Linnell, Jason. "Feedback Needed on Industry Survey on Environmental Management Systems." EIA's "Inside Skinny Report" 15 June 2001, 3.

Maccoby, Michael. "Learning to Partner and Partnering to Learn." Responsive Database Services, Inc. May 1997: 5. Lexis/Nexis Academic Universe. 31 December 2000.

Motorola, Inc. "Motorola and the Environment Supplier Information." Available: http://www.motorola.com/EHS/environment/supplier/. 7 February 2001.

Nagel, M.H. "Environmental Supply-Chain Management versus Green Procurement in the Scope of a Business and Leadership Perspective." Proceedings of the 2000 IEEE International Symposium on Electronics and the Environment. May 2000. Danvers: The Institute of Electrical and Electronics Engineers, Inc., 2000.

Roethlein, Christopher J. and Paul M. Mangiameli. "The Realities of Becoming a Long-Term Supplier to a Large TQM Customer." Interfaces Magazine. July –Aug. 1999: 71-81.

Rosen, Christine, Sara L Beckman, and Janet Bercovitz. "Environmental Supply Chain Management in the Computer Industry: A Transaction Costs Economics Perspective." n.p. Haas School of Business, U of California: Berkeley 2000.

"Saturn announces environmental program." Nashville Business Journal. 24 April 1998. Available: http://www.bizjournals.com/nashville/stories/1998/04/20/daily16.html. 18 December 2000.

"Self audit tool ECO-QUEST for suppliers of the electronics industry is fast and easy to work with." DfS newsletter main. Available: http://www.io.tudelft.nl/research/dfs/publication/newsletter/newsecoquest.html. 7 February 2001.

Stimson, Judith A. Supplier Partnerships. West Palm Beach: PT Publications, 1998.

Stundza, Tom. "New era dawns at Boeing." Purchasing Online 10 August 2000: 10. Manufacturing.net. Available: http://www.manufacturing.net/magazine/purchasing/archives/2000/pur0810.00/081world. 19 December 2000.

Suzik, Holly Ann. "Jack-of-All Trades: Quality Professionals Go Cross-Functional." Quality Magazine. Available: http://qualitymag.com/articles/1999/mar/039914.html. Mar. 1999.

"Toyota asks suppliers to get green." Cincinnati Business Courier. 1 August 2000. Available: http://www.bizjournals.com/cincinnati/stories/2000/07/31/daily8.html. 18 December 2000.

"Toyota Issues Environmental Guidelines to North American Suppliers; 500 Automotive Suppliers Challenged to Be Green Suppliers." PR Newswire 1 August 2000:3. Lexis/Nexis Academic Universe. 31 December 2000.

Toyota Motor Manufacturing North America, Inc. "Toyota Issues Environmental Guidelines to North American Suppliers..." Available: http://www.toyota.com/html/about/environment/news_awards/supplier.html. 9 January 2001.

Trochim, William M. K. Research Methods Knowledge Base, 2nd edition. 29 June 2000. Cornell U. Available: http://trochim.human.cornell.edu/kb/questype.htm. 26 January 2001.

UK Department of the Environment, Transport and the Regions. Greening Government: Suppliers' 'self assessment' checklist. 23 August 1999. Available: http://www.environment.detr.gov.uk/greening/greenpro/ssacheck/index.htm 6 January 2001

United States. Department of Commerce. National Institute of Standards and Technology. "Baldrige National Quality Program 2001: Criteria for Performance Excellence." 21 February 2001. http://www.quality.nist.gov/PDF%20files/2001%20Business%20Criteria.pdf

---. Environmental Protection Agency. Energy Star Labeled Printers, Faxes, Printer/Fax Combinations, and Mailing Machines: Key Product Criteria. 13 November 2001. http://www.epa.gov/nrgystar/purchasing/6e_pf.html#specs_pf

---. Environmental Protection Agency. Common Sense Initiative: Automotive Manufacturing Sector, Life-Cycle Management/Supplier Partnerships Project Team Conclusions Document. 27 March 1997: 7. 31 December 2000. http://www.epa.gov/commonsense/autos/concusn.htm.

---. Environmental Protection Agency. EPA's EPP: EPA Guidance – EPA's Final Guidance on EPP. 5 September 2000. 6 January 2001. http://www.epa.gov/opptintr/epp/finalguidanceappx.htm.

---. Environmental Protection Agency. Extended Product Responsibility. 17 December 1999: 3. 19 December 2000. http://www.epa.gov/epr/abt-over.htm.

---. Environmental Protection Agency. The Lean and Green Supply Chain: A Practical Guide for Materials Managers and Supply Chain Managers to Reduce Costs and Improve Environmental Performance. Comp. Jeff S. McDaniel, et al. Washington: Office of Pollution Prevention and Toxics, January 2000.

Walton, Steve V., Robert B. Hanfield and Steven A. Melnyk. "The green supply chain: integrating suppliers into environmental management processes." International Journal of Purchasing and Materials Management Spring 1998: 2-11.

Weddle, Jo An and Bill J. Priest. "Raising The Bar Of The Institute: Partnerships with suppliers can solve customer problems." Dallas Business Journal 13 July 1998. 18 December 2000. http://www.bizjournals.com/dallas/stories/1998/07/13/smallb4.html.

"Writing the Questionnaire." Online Development Corporation. 26 January 2001. http://www.odc.com/anthro/docs/survey/ch6.html

Appendix A

United Kingdom Department of the Environment, Transport and the Regions

http://www.defra.gov.uk /environment/greening/greenpro/ssacheck/pdf/ssacheck.pdf

Suppliers' "self assessment" checklist

This checklist was designed by the World Business Council for Sustainable Development to help manufacturers and suppliers to become more efficient and competitive and thereby improve their profits and environmental performance. You may find it useful. Details of some of the things which the Government is doing to improve its own performance are given on DETR's web site (http://www.environment.detr.gov.uk/greening/gghome.htm)

Material intensity

- ❑ Can the product or service be redesigned to make less use of material outputs ?
- ❑ Are there less-intensive raw materials ?
- ❑ Can raw materials be produced or processed in less material intensive ways ?
- ❑ Would higher quality materials create less waste in later stages ?
- ❑ Can water, waste water treatment or waste disposal costs be allocated to budgets to encourage greater control
- ❑ Can yields be increased by better maintenance, control and other means ?
- ❑ Can waste be utilized for other uses ?
- ❑ Can products be made smaller, or a different shape, to minimize use of material and packaging ?
- ❑ Can it be combined with others to reduce overall material intensity ?
- ❑ Can packaging be eliminated or reduced ?

Energy

- ❑ Can raw materials be produced with less or renewable energy ?
- ❑ Would substitute materials or components reduce the overall energy intensity ?
- ❑ Can energy costs be directly allocated to budgets to encourage better control ?
- ❑ Can energy be exchanged between processes ? Can waste heat be utilized ?
- ❑ Can processes be integrated to create energy savings ?
- ❑ Can process energy or the energy consumption of buildings be bettered monitored ?
- ❑ Could better maintenance improve energy efficiency ?
- ❑ Can processes or buildings be insulated more effectively ?
- ❑ Is there scope for better energy housekeeping, eg. energy efficient lighting ?
- ❑ Can the product or service be combined with others to reduce overall energy intensity ?
- ❑ Can the energy efficiency of products in use be improved ?
- ❑ Can transport be reduced or greater use be made of energy-efficient transport ?
- ❑ Are there incentives for employees to cycle or to use public transport or car pools ?

Toxic Dispersion

- ❑ Can toxic dispersion be reduced or eliminated using alternative materials or different processes ?
- ❑ Are products designed to ensure their safe distribution, use and disposal ?
- ❑ Can harmful substances be eliminated from production processes *?*
- ❑ Can harmful substances generated in use be reduced or eliminated ?
- ❑ Can any remaining harmful substances be recycled or incinerated ?
- ❑ Are remaining harmful substances properly handled during production and disposal ?
- ❑ Are equipment and vehicles properly maintained so that emissions are kept to a minimum ?

Recyclability

- ❑ Can the product be re-used, remanufactured or recycled ?
- ❑ Can wastes from raw material production be reused or recycled ?
- ❑ Can process waste be remanufactured, re-used or recycled ?
- ❑ Would separation of waste streams make recycling easier or reduce costs ?
- ❑ Can product specification be modified to enable greater use of recycled materials or components ?
- ❑ Can products be made of marked and easily recycled materials ?
- ❑ Can products be designed to facilitate customer revalorization ?
- ❑ Can products be designed for easy dissassembly ?
- ❑ Can product packaging be made re-usable or more recyclable ?
- ❑ Can old products and components be remanufactured or reused ?
- ❑ Are there opportunities to participate in waste exchange schemes ?
- ❑ Can products be made biodegradable or harmless so that less energy is required for disposal ?

Appendix A (continued)

Resources

- ❑ Can renewable or abundant materials be substituted for scarce or non-renewable ones ?
- ❑ Can more use be made of resources that are certified as being sustainably produced ?
- ❑ Can products be redesigned to utilize renewable or abundant materials ?

Durability

- ❑ Can materials or processes be altered to improve longevity ?
- ❑ Can products or components be made more modular to allow easy upgrading ?
- ❑ Can whatever aspects of the product that limit durability be redesigned ?
- ❑ Can maintenance of the product be improved ?
- ❑ Can customers be informed about ways to extend product durability ?

Service intensity

- ❑ What are customers really getting from your product ?
- ❑ Can this be provided more effectively or in a completely different way ?
- ❑ What service will customers need in the future ?
- ❑ Can you design new or develop existing products to meet them ?
- ❑ Is your product improving other services as well as the most obvious one ?
- ❑ Can it be integrated/synchronized with others to provide multifunctionality ?
- ❑ Can customers disposal problems be eliminated by providing a take-back service ?
- ❑ Can production be localized both to enhance service and reduce transport needs ?

The Department of the Environment, Transport and the Regions is grateful to Greenleaf Publishing for

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Appendix B

Supply Chain Environmental Management: Lessons from Leaders in the Electronics Industry (Table 2, page 20) http://www.usaep.org/scem/report.html

Tools in ESCM: A Collection of Environmentally Related Supplier Initiatives

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

Appendix B (continued)

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

Appendix C

United States Environmental Protection Agency
EPA Final Guidance on Environmentally Preferable Products

Menu of Environmental Attributes

Executive agency personnel are reminded that the attributes listed and defined below are not comprehensive. In addition, Executive agency personnel should note that not all of these attributes will be applicable to every product or service. Furthermore, different attributes may be applicable to each product or service life cycle stage being considered.

A. Natural Resources Use

- **Ecosystem impacts**, such as endangered species, wetlands loss, fragile ecosystems, erosion, animal welfare, etc.
- **Energy consumption**, which can serve as an indicator of acid rain, climate change potential, air pollution, and associated human health risks.
- **Water consumption** which can serve as an indicator of water quality impacts, risks to aquatic ecosystems, and degradation of drinking water resources.
- **Non-renewable resource consumption**, which can serve as an indicator of acid rain, climate change potential, air pollution, and associated human health risks and risks to endangered species and fragile ecosystems.
- **Renewable resource consumption**, which can serve as an indicator of loss of biodiversity and increased erosion. Although in many cases the use of renewable resources is considered environmentally preferable to use of nonrenewable resources, products made from renewable resources may also have negative environmental impacts (e.g., ethanol is derived from a renewable resource, yet its manufacture can lead to releases of VOCs).

B. Human Health and Ecological Stressors

- Bioaccumulative pollutants.
- Ozone depleting chemical global warming gases.
- Chemical releases
  (Toxics Release Inventory (TRI) list chemicals or others.)
- Ambient air releases
  (other than TRI, including volatile organic compounds and particular matter).
- Indoor environmental releases
  (consumer and occupational).
- Conventional pollutants released to water.
- Hazardous waste.
- Non-hazardous solid waste
  (e.g., municipal solid waste, large volume waste, surface impoundments).
- Other stressors.

C. Hazard Factors Associated With Materials

Human Health Hazards:
— acute toxicity
— carcinogenicity
— developmental/reproductive toxicity
— immunotoxicity
— irritancy
— neurotoxicity
— sensitization
— corrosivity
— flammability
— reactivity
— other chronic toxicity

Ecological Hazards:
— aquatic toxicity
— avian toxicity
— terrestrial species toxicity

D. Positive Attributes

The attributes listed below are viewed as positive because they either serve as proxies for minimizing natural resource use or avoiding waste and the associated environmental impacts identified in A, B, and C. These attributes also are linked to authorities and requirements in statutes or executive orders that encourage the Federal government to promote their use. "Recyclability" and "recycled content" are attributes encouraged under RCRA. There are executive orders that encourage Federal agencies acquire bio-based products, and to promote energy efficiency and water conservation. "Durability", "reusability", "take-back", and "reconditioned or remanufactured" are positive attributes that encourage source reduction. "Product disassembly potential" increases the potential for source reduction and recycling of product components. Agencies should note that the presence of these attributes alone does not automatically make a product or service environmentally preferable. When making purchasing decisions, executive agencies should consider a range of environmental impacts associated with products from a life cycle perspective when making purchasing decisions.

Recycled content	Recyclability	Energy efficiency
- Product disassembly potential	Durability	Water efficiency
Reconditioned or remanufactured	Reusability	Take-back
Bio-based		
- Other attributes with positive environmental effects		

Appendix D:

CIQC Standard 0014

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?

Appendix D (continued)

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?

Appendix E

Description of Trade Associations

Electronics Industries Alliance (EIA)
The Electronic Industries Alliance is a trade organization representing the United States high technology community, sponsoring technical standards development, market analysis, government relations, trade shows and seminar programs. It is comprised of over 2,100 members and represents over eighty percent of the $550 billion electronics industry including telecom, space, defense, governments, consumer, assemblies, components, semiconductors, and electronic data interchange.
http://www.eia.org/about/index.cfm

Information Technology Industries Council (ITI)
ITI, the Information Technology Industry Council, represents the leading U.S. providers of information technology products and services. It advocates growing the economy through innovation and supports free-market policies. ITI members had worldwide revenues of more than $460 billion in 1999 and employed more than 1.2 million people in the United States. http://www.itic.org/whoweare/

American Electronics Association, Europe (AEA, Europe)

AEA Europe was established in 1991, headquartered in Brussels. Its 80 members are European companies of American parentage that together represent a major portion of the European electronics industry. AEA Europe member companies currently have a combined yearly sales figure in Europe of well over US$70 billion. Local members directly employ more than 300,000 people in over 100 EU manufacturing sites, 105 EU R&D laboratories and scientific centers and 1,120 EU sales and support offices. A further 1 million employees in EU supplier companies are dependent on AEA Europe member-companies for their livelihood.
http://www.esi.es/Information/ITAssociations/Associations/assoc173.html

ECMA – Standardizing Information and Communication Systems
(formally the European Computer Manufacturers Association)
EMCA is composed of computer vendors and business-equipment manufacturers and suppliers, and oversees standardizing information and communications systems. Along with the appropriate National, European, and International organizations, ECMA aims to develop standards and technical reports, to encourage the correct use of standards by influencing the environment in which they are applied, and to herald the various standards that it produces. ECMA believes that economic growth in the world markets depends on the effective interchange of commercial, technical, and administrative data, text, and images. To this end, ECMA promotes standardization in a non-competitive mode and parallel with the product development teams of all interested parties.
http://www.ecma.ch/

Appendix F

Introductory Letter

Date

TO: Company to be Surveyed
FROM: Cavan Kelsey, Director, Design for Health, Safety, and Environment,
Eastman Kodak Company
VIA e-mail
SUBJECT: Environmental Supply Chain Management Survey

As part of a graduate thesis for the Rochester Institute of Technology, I am conducting a survey of electronic equipment manufacturers to determine how environmental supply chain management is being applied to the procurement of finished products. This survey is confidential and results will be aggregated. Following the conclusion of the survey, a small number of companies will be asked to participate in a brief telephone interview in an attempt to better understand current industry practices.

Attached is a short 15 minute survey intended to be completed by an individual familiar with the purchasing of finished products (ideally this will be a purchasing professional or an environmental professional). For purposes of this study, a finished product is defined as a product provided by a supplier to a purchaser that already meets the customer requirements and does not require additional value added by the purchasing organization. These products are typically branded by the supplier according to the purchaser's specifications.

Please complete the attached survey and kindly e-mail it back to me by RETURN DATE. If you have any questions, please feel free to call me at (716) 726-9549.

Thanks for your attention and cooperation in this area.

Sincerely,

Cavan Kelsey
Director, Design for Health, Safety & Environment
Eastman Kodak Company

e-mail: cavan.kelsey@kodak.com

Appendix G

Environmental Supply Chain Management Survey

Please complete the following survey and e-mail it to Cavan Kelsey at e-mail: cavan.kelsey@kodak.com

Your Name: **Phone Number:**

Your Title: **Your e-mail:**

Company Name:

Company Information:

1) Please select (X) the one industry that best describes the products your company produces

__ Consumer Electronics __ Medical Devices __ Office Equipment

__ Industrial Equipment __ Telecommunications __ Other

2) What is the relative size (number of employees) of your company?

__ 100 – 1000 __ 1000-10,000 __ 10,000 – 50,000

__ 50,000 – 100,000 __ >100,000

3) What percentage of your products is purchased as "finished products" (i.e., products manufactured by another manufacturer and branded for your company's resale)?

__ None __ 0% - 5% __ 5% - 10%

__ 10% - 25% __ 25% - 50% __ > 50%

If you answered "None" to question 3, please stop and return your survey.

Appendix G (continued)

Supplier Characterization:

4) For those finished products that you purchase, what one phrase would best characterize your suppliers?

(a) __ Most suppliers are smaller in size than our company (go to question 5 a).

(b) __ Most suppliers are larger in size than our company (go to question 5 b).

(c) __ We procure finished products approximately equally from smaller and larger suppliers (go to question 5 a and 5 b).

(d) __ None of the above.

Please provide any additional comments below.

Quality Integration:

5) (a) For those finished products suppliers that are smaller than your company, what one phrase would best characterize the influence you have over those suppliers to meet your quality requirements?

__ Smaller finished products suppliers understand that they are responsible to meet our quality requirements. Supplier's failure to do so will result in a loss of our business.

__ Since our smaller finished products suppliers provide unique strategic products, we depend solely on our their quality program to provide quality products.

__ We work jointly with our smaller finished products suppliers to identify quality requirements that match their manufacturing systems and our customer needs.

__ None of the above.

Please provide any additional comments below.

5) (b) For those finished products suppliers that are larger than your company, what one phrase would best characterize the influence you have over those suppliers to meet your quality requirements?

__ Larger finished good suppliers understand our quality requirements. If the supplier fails to meet our quality requirements, the supplier will lose our business.

__ We don't have much influence over larger finished good suppliers, so we rely on the supplier's quality program to provide quality products.

__ We work jointly with our larger finished products suppliers to identify quality requirements that match the supplier's manufacturing systems and our customer needs.

__ None of the above.

Please provide any additional comments below.

6) Select the one term that best describes how you have integrated quality requirements into your purchase of finished products

__ Quality requirements are not specified in the procurement of finished products.

__ Quality requirements are part of our engineering product specifications.

__ Quality requirements are a separate attachment in the supply agreement.

__ None of the above.

Please provide any additional comments below.

Appendix G (continued)

Environmental Requirements:

7) What one statement best describes the environmental management system in your company?

__ Our environmental management system is just beginning to be developed.

__ Our environmental management system is developed, although it is not necessarily integrated into the commercialization of new products.

__ Our environmental management system is developed and is proactively affecting the way in which we design new products.

__ None of the above.

Please provide any additional comments below.

8) Select the one term that best describes how you have integrated environmental requirements into your purchase of finished products.

(a) __ We have not integrated environmental requirements into our procurement processes.

(b) __ We have not yet integrated environmental requirements into our procurement of finished products, although we have integrated requirements into our procurement of commodities (raw materials, parts, and components).

(c) __ We have integrated environmental requirements into our procurement of finished products.

(d) __ None of the above.

Please provide any additional comments below.

Appendix G (continued)

9) If you answered c on the previous question #8, please check the types of environmental requirements that you typically include in the procurement of finished products (check all that apply).

__ designed without the use of certain materials

__ designed with recycled content (other than in packaging)

__ designed to meet certain low energy levels when in use or not in use

__ designed to be easily disassembled

__ designed to be reconditioned or remanufactured

__ designed such that the supplier shares some responsibility for the product at the end of its useful life

__ Other Attributes: please list below.

10) Please provide any additional comments that you believe are valuable in the space below.

Thank you for taking the time to participate in this survey!

Appendix H

Interview Guide

Name of Participant: Date:
Title: Company:

Introduction: Thanks for taking the time to talk to me today. I'll be capturing your responses in written note format during the interview. As with the survey, any information provided by an individual company will be masked in the final report. I'd like to discuss how your company is integrating environmental supply chain management into the procurement of finished products. This interview should only take 30 or 40 minutes. For this interview, a finished product is defined as a product provided by a supplier to a purchaser that already meets the customer requirements and does not require additional value added by the purchasing organization. These products are typically branded by the supplier according to the purchaser's specifications.

1) Please describe the types of finished products that your company purchases.

   (key thoughts to consider: electrical equipment, size & complexity of products, who the suppliers if not proprietary, where the suppliers might be located)

2) How would you describe your relationship with these finished product suppliers?

   (key thoughts to consider: strategic, partnership, alliance, joint learning)

3) How do these relationships differ with regards to your ability to influence the quality requirements of finished products provided by suppliers?

   (key thoughts to consider: range of influence across supplier base, age and number of agreements with any one supplier, strength of the purchasers quality program)

4) How do these relationships differ with regards to your ability to influence the environmental design requirements of finished products provided by suppliers?

   (key thoughts to consider: range of influence across supplier base, age and number of agreements with any one supplier, strength of the purchasers quality program)

Appendix H (continued)

5) What types of environmental requirements are typically considered for the purchase of finished products?

   (key thoughts to consider: raw material restrictions, energy efficiency of product in use, recycled content, disassembly, reconditioning/remanufacturing, end-of-life take back)

6) How are these requirements integrated into the purchase of finished products?

   (key thoughts to consider: contracts, product specifications, quality requirements, separate attachment or agreement)

7) What type of obstacles might keep you and the supplier from meeting all of your environmental requirements?

   (key thoughts to consider: strategic need, amount of leverage, effectiveness of supplier's environmental management system)

Thank you for your time and cooperation. Your insights were most valuable and have helped me to better understand your environmental supply chain management system.

Appendix I

EIA/EICTA/Japanese Material Declaration Comparison

I. Common Substances List

Substances found in all three material declaration guidelines

Antimony and its compounds
Arsenic and its compounds
Beryllium and its compounds
Chromium VI and its compounds
Cadmium and its compounds
Chlorinated paraffins
Flame retardants (organic and inorganic)
Lead and its compounds
Mercury and its compounds
Nickel and its compounds
Organophosphorus compounds
Ozone depleting substances
PBB and PBDE
PCBs
Phthalates
Selenium and its compounds

II. Gap Analysis

Differences among the three material declaration chemical lists

Substance	EIA	EICTA	JEITA
Asbestos	X		X
Azo-based colorants	X	X	
Barium and its compounds		X	
Bismuth and its compounds		X	
Chromium III and its compounds		X	
Cobalt and its compounds		X	X
Copper and its compounds	X	X	
Chlorinated polymers	X		X
Cyanides		X	X
Ethylene glycol ethers	X		
Gold and its compounds	X	X	
Magnesium and its compounds	X	X	
Organostannic compounds		X	
Organic tin compounds		X	X
Palladium and its compounds	X	X	
Polychlorinated naphthalenes		X	X
Radioactive substances	X	X	
Silver and its compounds	X	X	
Tantalum and its compounds		X	
Tellurium and its compounds			X
Thallium and its compounds		X	X
Tin and its compounds		X	
Zinc and its compounds		X	

Appendix I (continued)

Other Key Differences

Material Declaration Aspect	EIA	EICTA	JEITA
Threshold	**1000 ppm**	**No minimum – all "knowingly present substances" must be declared**	**No minimum currently defined**
Scope	**Only substances on "list" to be reported**	**99% of all "material content" to be reported in addition to substances**	**Draft unclear**

Appendix J

Energy Star Specifications for Printers

http://www.epa.gov/nrgystar/purchasing/6e_pf.html#specs_pf

Table 1: Tier 1
Standard Size Printers and Printer/Fax Combinations*(11/1/00 - 10/31/01)
(designated to accommodate primarily A3, A4, or 8.5" x 11" sized paper)

Product Speed in Pages Per Minute (ppm)	Sleep Mode (Watts)[2]	Default Time to Sleep Mode
0 < ppm ≤ 10	≤ 10[3]	≤ 5 minutes
10 < ppm ≤ 20	≤ 20[3]	≤ 15 minutes
20 < ppm ≤ 30	≤ 30	≤ 30 minutes
30 < ppm ≤ 44	≤ 40	≤ 60 minutes
44 < ppm	≤ 75<	≤ 60 minutes

* Including monochrome electrophotography, monochrome thermal transfer, and monochrome and color ink jet.

Table 2: Tier 1
Impact Printers designed to accomodate
primarily A3 paper (11/1/00 - 10/31/01)

Sleep Mode (Watts)	Default Time to Sleep Mode
≤ 30	≤ 30 minutes

Table 3: Tier 1
Large/Wide-Format Printers (11/1/00 - 10/31/01)
(designed to accommodate primarily A2 or 17" x 22", or larger paper)

Product Speed in Pages per minute (ppm)	Sleep Mode (Watts)[2]	Default Time to Sleep Mode
0 < ppm ≤ 10	≤ 35	≤ 30 minutes
10 < ppm ≤ 40	≤ 65	≤ 30 minutes
40 < ppm	≤ 100	≤ 90 minutes

[2]For printers that utilize a functionally integrated computer, whether contained within or outside of the printer cabinet, the power consumption of the computer does not have to be included when determining the sleep mode value of the printer unit. However, the integration of the computer must not interfere with the ability of the printer to enter or exit its Sleep Mode state. This provision is conditioned upon the manufacturer agreeing to provide potential customers with product literature that clearly states that the power consumed by the integrated computer is in addition to the power consumed by the printer unit, especially when the printer unit is in Sleep Mode.

[3]For Tier 1, a one-time 5-Watt allowance is permitted for those products that are shipped "network ready" (i.e., inclusive of network functionality "out of the box"). For those products shipped as not "network ready", the additional one-time 5-Watt allowance does not apply

Appendix J (continued)

Table 4: Tier 1
Color Printers* (11/1/00 - 10/31/01)
(designed to accommodate primarily A3, A4, or 8.5" x 11" sized paper)

Product Speed in Pages per minute (ppm)	Sleep Mode (Watts)[2]	Default Time to Sleep Mode
0 < ppm ≤ 10	≤ 35[3]	≤ 30 minutes
10 < ppm ≤ 20	≤ 45	≤ 60 minutes
20 < ppm	≤ 70	≤ 60 minutes

*Including color electrophotography and color thermal transfer.

Table 5
Stand Alone Fax Machine (11/1/00 - 10/31/02)
(designed to accommodate primarily A4, or 8.5" x 11" sized paper)

Product Speed in Pages per minute (ppm)	Sleep Mode (Watts)	Default Time to Sleep Mode
0 < ppm ≤ 10	≤ 10	≤ 5 minutes
10 < ppm	≤ 15	≤ 5 minutes

Table 6
Mailing Machines (11/1/00 - 10/31/02)

Product Speed in Mail Pieces per minute (ppm)	Sleep Mode (Watts)	Default Time to Sleep Mode
0 < mppm ≤ 50	≤ 10	≤ 20 minutes
50 < mppm ≤ 100	≤ 30	≤ 30 minutes
100 < mppm ≤ 150	≤ 50	≤ 40 minutes
150 < mppm	≤ 85	≤ 60 minutes

Table 7: Tier 2
Standard Size Printers and Printer/Fax Combinations* (11/1/01 - 10/31/02)
(designed to accommodate primarily A3, A4, or 8.5" x 11" sized paper)

Product Speed in Pages per minute (ppm)	Sleep Mode (Watts)	Default Time to Sleep Mode
0 < ppm ≤ 10	≤ 10	≤ 5 minutes
10 < ppm ≤ 20	≤ 20	≤ 15 minutes
20 < ppm ≤ 30	≤ 30	≤ 30 minutes
30 < ppm ≤ 44	≤ 40	≤ 60 minutes
44 < ppm	≤ 75	≤ 60 minutes

Table 8: Tier 2
Impact Printers designed to accommodate primarily A3 paper (11/1/01 - 10/31/02)

Sleep Mode (Watts)	Default Time to Sleep Mode
≤ 28	≤ 30 minutes

Table 9: Tier 2
Large/Wide-Format Printers (11/1/01 10/31/02)
(designed to accommodate primarily A2 or 17" x 22", or larger paper)

Product Speed in Pages per minute (ppm)	Sleep Mode (Watts)	Default Time to Sleep Mode
0 < ppm ≤ 10	≤ 35	≤ 30 minutes
10 < ppm ≤ 40	≤ 65	≤ 30 minutes
40 < ppm	≤ 100	≤ 90 minutes

Table 10: Tier 2
Color Printers* (11/1/01 - 10/31/02)
(designed to accommodate primarily A3, A4, or 8.5" x 11", or sized paper)

Product Speed in Pages per minute (ppm)	Sleep Mode (Watts)	Default Time to Sleep Mode
0 < ppm ≤ 10	≤ 35	≤ 30 minutes
10 < ppm ≤ 20	≤ 45	≤ 60 minutes
20 < ppm	≤ 70	≤ 60 minutes

*Including color electrophotography and color thermal transfer.

Appendix K

Blue Angel Requirements for Printers

http://213.198.61.142/blauer/Englisch/index.htm

Printers
RAL-UZ 85

Output: February 2001

Environmental Aspects

Pollutant emission avoidance and waste avoidance as well as the utilization of used products are important aims of environmental protection. Pursuance of these aims helps to prevent possible entries of pollutants into the environment, protect resources and save disposal site space.

The Environmental Label for Printers may be awarded to devices distinguishing themselves by the following environmental features:

- The design of the devices shall be such as to make them long-lived and recyclable.
- Noise emissions and energy consumption shall be as low as possible.
- Alarming pollutant loads of indoor spaces and the use of environmentally harmful substances in the materials shall be avoided.

Scope

These Basic Criteria apply to matrix printers, ink-jet printers and electrophotographic office printers (e.g. laser printers), i.e. print rate <= 25 pages per minute to be determined according to DIN 32751 or ISO 10561, respectively.

The provisions of these Basic Criteria relating to the consumables refer to the unchanged material supplied along with the original equipment of the devices only.

Appendix K (continued)

Requirements

1 Longevity of the Devices

1.1 Expansion of Performance

Provided that electrophotographic printers have a main memory the latter must be expandable or exchangeable, resp.. Excluded are printers which - adjusted to maximum resolution - can print on the full maximum size of paper (printing area).

1.2 Manufacturer's Guarantee

The applicant shall give a three-year guarantee on the device. If in connection with this guarantee extra costs are charged the customer shall have the right to choose the period of guarantee (and with that the price) as from 1 year on.

1.3 Repair Guarantee

The applicant undertakes to see to it that the supply of spare parts for a repair of the devices is guaranteed for at least 5 years as from the termination of production.

1.4 The applicant undertakes to see to it that the consumables too are available for 5 years from the termination of products.

1.5 Information on the Longevity

The product papers must include information on the requirements as specified in paras.1.1 to 1.4.

2 Recyclable Design

The devices must comply with the principles of VDI Directive 2243 "Konstruieren recyclinggerechter technischer Produkte" (Design of recyclable technical products) on the basis of characteristic features which can be seen from the Check List "Recyclable Design" (cf. Appendix 1 to these Basic Criteria RAL-UZ 85) and which have been set by the manufacturer taking the future reuse and material utilization processes into account.

Such characteristic features are among others:

- Avoidance of non-separable connections (e.g. by glueing, separable mechanical connections;
- Avoidance of coatings and composite structure materials;
- Easy detachability of devices and modules, also for the purpose of easy repair;
- Reduction of the multitude of materials;

3 Reduction of the Number of Plastics

Large-size plastic case parts (weighing more than 25g) must consist of a single homopolymer or a copolymer. Polymer blends (polymer alloys) shall be allowed. Polymer blends are specific mixtures of two or more plastics offering better properties than the pure plastics contained in the mixture (cf. ISO 472). The plastic cases may be made of a total of four separable polymers or polymer blends at the most. Large-size plastic case parts must

be so designed as to ensure the reutilization of the plastics used on the basis of existing technologies for the production of high-quality and long-lived products.

4 Material Requirements for the Plastics forming Cases and Case Parts of Printers

No substances which may form dioxin or furane may be used for the production of the cases. That is why halogenated polymers and additions of halogenated organic compounds - especially as flame retardants - are prohibited.

The flame retardants used must neither be classified as carcinogenic according to TRGS 905, TRGS 900 or MAK-value list[1)], as amended, nor suspected of being carcinogenic according to MAK III1, III2, III3 or EC categories Carc.Cat.1, Carc.Cat.2 or Carc.Cat.3.

Exempted from this rule are:

- Fluoroorganic additives (such as, for example, antidripping reagents) used to improve the physical properties of the plastics, provided that they do not exceed 0,5 weight per cent,
- process-induced, technologically unavoidable impurities,
- industrial zoot (Carbon Black) used as a pigment,
- special plastic parts located close to the heating and fusing facilities. These parts must not contain any PBB (polybrominated biphenyls), PBDE (polybrominated diphenyl ethers) or chlorinated paraffins.

5 Marking of Plastics

Plastic parts shall be marked according to DIN ISO 11 469. Exempted from this rule are small parts weighing less than 25g or covering less that 200 mm^2 of plane surface.

6 Acceptance of the Return of Used Devices

The applicant undertakes to take own products marked with the Environmental Label back after use in order to forward them to reuse or material utilization, respectively. Non-recyclable device parts shall be forwarded to proper disposal. The devices marked with the Environmental Label shall be returned in a condition corresponding to the intended use.

The devices may be returned to a device return station (e.g. dealer) to be named by the applicant. Such device return stations must be located in Germany. The customer must be able to return his/her device either personally or by mail. The product papers shall include information on the possibility to return used devices.

Appendix K (continued)

7 Noise Emissions

Ten times the declared sound-intensity-level L_{WAd} according to para 3.2.5 of ISO 9296 shall not exceed the following values for measurement purposes during the printing operation:

Printing rate pages per minute	Noise emission of ink-jet printers and electrophotographic printers	Noise emission of matrix printers
<= 7	L_{WAd} <= 58 dB (A)	L_{WAd} <= 72 dB(A)*
7 > and <= 14	L_{WAd} <= 62 dB (A)	
> 14	L_{WAd} <= 67 dB (A)	

The noise emission measurements must be carried out in accordance with DIN EN 27 779 adjusted to the highest print quality.

The determination of the print rate shall be done in accordance with the product papers.

The applicant shall include a note into the product papers.

If the noise measurement will be only done with one piece, the following formular must be basis for the determination for the sound-intensity-level L_{WAd}:

$L_{WAd} = L_{WA} + K$ $\sigma_M = 2{,}0$ dB(A) (see ISO 9296)
$K = 1{,}5 \times \sigma_M$
$L_{WAd} = {}^*L_{WA} + 3$ dB(A) 1,5 $\triangleq$ student factor

* single measurement

** The applicant shall include a note into the product papers informing about the fact that printers with LWAd >= 63 dB(A) should not be used in rooms mainly used for intellectual work but should be in stalled in separate rooms because of their high noise emission.

8 Batteries/Accumulators

Provided that the device includes batteries, these batteries must not contain the heavy metals cadmium, lead or mercury.

Batteries which cannot be exchanged by the user himself /herself must be either rechargeable or have a useful life of at least 10 years.

Appendix K (continued)

9 Power draw

Printers must be equipped with a special energy-saving idle state which activates itself automatically. In this state the power draw of the device must not exceed the following values (in accordance with the international EPA specification).

Print rate (pages per minute)	Activation period for the energy-saving idle state after a maximum of	Maximum power draw in the energy saving idle state
1 - 7	15 minutes	15 watts
8 - 14	30 minutes	30 watts
more than 14 and all high-performance printers	60 minutes	45 watts

In the operating mode "OFF" the power draw must not exceed 2 watts.

In addition, the product papers must include the following data:

- Printing rate (number of pages per minute),
- Power draw in the energy-saving idle state,
- Power draw in the operating mode "OFF"
- Activation period in the energy-saving idle state,
- The applicant shall include detailed information into the product papers regarding the power draw in the "OFF" mode. If a power draw is recorded the applicant shall include a note stating that such energy consumption can be prevented by disconnecting the device from the mains.

10 Device Safety

The devices must meet the device safety requirements as specified in DIN EN 60 950 (corresponds to DIN VDE 0805).

11 Electromagnetic Compatibility

The devices must comply with the requirements of the Directive on Electromagnetic Compatibility 89/336/EEC. With regard to radio interference suppression the devices must fulfill the requirements as specified in EN 55 022 (corresponds to DIN VDE 0878, Part 3).

12 Printing Paper

The devices mus t be able to print on recycled paper made of 100 % waste paper provided that such paper complies with the requirements of DIN 19 309 (copying paper). The applicant shall recommend certain types of recycled paper. The product papers shall include the following note: "Suitable for the use of recycled paper according to DIN 19 309."

Appendix K (continued)

13 Inked-Ribbon Cartridges, Toner Cartridges and Ink Cartridges

13.1 Recyclable Design of the Consumables

The inked-ribbon cartridges, toner cartridges and ink cartridges supplied by the applicant along with the original equipment must be so designed that they can be forwarded to reuse or material utilization, respectively.

They must comply with the requirements given in the Check List "Recyclable Design" of Consumables (Appendix 2 to the Basic Criteria of RAL-UZ 85).

13.2 Acceptance of the Return of Consumables

The applicant undertakes to accept the return of the inked-ribbon, toner and ink cartridges supplied along with original equipment in order to forward them to reuse or material utilization, respectively. Third parties may be assigned to this task.

Non-recyclable product parts shall be forwarded to proper disposal. The consumables may be returned to a return station to be named by the applicant where they may be returned free of charge either personally or by mail.

Such return stations must be located in Germany. Return stations abroad are admissible if it is possible to send the consumables there free of postage.

The product papers of the device shall include information on the possibilities to return the consumables.

13.3 Information on the Proper Handling of Toner Cartridges and Appliance Maintenance

Toner Cartridges must be hermetically sealed to prevent toner dust from escaping during storage and handling as long as the toner cartridge is not properly fitted into the appliance for its final use.

The user must be informed about the proper handling of toner cartridges. In addition, the product papers must include a note stating that toner cartridges must not be opened by force and that - if toner dust has escaped as a result of improper handling - inhaling of dust and skin contact must be avoided as a precaution.

In addition, the product papers must underline that toner cartridges must be kept out of the reach of children.

Cleaning, maintenance and disposal shall be done by trained personnel only.

14 Packaging

The plastics used for the packaging of the devices must not contain any halogenated polymers.

They shall be marked in accordance with DIN 6120.

15 User Manual

The written reference material supplied along with the devices shall be printed on paper bleached without chlorine (fresh fibre or waste paper).

Appendix K (continued)

16 Substance-related standards for toners used in electrophotographic printers, inks used in ink-jet printers and inks used in matrix printers

16.1 Heavy metals

These products must not include any substances containing mercury, lead, cadmium or chromium VI compounds as constituent parts.

16.2 Azo dyes

No Azocolorants (dyes and pigments) may be used which as amine components contain substances which according to the MAK-value list are classified as carcinogenic or suspected of being carcinogenic (MAK III1, III2, III3) (cf. "Special Substance Groups" Chapter III of the MAK-value list).

16.3 Other Hazardous Substances

Toners used in electrophotographic printers, inks used in ink-jet printers and inks used in matrix printers must not contain any substances as constituent parts:

- which are classified according to Section 4a of the "Gefahrstoffverordnung" (Ordinance on Hazardous Substances) - in connection with Annex I to Directive 67/548/EEC (List of hazardous substances and preparations) and which - according to Annex III to Directive 67/548/EEC -require marking with the following R-set danger criteria:
    - R 26 (very toxic when inhaled)
    - R 27 (very toxic upon contact with the skin)
    - R 40 (possible irreversible damage)
    - R 42 (possible sensitization by inhalation)
    - R 45 (may cause cancer)
    - R 46 (may cause genetic damage)
    - R 49 (may cause cancer if inhaled)
    - R 60 (may impair the reproductiveness)
    - R 61 (may be harmful to the embryo)
    - R 62 (may possibly impair the reproductiveness)
    - R 63 (may possibly be harmful to the embryo)
    - R 64 (may be harmful to the infant via the mother's milk),
- which in the MAK-value list (Carcinogenic Working materials), as amended, are classified as carcinogenic or suspected of having a carcinogenic potential according to MAK III1, III2, III3[2)] or the EC categories Carc.Cat.1, Carc.Cat.2 or Carc.Cat.3,
- which according to TRGS 905 (as amended) are classified as carcinogenic.

- mutagenic or teratogenic substances,
- which require marking of the entire product with the danger symbols pursuant Annex II to Directive 67/548/EEC,
- which require marking of the entire product with the R-43 set of danger criteria (possible sensitization upon contact with the skin).

17 Pollutant Emissions of Electrophotographic Printers

17.1 Dust:

The dust emission of the device shall not lead to an indoor-air concentration exceeding 0,150 mg/m^3 (maximum immission concentration as 24h-average value on successive days) (cf. VDI 2310, Sheet 19). The dust concentration shall be measured in accordance with the test conditions listed in Appendix 3 to the Basic Criteria of RAL-UZ 85.

17.2 Ozone:

The ozone emission of the device shall not lead to an indoor-air concentration exceeding 0,02 mg/m^3. The ozone concentrarion shall be measured in accordance with the test conditions listed in Appendix 4 to the Basic Criteria of RAL-UZ 85.

17.3 Styrene:

The styrene emission of the device shall not lead to an indoor-air concentration exceeding 0,07 mg/m^3 (WHO standard, cf. WHO Air Quality Guidelines). The styrene concentration shall be measured in accordance with the test conditions listed in Appendix 5 to the Basic Criteria of RAL-UZ 85.

If toners of identical composition are used for different device types within the same print rate the category of this measurement shall be required for one device type only.

18 Quality of the photoconductor drum of electrophotographic printers

18.1 The photoconductor drums of electrophotographic printers must not contain any lead, cadmium or mercury as constituent parts.

18.2 Acceptance of the Return of Photoconductor Drums

The photoconductor drums of electrophotographic printers must be suitable for reprocessing or recycling of the metal cylinder. The applicant shall accept the return of worn photoconductor drums. The returned photoconductor drums must be reprocessed for the purpose of renewed installation into the devices or material recycling of drums which are no longer usable. No cadmium-plated substances or parts may be used for the retreatment process. The product papers shall inform about the possibility to return and recycle photoconductor drums. The return station to be named by the applicant must be located in Germany. It must be possible to return the photoconductor drums to such stations either personally or by mail.

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1) Maximum concentration at the place of work and biological tolerance values for working materials, Deutsche Forschungsgemeinschaft, Senate Commission for the testing of hazardous substances, Wiley-VCH, Weinheim, Communication 36 or in its current version.

Appendix K (continued)

2) In 1999, carbon black was put on the MAK List III 3. Provided that carbon black cannot be technologically substituted by another pigment on a short-term or medium-term basis carbon black may be contained in the toner material. This regulation shall hold good until December 31, 2002 for the time being, unless an assessment or classification of toner material by the MAK Commission, AGS or the EU Commission leads to the cancellation of such regulation prior to that date.