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REPORT OF SURVEY CONDUCTED AT

**POLAROID CORPORATION  
WALTHAM, MA**

MARCH 1997

## ***Best Manufacturing Practices***



**BEST MANUFACTURING PRACTICES CENTER OF EXCELLENCE**  
College Park, Maryland  
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# Foreword

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This report was produced by the Best Manufacturing Practices (BMP) program, a unique industry and government cooperative technology transfer effort that improves the competitiveness of America's industrial base both here and abroad. Our main goal at BMP is to increase the quality, reliability, and maintainability of goods produced by American firms. The primary objective toward this goal is simple: to identify best practices, document them, and then encourage industry and government to share information about them.

The BMP program set out in 1985 to help businesses by identifying, researching, and promoting exceptional manufacturing practices, methods, and procedures in design, test, production, facilities, logistics, and management – all areas which are highlighted in the Department of Defense's 4245-7.M, *Transition from Development to Production* manual. By fostering the sharing of information across industry lines, BMP has become a resource in helping companies identify their weak areas and examine how other companies have improved similar situations. This sharing of ideas allows companies to learn from others' attempts and to avoid costly and time-consuming duplication.

BMP identifies and documents best practices by conducting in-depth, voluntary surveys such as this one at the Polaroid Corporation, Waltham, Massachusetts conducted during the week of March 17, 1997. Teams of BMP experts work hand-in-hand on-site with the company to examine existing practices, uncover best practices, and identify areas for even better practices.

The final survey report, which details the findings, is distributed electronically and in hard copy to thousands of representatives from government, industry, and academia throughout the U.S. and Canada – *so the knowledge can be shared*. BMP also distributes this information through several interactive services which include CD-ROMs, BMPnet, and a World Wide Web Home Page located on the Internet at <http://www.bmpcoe.org>. The actual exchange of detailed data is between companies at their discretion.

The future success of Polaroid depends on traditional business achievements intertwined with continued improvement of environmental and safety performance. Polaroid was one of the first companies to integrate health, safety, and environmental functions, and continues to support its commitment to environmental stewardship. Among the best examples were Polaroid's accomplishments in occupational medical program; community outreach; cooling tower make-up water metering; ultraviolet light treatment; watershed protection; pressure nutsche; and safety ambassador.

The Best Manufacturing Practices program is committed to strengthening the U.S. industrial base. Survey findings in reports such as this one on the Polaroid Corporation expand BMP's contribution toward its goal of a stronger, more competitive, globally-minded, and environmentally-conscious American industrial program.

I encourage your participation and use of this unique resource.

A handwritten signature in cursive script, reading 'Ernie Renner'.

Ernie Renner

Director, Best Manufacturing Practices

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## Polaroid Corporation

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# Section 1

## *Report Summary*

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### ***Background***

Dr. Edwin Land founded the Polaroid Corporation in 1937. Although best known as the inventor of the instant photography process and the Polaroid Land camera, Dr. Land was a strong social advocate. For example, he started a family practice health clinic for his employees and their families; established a safety program in the 1950s; and initiated environmental efforts in preparation for the first Earth Day in 1970. Originally, Polaroid produced light polarizing filters. Today, the company designs, manufactures, and markets instant imaging recording products worldwide, such as instant photographic cameras and films; electronic imaging recording devices; conventional films; and light polarizing filters and lenses. With its corporate headquarters located in Cambridge, Massachusetts, Polaroid maintains eight U.S. sites, employs 8,500 personnel worldwide, and achieved \$2.5 billion in revenues for 1996.

The BMP survey focused on Polaroid's Waltham (Main Street), Massachusetts site which employs 1,200 personnel, and encompasses 150 acres. Featuring Polaroid's Chemical Operations Division, this site synthesizes chemical components used in Polaroid film; manufactures chemical reagents; coats photographic materials; assembles technical and industrial film products; and performs research, engineering, and wastewater treatment. Polaroid promotes proactive approaches; open communication; environmental and safety commitments; and community involvement. Among the best examples were Polaroid's occupational medical program; community outreach; cooling tower make-up water metering; ultraviolet light treatment; watershed protection; pressure nutsche; and safety ambassador.

Envisioning complete healthcare for all Polaroid employees and their families, Dr. Land initiated a family practice health clinic. Over the years, the clinic evolved into an exceptional occupational health clinic. Today, Polaroid's occupational medical program promotes and supports healthy work environments and healthy lifestyles for its employees.

Polaroid advocates community outreach efforts through the Polaroid Foundation, Project Bridge

and facility tours; maintains a continuing dialogue on environmental issues at the local, regional, national, and international levels; and supports open communications with environmental groups, government agencies, educational and healthcare institutions, customers, and the public. In addition, Polaroid provides educational programs for its employees to inform them about environmental issues and processes within the company.

Although Polaroid's cooling towers consume large amounts of water for operation, only about 10% of the water returns to the sewer system while the remaining 90% evaporates from the towers. Through its cooling tower make-up water metering efforts, Polaroid negotiated with the City of Waltham's Water Department for an annual rebate of sewer charges for the water that evaporates from its cooling towers.

Approximately eight years ago, Polaroid began installing ultraviolet light water jackets for the humidifiers located in its air handling systems. These air handling systems service the comfort and health needs of the employee as well as the stringent production requirements for making instant print films. The ultraviolet light treatment drastically reduced the typical inlet conditions caused by bacterial growth and decreased humidifier maintenance.

Polaroid and the Waltham community became aware of site spill risks and the potential for liability in the 1980s. Since the facility sits on a steep hill, runoff water flows directly into a drainage area adjacent to a major commuting highway, and then into the community reservoir. Polaroid developed a watershed protection plan to minimize the site spill risks to the community. The plan led to various outgrowths such as road improvements, roof runoff collection and usage, and Waltham Earth Day festivals.

Since 1988, Polaroid has been implementing a program to replace its traditional centrifuges and dryers with pressure nutsche technology. Pressure nutsches work as self-contained vessels to mix, dry, and separate chemical mixtures while removing vapors and emissions. Through pressure nutsche technology, Polaroid has improved safety for its employees, reduced air emissions by 80%, and increased operational performance.

Polaroid's Safety Ambassador program makes each employee a contributing element of the process, incorporates safety with other aspects of production, and provides meaningful measure and safety performance display metrics. Employees are trained as ambassadors for continual safety improvement by locating known problem areas, potential hazards, and possible risk areas. In addition, Polaroid operates the program as a recognition and reward system.

The future success of Polaroid depends on traditional business achievements intertwined with continued improvement of environmental and safety performance. Polaroid was one of the first companies to integrate health, safety, and environmental functions, and continues to support its commitment to environmental stewardship. In addition, Polaroid maintains a strong belief in accountability through environmental compliance, employee training, and community outreach programs. Faced with today's challenges and opportunities, Polaroid is expanding into a full-service imaging company by developing electronic and medical imaging capabilities to complement its core photographic products and services. The BMP survey team considers the following practices to be among the best in industry and government.

### **Best Practices**

The following best practices were documented at Polaroid:

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| <b>Product Safety Emission Testing</b>                                                                                                                                                                                                                                                                                                                                                                 | 11   |
| Ongoing research continues to establish limits and guidelines for indoor air quality in occupational settings and for volatile organic compound emissions from various sources such as furniture, carpets, and office equipment. Polaroid regularly conducts tests to characterize and quantify volatile organic compound emissions generated and emitted during the operation or use of its products. |      |
| <b>Activity-Based Risk Management Performance System</b>                                                                                                                                                                                                                                                                                                                                               | 11   |
| In 1994, Polaroid began implementing an Activity-Based Risk Management Performance system to improve the safety record of its Components Division plants. To recognize, encourage, and reward employee participation, the system used safety metrics which focused on the posi-                                                                                                                        |      |

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| tive aspects of injury prevention. The positive metrics also helped in identifying and correcting underlying factors that could lead to injuries.                                                                                                                                                                                                                                                                                                                                              |      |
| <b>Asbestos Management Program</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 12   |
| Many of Polaroid's buildings were built between 1962 and 1985, and those pre-dating 1975 were constructed with a variety of asbestos-containing materials. In 1995, Polaroid established the Asbestos Management program to increase employee awareness and improve asbestos management at all its facilities.                                                                                                                                                                                 |      |
| <b>Chemical Labeling</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 13   |
| Polaroid has implemented a new chemical labeling system that features bar codes to maintain the information required for each chemical reagent. The operator scans the bar code into the computer which displays the weight amount needed and then produces a bar code containing information for the next stage in the process.                                                                                                                                                               |      |
| <b>Drum Handling</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 14   |
| In 1994, Polaroid began focusing on improvements that minimized or avoided injuries and hazards during material handling. Employee options for reducing drum handling risks included wearing back supports, using mechanical aids such as forklifts, and increasing the number of personnel needed to move drums. In addition, Polaroid initiated the use of totes; pressure nutsches; eduction wands; and air-operated drum lifters/movers to further minimize or avoid injuries and hazards. |      |
| <b>Early Suppression Fast Response Fire Protection</b>                                                                                                                                                                                                                                                                                                                                                                                                                                         | 14   |
| Fire suppression is a critical need in warehouse settings. Three years ago, Polaroid began retrofitting its facilities with Early Suppression Fast Response fire protection sprinkler systems. This system differs from the traditional water sprinkler system by relying on fire suppression rather than fire control.                                                                                                                                                                        |      |
| <b>Electrostatic Discharge Machining Oil Removal</b>                                                                                                                                                                                                                                                                                                                                                                                                                                           | 15   |
| Polaroid has developed a two-step carbon and clay filter system which removes oil and detergent from Electrostatic Discharge Machining operation wastewater. The system's initial objective was to maintain or reduce operating costs, and meet the sewer permit requirements set by the Massachusetts Water Resource Authority.                                                                                                                                                               |      |

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| <b>Emergency Planning Program</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 15   | environmental impact categories based on toxic characteristics, physical attributes, and chemical properties. Polaroid then targets these categories for reduction or recycling.                                                                                                                                                                                                                                                                                                                                                          |      |
| The philosophy behind Polaroid's Emergency Planning program is prevention and preparedness as equal partners in any emergency situation. Polaroid mandates that all divisions have preparedness plans which are integrated with the building, site, and community plans. Polaroid audits and updates its preparedness plans at least yearly. In addition, an emergency procedure manual addresses preparedness, prevention, response, and recovery.                                                                                                                     |      | <b>Hazardous Waste Disposal Audit Procedure</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 20   |
| <b>Engineering Controls</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 16   | Polaroid recognized that various factors can warrant a need for altering a waste stream's disposal method. To standardize the procedure, Polaroid developed an auditing process for determining the proper means of disposing hazardous waste and selecting vendors and proper treatment options. The auditing process includes a matrix that outlines the appropriate disposal methods for on-site recovery, fuel blend disposal, recycling sales, or disposal via a Treatment, Storage, and Disposal Facility.                          |      |
| Polaroid developed state-of-the-art engineering controls to reduce chemical hazard exposure of its employees. Dust and fumes are vented out of the working area and solvent emissions are sent to either a vapor recovery system or a thermal destruction pollution control device. These practices reduced worker exposure in the chemical facilities by 98%.                                                                                                                                                                                                          |      | <b>Landfill Avoidance</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 20   |
| <b>Environmental Scorecard</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 16   | In 1987, Polaroid's CEO made a commitment that his company would avoid sending chemical waste to landfills unless it truly was the best alternative. As a result, Polaroid developed a landfill avoidance procedure. All hazardous waste disposal contracts must be reviewed by the Purchasing Environmental Manager at the corporate level. Spent hazardous waste which cannot be recycled, reclaimed, or reused in another process is sent to a chemical waste disposal facility as determined by the Purchasing Environmental Manager. |      |
| In the early 1990s, Polaroid recognized that its successful proactive approach to environmental regulatory requirements lacked comprehensive metrics for tracking corporate environmental performance. As a result, Polaroid developed the Environmental Scorecard in 1993 to measure and report emission excursions and official notifications of non-compliance. Designed as a spreadsheet, the Environmental Scorecard tracks written violation documents; specific violations within the document; and excursions that extend beyond the allowed regulatory limits. |      | <b>Local Emergency Planning Committee Membership</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 21   |
| <b>Ergonomic Program</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 16   | Polaroid works closely with local community officials to keep them informed on the risk factors, hazardous materials used at manufacturing sites, and precautions taken to ensure the safety of employees and the public. Polaroid employees serve as members on community-based Local Emergency Planning Committees to ensure an effective, ready response in the event of a hazardous material accident from any source in the community.                                                                                               |      |
| In 1992, Polaroid Corporation developed an ergonomic program and supporting guidelines to promote continuous health and safety performance improvements while maintaining product quality and sustaining profitability. Polaroid tests the effectiveness of its ergonomic improvements by incorporating a mission; policies; guidelines; job analysis evaluations; redesign methodology; in-house expertise training; and pilot programs.                                                                                                                               |      | <b>Pressure Nutsche</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 21   |
| <b>Establishment of Chemical Categories</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 18   | Since 1988, Polaroid has been implementing a multimillion dollar program to replace the traditional centrifuges and dryers at its Chemical Operations Division with pressure nutsche technology. This change improves safety for employees, prevents pollution, and provides increased operational performance.                                                                                                                                                                                                                           |      |
| Polaroid's Toxic Use and Waste Reduction program was developed to reduce toxin use and waste sources as a means of preventing pollution. A critical element of the program was to assign chemicals used in production lines to five                                                                                                                                                                                                                                                                                                                                     |      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |      |

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| <b>Process Safety Management</b>                                                                                                                                                                                                                                                                                                                                                                                                                              | 22   | tively influence its employees' behavior by focusing on the motivations of an individual's action.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |      |
| Approximately 60 chemical processes which run at Polaroid fall under the volume or flammability criteria of OSHA requirements. In May 1992, Polaroid began complying with OSHA's Process Safety Draft Document by establishing safety teams and committees at each chemical manufacturing site to interpret OSHA requirements, write policy manuals, and implement the procedures.                                                                            |      | <b>Toxicity Bulletin</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 25   |
| <b>Product Delivery Process</b>                                                                                                                                                                                                                                                                                                                                                                                                                               | 22   | In 1965, Polaroid published its first Toxicity Bulletin as part of its Consumer Product Safety program. The bulletin provides general information on the toxicity of Polaroid products and answers potential health and toxicity questions raised by customers.                                                                                                                                                                                                                                                                                                                                                                                                          |      |
| Polaroid typically develops dozens of new products each year. To guide the development of products, Polaroid formalized a structured process in the late 1980s called the Product Delivery Process. Its purpose was to reduce the break-even cost and time; determine a programmatic development approach; and more clearly identify the individual responsibilities for new products.                                                                        |      | <b>Cooling Tower Make-up Water Metering</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 26   |
| <b>Reinforcing Safety Values at Polaroid Program</b>                                                                                                                                                                                                                                                                                                                                                                                                          | 23   | Typically, sewer charges for industrial sites are based on the percentage of cubic feet of water metered to a company's site regardless of its usage. Although Polaroid's cooling towers consume large amounts of water for operation, only about 10% of the water returns to the sewer system while the remaining 90% evaporates from the towers. As a result, Polaroid negotiated with the City of Waltham's Water Department for an annual rebate of sewer charges for the water that evaporates from its cooling towers.                                                                                                                                             |      |
| Prior to 1989, Polaroid had an OSHA recordable incident rate of 2.4 while the average national manufacturers' incident rate was 8 to 9. In 1989, Polaroid designed and developed the Reinforcing Safety Values at Polaroid program as a management tool to reduce its injury rate by 50% and to reinforce safety values. Polaroid's goal is to minimize accidents and eliminate hazards in the workplace and to enhance its leadership role in safety issues. |      | <b>Free Cooling with Evaporate Fill Media Pads</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 26   |
| <b>Safety Ambassador</b>                                                                                                                                                                                                                                                                                                                                                                                                                                      | 24   | Approximately 15 years ago, Polaroid's facilities engineers began retrofitting and installing new process, manufacturing, and office space heating, ventilating, and air conditioning systems using evaporative fill media pads. Concurrently, the air handling units were redesigned and retrofitted to incorporate the advantages of a positive pressure, blow-through system. This modification reduced the possibility of chilled water coils freezing in the winter due to air stratification; eliminated the need for a preheater coil; and extended the life expectancy of equipment by housing the fan, motor, and drive in a dry, contaminant-free environment. |      |
| In October 1985, Polaroid established the Safety Ambassador program to improve its Battery Division's safety record. The program makes each employee a contributing element of the process, incorporates safety with other aspects of production, and provides meaningful measure and safety performance display metrics.                                                                                                                                     |      | <b>Moving Crates</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 27   |
| <b>Safety Values Process</b>                                                                                                                                                                                                                                                                                                                                                                                                                                  | 24   | Polaroid recognized that the practice of purchasing corrugated moving boxes, recollecting them after a move, and then recycling the used boxes was a waste of natural resources and an unnecessary budget commitment. To rectify the situation, Polaroid purchased 100 plastic stackable moving totes with hinged lids at \$20.00 each. These totes are loaned to employees and returned after each move.                                                                                                                                                                                                                                                                |      |
| Polaroid's Safety Values process works as a behavioral intervention program which reinforces the idea that health, safety, and well-being are every employee's personal responsibility. Begun in the early 1990s, the Safety Values process offered Polaroid a way to posi-                                                                                                                                                                                   |      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |

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| <b>Power Factor Correction for Energy Conservation</b>                                                                                                                                                                                                                                                                                                                                                                                                                                       | 27   |
| In 1975, engineers at Polaroid's Norwood Plant initiated a project to add capacitance to its inductive electrical load to increase the total power factor on its electrical grid. Besides increasing the power factor to more than 95%, this method efficiently uses Polaroid's purchased electrical energy, directly conserves electrical energy, and reduces reactive power problems for the surrounding electrical grid.                                                                  |      |
| <b>Preheated Boiler Make-up Water</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 28   |
| At Polaroid, the proximity of the air compressors to the high-pressure steam boilers allowed the discharge water to be directed to the boiler as boiler make-up water to generate steam. However, the boiler must consume more fuel than normal to counter the effects of the cooler water re-entering the system. To solve this problem, Polaroid preheated the make-up water entering the boiler by consuming the heat energy dissipated via the air compressors.                          |      |
| <b>Ultraviolet Light Treatment</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 28   |
| Approximately eight years ago, Polaroid's Core Engineering Department began installing ultraviolet light water jackets for the humidifiers located in its air handling systems. Since installation, the ultraviolet light treatment has reduced typical inlet conditions from 200 to 10 colonies of bacterial growth per cubic meter and decreased humidifier maintenance by 75%.                                                                                                            |      |
| <b>Variable Air Volume Heating, Ventilating, and Air Conditioning System</b>                                                                                                                                                                                                                                                                                                                                                                                                                 | 29   |
| Approximately seven years ago, Polaroid began retrofitting the heating, ventilating, and air conditioning distribution systems at its Integral Coatings Division and installed energy-efficient, integrated, self-contained, thermally-activated diffusers on the variable air volume distribution system for its comfort cooling applications. The modifications eliminated the need for zone thermostats and provided an energy-efficient way to maintain consistent, comfortable cooling. |      |
| <b>Volatile Organic Compound Abatement System</b>                                                                                                                                                                                                                                                                                                                                                                                                                                            | 29   |
| To meet air pollution standards levied in 1984, Polaroid designed the specifications of the Volatile Organic Compound Abatement system. Built                                                                                                                                                                                                                                                                                                                                                |      |

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| by REECO and operational in January 1985, this high-efficiency regenerative cycling incineration system abates the hydrocarbons contained in solvent laden process exhaust.                                                                                                                                                                                                                                                                                                                                          |      |
| <b>Watershed Protection</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 30   |
| In the mid-1980s, Polaroid and the Waltham community became aware of site spill risks and the potential for liability. Although Polaroid had spill response plans for specific buildings at its facility, it had no unified site plan to accommodate a spill which might flow beyond the boundaries of a building. In response, Polaroid developed a watershed protection plan for minimizing site spill risks to the community.                                                                                     |      |
| <b>Beyond Environmental Compliance</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 31   |
| Polaroid's drive for excellence in environmental stewardship led to the development of an internal pollution prevention program known as the Toxic Use and Waste Reduction program. In support of this program, a centralized measuring system called Environmental Accounting and Reporting System was also developed which integrates data collection throughout the corporate structure and monitors and reports the rates of toxic use and waste generation for chemical materials.                              |      |
| <b>Community Outreach</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 31   |
| Polaroid promotes community involvement and open communications within its facilities through facility tours, community meetings, communication links, a community newsletter, and an environmental report. Besides community education, Polaroid also created internal educational programs for its employees to inform them about environmental issues and processes within the company.                                                                                                                           |      |
| <b>Environmental Reporting</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 32   |
| Polaroid's corporate philosophy maintains that its business will be operated in an environmentally responsible and sustainable manner. One aspect of this responsibility entails keeping the company's stakeholders, including the local communities, informed on Polaroid's environmental efforts and performance. As a result, Polaroid has recently published its eighth annual report on the environment, the second of which follows the guidelines of the Coalition for Environmentally Responsible Economies. |      |

| Item                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Page | Item                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Page |
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| <b>Ethics and Compliance Awareness Training</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 32   | vide services which promote life skills development to those less advantaged. The Polaroid Foundation promotes the well-being of the local area and its citizens; reinforces the support of the community; and allows Polaroid employees to select which community activities to support.                                                                                                                                                                                                                                                                             |      |
| Polaroid's training directors recognized that a successful environmental training program required employee support not only from a compliance perspective, but also from an ethical awareness perspective. As a result, Polaroid has developed a unique training program which successfully instills personal ethical responsibility and stewardship concerning environmental compliance and behavior.                                                                                                                                                                                                                                                                          |      | <b>Proactive Roles with Public Groups, Boards, and Committees</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 35   |
| <b>Indoor Air Quality Management</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 33   | Polaroid recognized that environmental policy development by agencies benefits from full understanding of the nature of business and industry. In response, Polaroid's Environmental Leadership Group is actively involved in external environmental activities in addition to its complex reporting, planning, and maintenance duties on environmental compliance issues. The Group's members donate their time to participate proactively with public groups, boards, and committees which help influence public policy and environmental statutes and regulations. |      |
| Polaroid started its Indoor Air Quality program in 1987 and is taking an increasingly proactive approach to indoor air quality. Over the years, Polaroid has performed more than 29 separate investigations and conducted 10 proactive indoor air quality investigations and studies. These studies involve sampling and testing the air inside buildings for volatile organic compounds, carbon dioxide levels, dust, bacteria count, relative humidity, and temperature.                                                                                                                                                                                                       |      | <b>Product Safety Management Guidelines</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 35   |
| <b>Occupational Medical Program</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 33   | In 1993, Polaroid began to transform its reactive-approach Product Safety Committee into a proactive, comprehensive product safety program. A risk assessment evaluation is now required for each new or existing product and a methodology for assessing risk is discussed. The practices set forth by the program save time and money because safety concerns are discovered and averted in the early stages of product design and development.                                                                                                                     |      |
| Dr. Edwin H. Land, the founder of Polaroid, envisioned complete healthcare for all employees and their families. The Occupational Health Department began as a family practice health clinic for its employees and evolved into an occupational health clinic. Polaroid promotes and supports healthy work environments and healthy lifestyles for its employees.                                                                                                                                                                                                                                                                                                                |      | <b>Professional Development Committee</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 35   |
| <b>Polaroid Exposure Guidelines</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 34   | Polaroid has a tradition of helping employees improve their work-related knowledge and skills. To provide additional focus in the areas of Health, Safety, and Environment, Polaroid established the Professional Development Committee in 1994 which assists company HSE employees in their continued skill development.                                                                                                                                                                                                                                             |      |
| In the late 1970s, Polaroid developed Polaroid Exposure Guidelines for materials handled in significant quantities based on current literature and toxicity test results from Polaroid-sponsored studies and existing established limits. These guidelines are usually set at one-half of the lowest limit of an existing Polaroid Exposure Guideline or the American Conference of Governmental and Industrial Hygienists, or less if the Polaroid review team deems it to be prudent. Although Polaroid Exposure Guidelines are self-imposed guidelines rather than federally-imposed limits, Polaroid strives to maintain that worker exposure is less than these guidelines. |      | <b>Project Bridge</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 36   |
| <b>Polaroid Foundation</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 34   | Polaroid's Project Bridge began 15 years ago as a unique community human resource program with the local school board. Teachers take a one-year sabbatical from their academic responsibilities and work in a Polaroid facility. The experience allows the teachers to gain valuable life experiences which they take back to the classroom and enhance the educational teachings of the community's young people.                                                                                                                                                    |      |
| Established 25 years ago, the Polaroid Foundation supports non-profit organizations that pro-                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |      |

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| <b>Regulatory Training Requirements</b> | <b>37</b> |

Several regulatory agencies require companies to provide safety and environmental training for every employee. Although regulatory agencies may have similar training requirements, each agency involves specific topics to be addressed for compliance. To eliminate redundant training, Polaroid developed a consolidated approach by grouping similar requirements into a package that met the criteria of several regulatory agencies at the same time.

## **Information**

The following information items were documented at Polaroid:

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| <b>Chiller Performance</b> | <b>39</b> |

Polaroid's production requirements made it necessary to operate the cool water chillers during the winter months. However, the cold winter air's cooling effect on the water temperature in the condenser caused the chiller to constantly load and unload, resulting in higher energy cost. To resolve the situation, Polaroid retrofitted its cool water chillers with variable pitch fan blades and control systems, and installed variable speed devices on its motors and pumps.

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| <b>Variable Speed Chilled Water Pump</b> | <b>39</b> |
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While investigating the chilled water problems at its New Bedford facility, Polaroid discovered that 800 feet of the main chilled water piping was improperly sized and causing excessive pressure losses and decreased chilled water flow. Polaroid devised a cost-effective alternative to retrofitting the entire piping system by installing a variable speed booster pump in the existing 12-inch system to handle peak conditions.

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| <b>Product Safety Testing</b> | <b>40</b> |
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Polaroid's Product Certification Charter requires that products carrying the Polaroid name must comply with the product safety and certification laws of the countries where they will be marketed. Worldwide product safety regulations, voluntary standards, federal standards, and testing protocols are met by all Polaroid products, including those purchased by the company and repackaged for sale under the Polaroid name.

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| <b>Safety Inspection Schedule</b> | <b>40</b> |

Polaroid's corporate policy requires that all facilities and equipment whose failure or malfunction could seriously endanger personnel or property shall be inspected regularly. The Corporate Safety Office established and documented periodic inspection intervals for common facilities and equipment throughout the company. Upon finding a violation, inspectors immediately take the defective item out of service. Any items used to protect employees or property must be immediately repaired or replaced.

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| <b>Corporate Safety Instructions</b> | <b>41</b> |
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In the late 1970s, Polaroid's safety policies were updated and transformed into formal instructions to comply with the newly-instituted OSHA standards. These updated safety policies were then incorporated into a document entitled *Corporate Safety Instructions*. Known as the Green Book, the document was used by employees as a safety bible and reflected the U.S. laws and cultures.

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| <b>Hazardous Materials Response Team</b> | <b>41</b> |
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Polaroid's corporate policy requires each division to establish emergency preparedness plans which are integrated with building, site, and community plans. Approximately three years ago, the Chemicals Division (and other Waltham site divisions) set up and began operating a Hazardous Materials Response Team which not only complied with Polaroid's statutory requirements, but also promoted good business and community relations.

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| <b>Health, Safety, and Environmental Audit Program</b> | <b>42</b> |
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Polaroid considers its Health, Safety, and Environmental Audit program as a value-added tool that helps drive its performance in health, safety, and environmental issues. However, to increase the effectiveness and overall value of its audits, Polaroid began addressing five major themes: Identification of True Risk; Continuous Improvement; Balanced Audit Reporting; Verification of Corrective Actions; and Providing a Clear Purpose. Polaroid expects to benefit by obtaining a truer risk-oriented picture of its manufacturing plants and more efficient measurement and balanced reporting methods for problem areas.

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| <b>Ozone Depleting Substance Elimination</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 43   | <b>New Bedford Power Plant Optimization Program</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 44   |
| To comply with the Clean Air Act, Polaroid began eliminating ozone depleting substances from its camera parts cleaning, camera parts coating, and shutterblade coating processes in 1992. In addition, Polaroid instituted a Just Say No More Chlorofluorocarbons program and worked with its vendors to improve the cleanliness requirements for parts, and develop air and non-ozone depleting substance solvent cleaning methods.                                                                                                                                                     |      | Polaroid Corporation's Negative Manufacturing and High Resolution Media Manufacturing Divisions in New Bedford, Massachusetts have commissioned a Power Plant Optimization Program for its power plant and utility services building. The program will include upgrading two existing oil/gas fired boilers, upgrading four existing chillers, installing a new glycol chiller, installing a new process water chiller, installing a digital distributed control system, constructing two new cooling tower cells, rehabilitating the fuel storage facility, and upgrading or replacing peripheral equipment to support existing and future production demands. |      |
| <b>Supplier Principles of Conduct</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 43   | <b>Polychlorinated Biphenyl Elimination</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 45   |
| Polaroid conducts its materials and services purchasing business based on seven global sourcing principles. The first six are standard principles in industry; however, the seventh (Principles of Conduct) is somewhat unique to Polaroid. The Principles of Conduct requires that excellent health, safety, environmental, social, ethical, and legal standards must be met or exceeded in all sourcing activities by both the company and all suppliers. As a result, Polaroid strives to have business relationships with those suppliers who comply with the Principles of Conduct. |      | In the late 1980s, Polaroid decided to remove polychlorinated biphenyls from the approximate 75 transformers located at six sites throughout the United States, or to replace them where possible. While the transformer replacement project was being completed, Polaroid then began replacing its facility lights under its Green Light program. This action led to Polaroid's 1995 decision to locate and replace all polychlorinated-biphenyl-containing capacitors, most of which were found in sensitometer testing units.                                                                                                                                |      |
| <b>Catastrophic Business Interruption Planning</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 43   | <b>Side Skirts and Rails</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 45   |
| Catastrophic Business Interruption Planning is aimed at assessing the vulnerability of Polaroid's facilities worldwide and developing disaster recovery plans for reducing catastrophic disasters and special fire hazard losses. Polaroid has assembled Divisional Disaster Recovery Coordinators and set up a workshop which will offer guidance on how to perform disaster recovery and strategic planning. Plans are currently under development.                                                                                                                                    |      | In the late 1980s, Polaroid's Transportation Department entered into a lease agreement for heavy duty, over-the-road cargo vans for its transportation fleet. During the specification process, Polaroid decided to include state-of-the-art side skirts and rails to each trailer as a safety feature to keep mirrors and trucks cleaner.                                                                                                                                                                                                                                                                                                                      |      |
| <b>Chlorofluorocarbons in Chillers</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 44   | <b>Chemical Hygiene Program</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 45   |
| For years, chlorofluorocarbons have been used extensively as the prime cooling agent in mechanical cooling systems. Polaroid has 42 chiller systems, ranging in size from 150 to 2500 hp, of which 34 contain chlorofluorocarbons. In response to the stringent health and environmental issues associated with ozone depleting materials, Polaroid has taken corrective measures via replacement, conversion, and installation practices to eliminate chlorofluorocarbons from its chiller systems.                                                                                     |      | In 1991, OSHA established chemical hygiene standards for laboratory safety. In response, Polaroid established its own stringent standards through its Chemical Hygiene program by augmenting OSHA's requirements.                                                                                                                                                                                                                                                                                                                                                                                                                                               |      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      | <b>Environmental Training Procedures</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 45   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      | In 1992, Polaroid began addressing the rapidly changing environmental regulatory arena by developing standardized environmental training procedures which encompassed all environmental regulatory areas and provided continu-                                                                                                                                                                                                                                                                                                                                                                                                                                  |      |

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| ity for connecting training requirements, manufacturing procedures, and company policies. By developing a synergism between requirements, procedures, and policies, Polaroid enabled its managers and employees to grasp the reasons behind environmental training procedures; the method for maintaining current company information; and the insights to company goals and policies. |      |

#### **Health and Safety Management Systems Audit Procedure**

46

Polaroid has developed a draft Health and Safety Management Systems Audit procedure based on the draft ISO-14000 requirements. Most requirements already existed within the Corporate Health and Safety procedure, but did not meet the format requirements of ISO-14000. In addition, Polaroid uses the Accident Triangle as the foundation for developing procedures to audit an organization's preventive measures.

#### **Informational and Alert Memos**

46

Public media often raises issues to Polaroid on chemical issues or corporate-wide practices. Unfortunately, these broadcasted information stories were frequently inaccurate and caused undue anxiety in the surrounding Polaroid communities. To allay any arising fears, Polaroid prepares Informational and Alert Memos as fact sheets for distribution throughout Polaroid which focuses on risks to humans or other living organisms rather than on perceived risks.

#### **Material Safety Data Sheets Management**

47

Through its Material Safety Data Sheets management, Polaroid prepares Material Safety Data Sheets for all chemicals used in production. This practice enables Polaroid to maintain a consistent format for all chemical information; provide standard terminology over a variety of chemical categories; write Material Safety Data Sheets for mixtures used by employees; and facilitate employee handling and spill response training.

#### **Noise Exposure Management**

47

Polaroid's noise exposure management is central to Corporate Health, Safety and Environment. Readily-available exposure records date

back to 1974 and audiograms are performed at Polaroid's medical facility. In addition, Polaroid implemented a lower level dBA standard for better protection compared with OSHA requirements. In 1995, Polaroid adopted the 1994-1995 American Council of Governmental Industrial Hygienists' change to the 3 dBA exchange rate.

#### **Over-the-Road Emergency Response Plan**

47

As an environmentally-responsible company, Polaroid has developed a comprehensive Over-the-Road Emergency Response Plan which addresses the responsibilities of the truck driver in the event of a hazardous material spill. Through extensive training, drivers gain knowledge and expertise for communicating any problems encountered; notifying the appropriate company personnel; and protecting themselves, the public, and the environment in an emergency situation.

#### **Respirator Program Management**

48

To protect its employees from hazardous substances, Polaroid established comprehensive programs to manage the application and use of respiratory protective equipment. Polaroid uses a wide variety of respiratory protective equipment including air purifying, supplied air, and self-contained breathing apparatus. Each division has a written respirator program modeled after a corporate generic document, and trains hundreds of employees in the respirator program.

#### ***Point of Contact***

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## Section 2

### Best Practices

#### Test

##### Product Safety Emission Testing

The Polaroid Corporation regularly conducts product safety emission testing to determine how its products are impacting the operational environment. Ongoing research continues to establish limits and guidelines for indoor air quality in occupational settings and for volatile organic compound (VOC) emissions from various sources such as furniture, carpets, and office equipment. Many indoor air quality problems associated with VOC emissions have been documented. Polaroid conducts tests to characterize and quantify VOC emissions generated and emitted during the operation or use of its products.

Polaroid's test method was adopted from the ASTM D 5116-90 procedure entitled *Small Scale Environmental Chamber Determinations of Organic Emissions from Indoor Materials and Products* and modified to allow on-location testing of large manufacturing unit operations. The test chamber was constructed of wood and plastic sheets. Prior to product testing, background measurements were recorded on an empty test chamber, without equipment or materials present, so that VOC emissions present from the chamber's construction materials and ambient air could be quantified and subtracted from the product test results. Since the chamber was not airtight, the ventilation rates also had to be measured and adjusted in the test results. Measurements were performed via two techniques: Summa evacuated air canisters and Carbotrap solid adsorbent tubes. Both techniques produced measurements in good agreement with one another.

Examples of products tested include the Helios Medical Imaging System, an identification card production system, and Polaroid film packages. Figure 2-1 shows the test chamber configuration for the Helios Medical Imaging System. Results confirmed that all products tested well below the problematic levels or concentrations of VOC emissions. Polaroid has evaluated all products to determine the requirements for testing and the potential for VOC emissions.

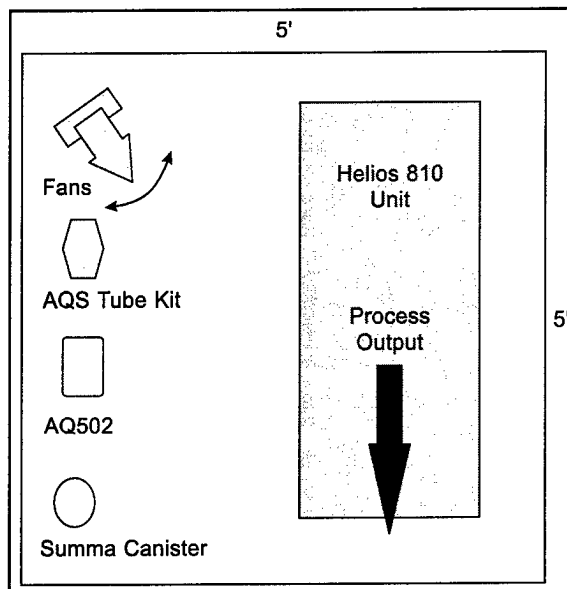


Figure 2-1. Test Chamber Configuration of Helios Medical Imaging System

#### Production

##### Activity-Based Risk Management Performance System

In 1994, Polaroid began implementing an Activity-Based Risk Management Performance system to improve the safety record of its Components Division plants. To recognize, encourage, and reward employee participation, the system used safety metrics which focused on the positive aspects of injury prevention. The positive metrics also helped in identifying and correcting underlying factors that could lead to injuries.

Polaroid solicited 50 high risk situations (HRSs) from its five Components Division plants. These solicited targets represented chronic-type issues that had a high potential for serious injury and could not easily be resolved. For each target, Polaroid developed a risk matrix which plotted the likelihood of an incident versus the degree of consequence. Safety professionals then reviewed the risk matrices pertaining to their division.

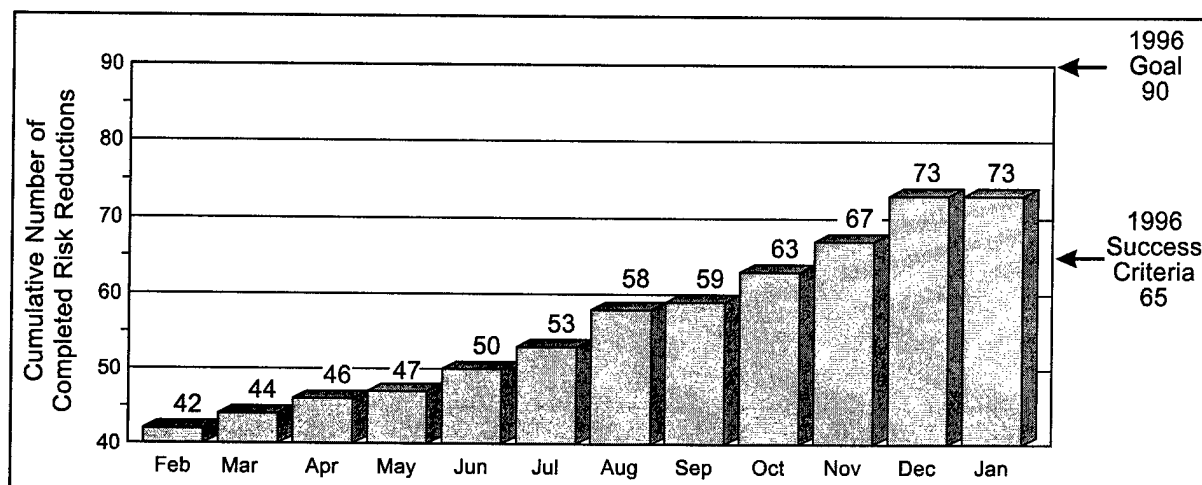


**Figure 2-2. 1996 Risk Reduction Metric**

In December 1996, Polaroid exceeded its two-year success criteria goal of 65 targets by reducing the risk of 73 targets (Figure 2-2). The goal for 1997 is to reduce the risk of 25 targets (out of 50 identified). As of March, Polaroid reduced the risk of two targets. One situation involved refinishing a warehouse floor so forklift operators could drive on a smoother surface. The original surface contained several cracks that had the potential of snagging equipment, tipping over forklifts, and severely injuring operators. As a serious/critical risk, this situation provided a one-in-a-hundred (quite possible) likelihood of an incident occurring. By resurfacing the floor with an epoxy finish, Polaroid protected its building in the event of a hazardous waste spill, provided a non-cracked surface for its forklift operators, and reduced the situation to a minor/marginal risk with only a one-in-a-million likelihood of an incident occurring. The second situation involved the potential for fire, vapor exposure, and back injury to an operator when centrifuging a chemical compound. Assessed as a potential serious risk, the situation had an incident potential of occurring once every five years. By moving the chemical compound preparation to a pressure nutsche, Polaroid reduced the situation to a minor risk with an incident potential of occurring once during the plant's lifespan. In addition, exposure, drum handling, and flammable vapors in the plant were minimized.

Monthly tracking of the risk reduction metrics began in June 1994 and continues as an ongoing process. Polaroid revises its target list annually to ensure the top 50 HRSs are represented. The suc-

cess rate of the project has exceeded original expectations, and may be attributed to the positive focus of the safety metrics and the involvement of the Components Division's managers.

### Asbestos Management Program

Many of Polaroid's buildings were built between 1962 and 1985, and those pre-dating 1975 were constructed with a variety of asbestos-containing materials. The Corporate Health, Safety, and Environmental (HSE) Office provided general guidance for managing asbestos-containing materials while each building's management was responsible for its own proper asbestos maintenance. In 1995, Polaroid established the Asbestos Management program to increase employee awareness and improve asbestos management at all its facilities.

Polaroid also created the Asbestos Management Council (AMC) to provide more guidance and establish ownership for proper, cost-effective asbestos management. AMC (Figure 2-3) includes participants from Corporate HSE, Purchasing, and Waste Disposal as well as Division representatives from all buildings containing asbestos materials. All AMC members have been trained (with several of them licensed) in proper asbestos management.

Division representatives maintain all asbestos records associated with their buildings including asbestos management and building asbestos maintenance plans; building asbestos surveys; project monitoring reports; and remediation project and disposal records. AMC representatives also develop annual reports for their assigned location

including asbestos removal projects summaries; sampling activities and results; building inspections; training activities; future asbestos-related activities plans; and customer satisfaction for asbestos abatement contractors. In addition, AMC has established a common process by developing various tools such as a list of required records, an asbestos awareness program, and a work notification form. These tools are available at Polaroid through AMC's Intranet website.

AMC meets quarterly to discuss issues and concerns, and to review the status on training and asbestos projects. Polaroid's Asbestos Management program has successfully established a common process throughout the company by providing guidance and creating ownership for proper, cost-effective asbestos management.

## Chemical Labeling

Polaroid makes chemical reagents for various coatings and developers. In the past, operators would weigh out the chemicals, place the amount into a plastic bag, and record the chemical name and weight on the plastic bag's label. This process depended solely on the operator to ensure that each chemical was correctly labeled and weighed for each batch. Implemented in 1992 and improved in

1996, Polaroid established a new labeling system which makes the process almost foolproof by bar coding the information required for each chemical. The operator scans the bar code into the computer that displays the weight amount needed and then produces a bar code containing information for the next stage in the process.

Polaroid's chemical labeling process runs on a customized computer software package. Personnel connected with the process worked with a programmer to design each specific module for the process. The computer system can track a chemical from the time it enters the building as raw material until it leaves the building as a final product. In addition, the system includes all hazard communication (HAZCOM) information as part of the bar code label.

Upon receiving a product from the chemical manufacturing division, the operator scans the bar code. The computer system creates a new bar code, with all the HAZCOM information and directions for using the product, and places it over the original bar code. The new bar code remains on the chemical's package until the raw product is completely used. In cases where the package is large enough (e.g., drum), a safety HAZCOM sticker will also be produced and placed on the container next to the new bar code.

Once the new bar code is placed on its package, the chemical goes to the next operator who scans

the bar code and receives information on the amount needed for a batch. If the bar code displays an incorrect lot number or chemical, the computer will alert the operator not to use this product. After weighing out the proper amount, the operator places the measured chemical into a plastic bag and attaches a bar code which describes the contents. Measured ingredients for a designated batch are placed on a cart and sent to the mixing vats. The operator then scans each measured ingredient's bar code before placing it into the vat. Upon completion of the final product, the operator places a new bar code on the vessel that holds the product. This

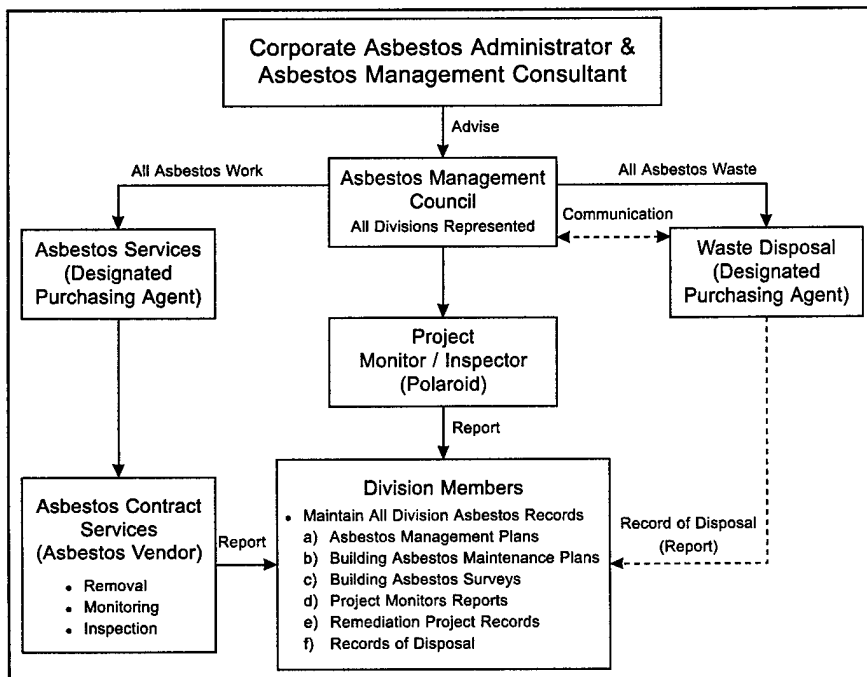


**Figure 2-3. Asbestos Management Council**

bar code contains encoded lot numbers which identify the source and batch of each chemical used. After a final product is used up, its bar code is removed and its vessel is cleaned for reuse.

By using bar codes, Polaroid's chemical labeling process improves the tracking of chemicals at each stage of its use and reduces operator error on weighing amounts. The computer system stores all pertinent information which can be accessed by authorized personnel (e.g., process engineers, operators, safety personnel), allowing for a more accurate chemical inventory. Major cost savings have resulted by virtually eliminating substandard batches, which in turn reduced scrap rates.

## Drum Handling

In 1994, the Chemical Operations Division began focusing on improvements that minimized or avoided injuries and hazards during material handling. Employee options for reducing drum handling risks included wearing back supports, using mechanical aids such as forklifts, and increasing the number of personnel needed to move drums. In addition, the Division initiated the use of totes; pressure nutsches; eduction wands; and air-operated drum lifters/movers to further minimize or avoid injuries and hazards.

Totes reduce the number of containers needed, eliminate manual labor as an option, and provide a safer mode of transportation for chemical substances. Typically, drums have a 55-gallon capacity while totes can hold between 300 and 400 gallons. The heavier totes reduce the risk of back injuries because they must be moved by a forklift. Discharging chemicals into totes for shipping helps reduce the hazard risks for shipping and receiving facilities. In one case, 48 batches of cyan dye required 240 drums per year. Polaroid replaced these drums with 48 totes. In a case involving sheet fluid, Polaroid replaced 280 drums per year with 40 totes.

Pressure nutsches reduce the number of drums needed for processing chemicals by filtering, washing, and drying chemicals in a single piece of equipment. Nutsches also minimize the risk of employee injury by using an internally-mounted blade to mix the chemicals and scrape material off the sides of the drum. For its opacification dye intermediate process, Polaroid reduced 192 drums to 40 which resulted in a 79% reduction in drum handling and provided operational/cycle-time, environmental, and safety benefits. Not all chemical processing can use the pressure nutsches because

some chemicals may not filter well. In addition, these expensive machines cost \$2.3 million apiece because special construction materials are needed to avoid reactions with certain chemicals.

An eduction wand eliminates the need to lift or move a drum by vacuuming the solids out of the drum. By using eduction wands, Polaroid achieved an avoidance benefit of 1,200 drums per year. Air-operated lifters/movers allow an operator to remotely control the dumping of drums by mechanical means. Polaroid has installed two air-operated drum lifters/movers next to fixed mixing vessels which have the greatest drum use. The apparatus was originally designed by engineers and modified by operators to meet their requirements; thus, the handling risk for these operators has been lessened by 744 drums per year.

Through these various material handling options, the Chemical Operations Division has successfully minimized or avoided employee injuries and hazards. In addition, these improvements have produced operational/cycle-time, environmental, and safety benefits.

## Early Suppression Fast Response Fire Protection

Fire suppression is a critical need in warehouse settings. Traditional water sprinkler systems use small-size orifices to create a mist for controlling a fire but lack strong suppression capabilities. Three years ago, Polaroid began retrofitting its facilities with Early Suppression Fast Response (ESFR) fire protection sprinkler systems.

The ESFR system possesses several characteristics which distinguish it from a traditional water sprinkler system. The major difference is that ESFR systems rely on fire suppression rather than fire control. By using larger-sized orifices, the system creates bigger droplets of water which penetrate and extinguish the fire before a severe fire plume develops. In addition, the system uses a thin thermal link that generates an extremely quick response time. Early suppression can be achieved with ESFR systems if controlling factors such as actual delivered density (ADD) and required delivered density (RDD) are properly addressed. ADD, the rate at which sprinklers dispense water, will decrease over time. RDD, the density required to achieve fire suppression, will increase over time and is affected by the fire's size at the time of application. ESFR systems work most effectively with an initially-high ADD and a low RDD.

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Polaroid's implementation of ESFR fire protection sprinkler systems is one of the company's primary defenses against the threat of fire. By using a phased retrofitting process for installing the ESFR systems, Polaroid alleviated its insurance company's concern that high risk materials needed to be more effectively protected. Areas are being retrofitted as problems arise, and all traditional water sprinkler systems will eventually be replaced. All new buildings will be equipped with ESFR systems, where appropriate. ESFR systems cost approximately \$1.50 per square foot.

### Electrostatic Discharge Machining Oil Removal

Polaroid has developed a two-step carbon and clay filter system which removes oil and detergent from Electrostatic Discharge Machining operation wastewater. The system's initial objective was to maintain or reduce operating costs, and meet the sewer permit requirements set by the Massachusetts Water Resource Authority (MWRA). Acceptable wastewater standards call for less than 15 parts per million of total petroleum hydrocarbons.

During the initial development phases of the project, Polaroid encountered some unique obstacles. Trial system #1 used a coalescing tank and carbon filtration media. However, the carbon media quickly clogged and required frequent and expensive changes. By adding clay to the filtration process, trial system #2 significantly improved the life of the media. However, the wastewater discharge still continued the consumption of water during the process and represented a 5% chance of placing Polaroid in jeopardy for MWRA violations. Trial system #3 addressed the unforeseen benefit of using a closed loop method to run the discharge water back into the rinse tank. This system lowered capital costs, eliminated the possibility of MWRA violations, reduced water consumption by 2,300 gallons per day, and had the added benefit of eliminating wastewater sampling costs.

Benefits from Polaroid's two-step carbon and clay filter system included decreasing water usage, reducing maintenance, and lowering the amounts of non-hazardous materials. Although it met the discharge standards with trial system #2, Polaroid chose to continue modifying and improving the filter system to the point of totally isolating the

MWRA process regulations and eliminating the associated environmental liability.

### Emergency Planning Program

Designing and establishing an emergency program for any business is a challenging but necessary task. The philosophy behind Polaroid's Emergency Planning program is prevention and preparedness as equal partners in any emergency situation. Polaroid mandates that all divisions have preparedness plans which are integrated with the building, site, and community plans. Polaroid audits and updates its preparedness plans at least yearly. In addition, an emergency procedure manual addresses preparedness, prevention, response, and recovery. These manuals cover in detail the aspects of how to handle an unexpected crisis in a controlled, effective manner. In effect for more than 20 years, Polaroid's Emergency Planning program relies on the site's fire administrators, 40 volunteer emergency personnel, and outside contractor support as needed.

Each year, the Emergency Planning program trains 100 to 150 people in the technical handling of emergency equipment and the use of procedures. This approach ensures the minimization of personal harm, property loss, and business interruptions. Other features include working with the surrounding neighborhoods and the local, regional, state, and federal agencies to establish emergency response procedures. Low level emergencies could occur each week. By using appropriate safety measures (e.g., emergency control stations, in-house emergency numbers, walkie-talkies, three to five minute response time), damage can be minimized and overall goals can be met. High level emergencies require critical decisions concerning resources and activities to be made under tremendous stress. Through the Emergency Planning program, planning and organization ensure the emergency will be handled in an efficient and effective manner that lessens personal harm and property loss.

Through its Emergency Planning program, Polaroid is guarding its livelihood by protecting its personnel, processes, chemicals, machinery, and equipment. Designed as an emergency control program to meet all eventualities that can be reasonably anticipated, the company strives for excellent control, not perfection.

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## Engineering Controls

Polaroid's philosophy emphasizes minimal exposure of chemical hazards to its employees through engineering controls. Engineering controls are employed to reduce worker exposure limits to well below regulatory limits. However, in those cases where employees cannot be completely protected through engineering control methods, personal protection equipment is then used.

Polaroid developed state-of-the-art engineering controls to reduce chemical hazard exposure of its employees. Dust and fumes are vented out of the working area, and solvent emissions are sent to either a vapor recovery system or a thermal destruction pollution control device. These practices reduced worker exposure in the chemical facilities by 98%. In addition, the facility's layout places the tank farm and hazardous waste storage at a remote distance from the process and administration areas. Table 2-1 describes the engineering control features used in the Chemicals Manufacturing Plant.

Polaroid has a proactive approach to employee protection. This approach provides a better working environment for the employees and produces an overall high rating in employee satisfaction.

## Environmental Scorecard

In the early 1990s, Polaroid recognized that its proactive approach to environmental regulatory requirements was very successful but lacked comprehensive metrics for tracking corporate environmental compliance performance. As a result, Polaroid developed the Environmental Scorecard in 1993, for use by top level managers, to measure and report emission excursions and official notifications of non-compliance.

Designed as a spreadsheet, the Environmental Scorecard tracks written violation documents; specific violations within the document; and excursions that extend beyond the allowed regulatory limits (currently not cited in documents). In addition, Polaroid established a three-level reporting and tracking system to provide insight into those areas which may become problematic but are not official violations. The three summary levels provide specific details on the Massachusetts Contingency Plan (sewer, air, and hazardous waste) and the Toxic Substances Control Act items for either the overall corporation or an individual facility. Accompanying data sheets to each scorecard detail

the number of inspections and violations at a site, and also the specifics and penalties for each violation.

Using the summarized data from the scorecards, Polaroid prepares monthly reports for the Vice President of the Global Supply Chain which document new items (e.g., excursions, notifications) and year-to-year comparisons of corporate environmental performance. The scorecard data also provides information for Polaroid's annual environmental report and identifies the operating results of plant managers and Environmental Operating Committee members.

Polaroid's Environmental Scorecard provides a quick and efficient way for high-level managers to familiarize themselves with environmental compliance issues. In addition, the scorecard has been instrumental in allowing upper management to develop and discuss detailed corporate goals for achieving zero environmental regulatory excursions.

## Ergonomic Program

In 1992, Polaroid Corporation developed an ergonomic program and supporting guidelines to promote continuous health and safety performance improvements while maintaining product quality and sustaining profitability. Polaroid tests the effectiveness of its ergonomic improvements by incorporating a mission; policies; guidelines; job analysis evaluations; redesign methodology; in-house expertise training; and pilot programs.

To gain employee confidence in the ergonomic concept, Polaroid began its program on a volunteer basis. In addition, Polaroid built management commitment by establishing a clear set of expectations, potential results, and benefits. However, acceptance of the program did not go unchallenged for various reasons: expected increases in injury and illness statistics due to increased reporting; costs versus benefits concerns; and ergonomics being portrayed as more than mere common sense. Eventually, the program evolved from a volunteer concept through six phases into an auditable requirement in 1997. The program's next challenge involved educating the employees about their risks for work-related cumulative trauma disorders, encouraging them to report these illnesses, and identifying ways to reduce or prevent risk factors in the workplace. To successfully implement its program, guidelines, and methods, Polaroid relied on total quality ownership as a key tool to modify its employees' attitude and thinking toward ergonomics.

**Table 2-1. Chemicals Manufacturing Plant**

| <b>BUILDING FEATURES</b>                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                             |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Explosion Proof Features:                                                                                                                                                                                                                                                                                                                                                               | Electricity Isolation<br>Grounding Clamps<br>Conductive Plastic<br>Static Discharge (PPE-footwear)                                                                                                                          |
| Building Construction:                                                                                                                                                                                                                                                                                                                                                                  | Blow-out Walls<br>Automatic Shut-off Valves (Panic Buttons)<br>Special Fire Extinguishing Equipment<br>Solid Walls Protect Staging Areas                                                                                    |
| Ventilation:                                                                                                                                                                                                                                                                                                                                                                            | General 6 to 10 Air Changes Per Hour<br>Emergency Exhaust Ventilation<br>Local Exhaust Ventilation (Hoods & Enclosures)                                                                                                     |
| Building Utilities:                                                                                                                                                                                                                                                                                                                                                                     | Nitrogen - Inerting Gas<br>Special Cooling Systems (Exothermic Reactions)<br>Automatic Exothermic Controls & Alarms<br>Emergency Generators for Electric Power<br>Hydraulic Fluid Systems<br>Vacuum Pumps, Liquid Transfers |
| Control Room Monitoring of Processes                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                             |
| <b>PROCESSING EQUIPMENT</b>                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                             |
| Reactors (Rupture Discs, Sampling Devices, Bottom Valve Shut-offs)<br>Condensers (Relief Valves)<br>Centrifuges (Safety Interlocks, O <sub>2</sub> Analyzer, Static Charge Measurement)<br>Dryers (Conical, Tray, Rotary)<br>Filters (Filter Breakdown Area)<br>Distillation Columns<br>Storage Tanks (Raw Materials, Waste Solvents, etc.)<br>Pressure Nutsche (Benefits of Operation) |                                                                                                                                                                                                                             |
| Reactor Area - Reactors in General:                                                                                                                                                                                                                                                                                                                                                     | Ventilation (Layout)<br>Special Controls (Location of Control Panel)<br>Special Valves (Fail-safe, Rupture Disk)<br>Charging & Sampling Procedures<br>Polymer (Monomer Chemistry)<br>Worker Protection                      |
| Filters, Centrifuges, Pressure Nutsches, etc. - Separating Equipment:                                                                                                                                                                                                                                                                                                                   | Safety Procedures (For Separating Solids)<br>Ventilation (Layout, Worker Location)<br>Other Hazards (Static Electricity, Dust & Solvent<br>Process Inerting N <sub>2</sub> & CO <sub>2</sub> Worker Suffocation)            |
| Weighing & Drying:                                                                                                                                                                                                                                                                                                                                                                      | Ventilation (Layout, Worker Location)<br>Impact of Improper Weighing<br>Static Electricity (Dust)                                                                                                                           |
| <b>OTHER FEATURES</b>                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                             |
| Remote Tank Farm - Solvent Storage Area:                                                                                                                                                                                                                                                                                                                                                | Safety Aspects (Ventilation, Grounding Clips)<br>Spill Containment, Double Walled Tanks, Leak Detection<br>Vapor Recovery<br>Groundwater Contamination Monitoring                                                           |

Training, such as task analysis and evaluation, was a significant factor in the success of Polaroid's ergonomic program and allowed the program to be applicable at the corporate level. To date, employee-owners from several professional disciplines have been trained and are conducting analysis and evaluation training themselves, as well as training additional instructors. This approach enables a wider dissemination of required skills for conducting task evaluation and redesign, thereby improving the health, safety, and quality of the workplace.

Another important feature of the ergonomic program has been Polaroid's method of investigating and categorizing occupational injuries and illnesses by type and cause. These categories serve as a framework which are applied to all accidents. The reframing of the Occupational Safety and Health Administration (OSHA) statistics helps Polaroid understand and address the underlying causes and consequences of workplace accidents. In addition, management receives the information needed to take preventive measures in the areas of greatest or immediate need.

Polaroid's study, "Ergonomic Evaluation and Analysis of a Film Processing Task," demonstrated the task evaluation analysis and redesign methodology aspect of the ergonomic program. This study employed quantitative analyses on the film processing task by using frame-by-frame, detailed analysis of the task's steps, and then evaluated the results against established criteria to design, implement, and validate cost-effective solutions. Through this study, Polaroid demonstrated how its ergonomic analysis would significantly reduce or eliminate almost all of the extreme body positions and potentially-damaging wrist motions associated with the film processing task. These improvements were, in fact, confirmed by film processing operators. Table 2-2 identifies the risk factors, associated causes, and actual solutions which resulted from this study.

Another successful implementation of ergonomics occurred at Polaroid's Vale Camera Division in Scotland. A team of employees in the Medical Management program worked together to develop a procedure for identifying and reporting cumulative trauma disorder (CTD)/repetitive strain injury (RSI) at work. After pilot-testing and adjusting the process, Polaroid implemented the procedure. Although Polaroid does not claim to have solved all of the problems associated with CTD/RSI, the procedure did demonstrate how to understand, address,

and identify solutions for avoiding or mitigating CTD/RSI disorders.

Polaroid uses its ergonomic program to improve the way employees relate physically and mentally to the workplace. By describing processes, implementing procedures, and examining statistics, Polaroid has achieved positive results from its program.

## Establishment of Chemical Categories

Polaroid's Toxic Use and Waste Reduction (TUWR) program was voluntarily developed to reduce toxin use and waste sources as a means of preventing pollution. A critical element of the TUWR program was to assign environmental impact categories to the chemicals that Polaroid uses in its production lines. After evaluating each material based on toxic characteristics, physical attributes, and chemical properties, Polaroid assigns it to one of the following categories:

- I - known human carcinogens, teratogens, and toxic reproductive agents; highly acutely toxic; or a great environmental threat
- II - known animal carcinogens, teratogens, and toxic reproductive agents; chronic toxicity; or an environmental threat
- III - suspected animal carcinogens, moderately-toxic chemicals, or corrosive materials
- IV - chemicals that cannot be classified in I, II, or III
- V - other materials such as plastic, paper, and cardboard

Based on this classification, Polaroid targets chemicals for either reduction (I and II) or recycling (III, IV, and V). As new chemical information becomes available, Polaroid evaluates and reclassifies its chemicals as appropriate. New chemicals are assessed before they can be introduced into production lines. Polaroid uses incentive plans to encourage the reduction of category I and II materials and the recycling of category III and IV materials in production lines. In addition, reduction and recycling goals are factored into each program manager's performance evaluations.

Although various regulations have established chemical lists, none meet the requirements of Polaroid. By comprehensively addressing and grouping chemicals specifically for its activities, Polaroid ensures that all its materials are included. Managers have a reliable and comprehensive source for identifying which chemicals should be eliminated and which can be managed through recycling.

**Table 2-2. The Workplace Risk Factors, Causes, and Actual Solutions**

| RISK FACTORS                       | CAUSES                                                                                                                                                                                                                                                                                                          | ACTUAL SOLUTIONS                                                                                                                                                                              |
|------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Potentially Damaging Wrist Motions | L/R Biological Clamp (camera).<br>L/R Point Of Operation (P.O.O.) too close to body (load/unload camera).<br>L Manual positioning/fixing of processed frames.                                                                                                                                                   | Holding device for cameras.<br>Holding device for cameras.<br>Holding devices for processed frames.                                                                                           |
| Extreme Wrist Positions            | L P.O.O. too far away and angled too far away from body (film tray unprocessed).<br>R P.O.O. too far away and angled too far away from body (film tray processed).<br>R P.O.O. too low and angled too far away from body (light box).                                                                           | Angled fixture for service trays and moved closer to operator.<br>Angled fixture for service trays and moved closer to operator.<br>Suspended Light Box overhead (also eliminated eyestrain). |
| Shoulder Flexion (extreme)         | L P.O.O. too far away from body (grasping camera).                                                                                                                                                                                                                                                              | Holding device with cameras already installed.                                                                                                                                                |
| Shoulder Abduction (extreme)       | R P.O.O. too close and angled too far away from body (pulling tab empty pack).                                                                                                                                                                                                                                  | Holding device for cameras.                                                                                                                                                                   |
| Shoulder Adduction (extreme)       | L P.O.O. too far to one side/ need both hands to hold/ place 5 processed packs in tray.<br>R P.O.O. too far to one side (left) (flips empty pack places on table).                                                                                                                                              | Positioned new angled trays closer to operator.<br>Positioned new angled trays closer to operator.                                                                                            |
| Arm Pronation (extreme)            | R P.O.O. too far away and angled too far away from body (processed film tray).                                                                                                                                                                                                                                  | Angled tray towards body.                                                                                                                                                                     |
| Elbow Extension (extreme)          | L P.O.O. too far away from body (camera).                                                                                                                                                                                                                                                                       | Cameras installed in holding device which eliminated this job task step.                                                                                                                      |
| Head Flexion 38°                   | Chair does not provide proper adjustments and support which leads to a variety of compensating postures to accommodate the seating. It also does not allow the operators to vary static posture during the day in order to alleviate muscle stress and increase circulation.<br><br>Individual postural habits. | Provided new adjustable chair with usable arm rests.                                                                                                                                          |
| Mechanical Stress of the Forearms  | R/L Resting forearms on the edge of the desk.                                                                                                                                                                                                                                                                   | Adjustable, padded armrests.                                                                                                                                                                  |

## Hazardous Waste Disposal Audit Procedure

Polaroid recognized that various factors such as new technology, process changes, cost advantage, and vendor replacement can warrant a need for altering a waste stream's disposal method. To standardize the procedure, Polaroid developed an auditing process for determining the proper means of disposing hazardous waste and selecting vendors and proper treatment options. The auditing process includes a matrix that outlines the appropriate disposal methods for on-site recovery, fuel blend disposal, recycling sales, or disposal via a Treatment, Storage, and Disposal Facility (TSDF).

The approval process begins with a meeting between Corporate Purchasing and HSE representatives to discuss financial, insurance, health, and safety issues. Next, an audit team consisting of Polaroid purchasing and environmental managers conducts a site visit at the TSDF to review labor relations, permits, site history, and other concerns.

|                                                                      |                                                   |
|----------------------------------------------------------------------|---------------------------------------------------|
| Profile # _____                                                      |                                                   |
| Vendor _____                                                         |                                                   |
| <b>TSD LANDFILL REQUEST</b>                                          |                                                   |
| Building _____                                                       | Date _____                                        |
| Waste Stream Name _____                                              |                                                   |
| EPA Waste Codes _____                                                |                                                   |
| Reason why landfilling is more appropriate than other methods _____  |                                                   |
| _____                                                                |                                                   |
| Estimate of Total Organic Content in % _____                         |                                                   |
| _____                                                                |                                                   |
| Cost to landfill                                                     | _____ \$/drum, gaylord, 5-gal pail<br>(specify)   |
|                                                                      | _____ \$/year based on estimated<br>annual amount |
| Does material meet LDR prohibition levels<br>(even if non-hazardous) | Yes/No                                            |
| Does landfill cost include treatment under<br>LDR provisions         | Yes/No                                            |
| Cost to incinerate (or other current practice - if so, specify)      |                                                   |
|                                                                      | _____ \$/drum, gaylord, 5-gal pail                |
|                                                                      | _____ \$/year                                     |
| SIGNATURE _____                                                      |                                                   |

**Figure 2-4. TSD Landfill Request**

The audit team also inspects the site's operations and processes; reviews community relations; and interviews local regulatory agencies. After completing the site visit, Corporate Purchasing prepares a report which summarizes the audit findings and outlines the business reasons for approving the TSDF. Then an environmental team reviews the report and makes a recommendation for approval or denial to the division that generates the waste. Corporate Purchasing monitors the business and environmental status of approved vendors by conducting follow-up audits within two years. Polaroid's Code of Conduct governs its procurement operations and states that "excellent health, safety, environmental, social, ethical, and legal standards must be met or exceeded in all sourcing activities by both the company and suppliers." These principles are also applied to all TSDF vendors and suppliers.

Through its unique auditing process, Polaroid has created a partnership between Corporate HSE, Corporate Purchasing, the divisions that generate the waste, vendors, and suppliers. This partnership ensures the continued protection of the environment and reduces the liability for Polaroid.

## Landfill Avoidance

In 1987, Polaroid's CEO, Mac Booth, made a commitment that his company would avoid sending chemical waste to landfills unless it truly was the best alternative. This decision was made prior to regulatory landfill-ban requirements. Additionally, the decision reflected concerns about the long term integrity of landfill storage and the potential for long term liability.

To implement the CEO's initiative, Polaroid developed a landfill avoidance procedure. All hazardous waste disposal contracts must be reviewed by the Purchasing Environmental Manager at the corporate level. Spent hazardous waste which cannot be recycled, reclaimed, or reused in another process is sent to a chemical waste disposal facility as determined by the Purchasing Environmental Manager. If the manager identifies a waste product that cannot be cost-effectively handled by one of these alternatives, then an exception form (Figure 2-4) is required. The exception form is completed by the vendor requesting the landfill option and reviewed for possible options by the Corporate environmental team.

Polaroid's commitment to environmental responsibility has greatly reduced long term liabilities. In addition, Polaroid has created an environmental awareness throughout the company in all of its programs.

## Local Emergency Planning Committee Membership

Polaroid works closely with local community officials to keep them informed on the risk factors, hazardous materials used at manufacturing sites, and precautions taken to ensure the safety of employees and the public. Polaroid employees serve as members on community-based Local Emergency Planning Committees (LEPCs) to ensure an effective, ready response in the event of a hazardous material accident from any source in the community. LEPC participation also includes representatives from other manufacturing companies who work in partnership with the communities to ensure public safety. Polaroid contributes funding, equipment, and its expertise on environmental and safety issues.

In 1995, Polaroid purchased computer hardware and modeling software (CAMEO) for the Waltham, Massachusetts LEPC. Local safety officials use the computer system to model and simulate various scenarios depicting the release of air emissions, maintain information on the chemicals used at local industrial sites, and store detailed maps of the area which pinpoint the locations of sensitive facilities such as schools and hospitals. The user can generate templates and map overlays that show the predicted spill footprints and air dispersion patterns under various conditions. The system can create detailed information on the effects of the material and appropriate responses for each environmental emergency scenario. Polaroid also provides computer training on this system for local officials and LEPC members.

The success of LEPCs is largely a result of Polaroid's commitment to the community and strong emphasis on openness. The company provides regular reports, an environmental newsletter, plant tours for interested community members, and annual community meetings at its manufacturing sites. In addition, local emergency responders have access to the material safety data sheets for all chemicals used at Polaroid.

## Pressure Nutsche

Since 1988, Polaroid has been implementing a multimillion dollar program to replace the traditional centrifuges and dryers at its Chemical Operations Division with pressure nutsche technology. This change has been improving the company's Toxic Use and Waste Reduction performance and will reduce the Division's air emissions by 80% in 1999.

Previously, products were isolated; washed on filter presses or in centrifuges; and dried in vacuum tray dryers. These dryers produced high VOC emissions, required labor intensive material handling, and had long cycle times. The process also exposed employees to VOC emissions, solvents, and fire risks. Pressure nutsches work as self-contained vessels to filter, dry, and separate chemical mixtures while removing vapors and emissions. Figure 2-5 shows a schematic of a typical pressure nutsche installation. Polaroid introduced pressure nutsches

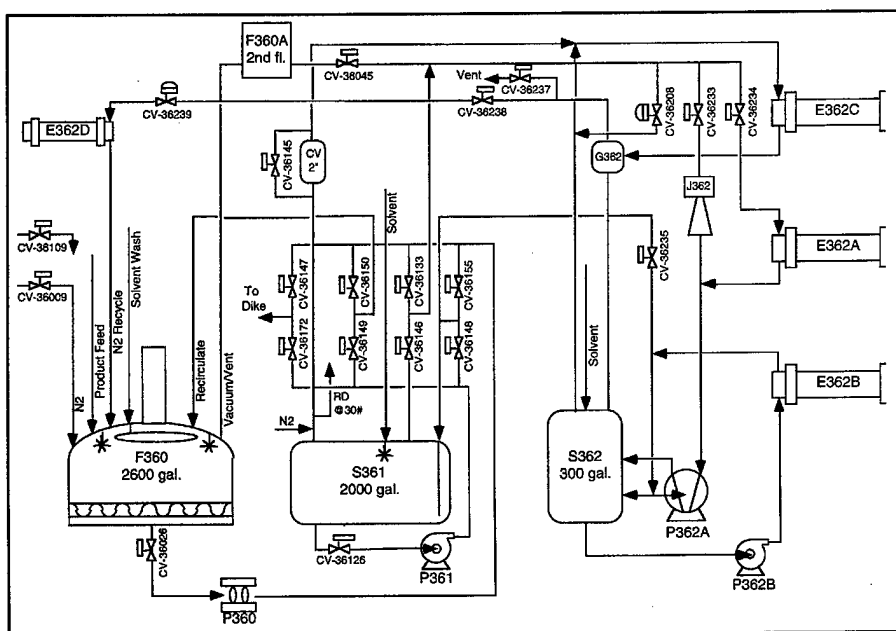


Figure 2-5. F360 Pressure Nutsche System

as a means to improve safety for employees, prevent pollution, and provide increased operational performance. The nutsches have also been accepted by environmental agencies as complying with the Clean Air Act requirements. To offset the high cost of pressure nutsches (\$2 million each), Polaroid has been upgrading its facilities gradually.

Polaroid modified the pressure nutsches to facilitate its material handling and cleaning operations. Benefits gained by Polaroid over the past five years include a decrease in baseline VOC emissions from 180 to 40 tons per year; a 95% reduction in VOC emissions from filtration and drying operations over traditional processes; and an estimated 20% to 30% increase in solvent collection for on-site reuse or off-site fuel burning. Pressure nutsche technology has also improved employee safety by reducing solvent exposure, minimizing drum handling; and decreasing fire hazards from flammable solvents. Employees are no longer handling solvent-wet cakes. Operational benefits include improved efficiency, reduced cycle times, increased product yields by 2% to 5%, and reduced labor hours.

## Process Safety Management

As a large-batch chemical manufacturer, Polaroid produces various types of chemicals (e.g., flammables, carcinogens, mutants) at its film-producing facilities in Waltham and Freetown, Massachusetts. Operations typically run 24 hours a day, seven days a week, and produce 500,000 to one million kilograms of chemicals per year. Approximately 60 chemical processes which run at Polaroid fall under the volume or flammability criteria of the Occupational Safety and Health Administration (OSHA) requirements. In May 1992, Polaroid began complying with OSHA's Process Safety Draft Document by establishing safety teams and committees at each chemical manufacturing site to interpret OSHA requirements, write policy manuals, and implement the procedures.

New processes must undergo a hazards and operability study. Process analyses follow a safety information checklist to ensure all process factors are considered while process hazard analyses use a what-if format. To improve the ease of using its Process Safety Management procedures, Polaroid computerized OSHA's Process Hazard Analysis (PHA). PHA requires the involvement of all process personnel (e.g., operator, engineer, supervisor,

building engineer, process engineer, chemist, electrical engineer, environmental representative). The procedures involve developing a process block diagram, analyzing the process' chemistry, and reviewing all material safety data sheets related to the process. Next, a draft report is generated and reviewed by all process personnel. The process engineer then prepares the final report on the process. Polaroid uses an Action Tracking System to sort and track action items by building or employee.

Polaroid uses PHAs on all of its processes regardless of whether they fall under OSHA requirements. Any modifications to the process chemicals, technology, equipment, or procedures must be identified and reviewed before implementing the change. For personnel changes, Polaroid reviews the employee's training and skills to ensure an appropriate expertise level is maintained.

Polaroid's Chemical Operations Division has shared the procedures of its process safety management throughout the corporation. These procedures have improved the safety environment of chemical processes by effectively reducing the severity and risk of potential accidents.

## Product Delivery Process

Polaroid typically develops dozens of new products each year. To guide the development of products, Polaroid formalized a structured process in the late 1980s called the Product Delivery Process (PDP). PDP's purpose was to reduce the break-even cost and time; determine a programmatic development approach; and more clearly identify the individual responsibilities for new products.

The process focuses on seven steps: idea exploration; concept; feasibility; product development; design pilot; manufacturing pilot; and commercialization. A PDP team (Figure 2-6), led by a program manager, combines personnel from market research, product design, manufacturing, marketing, sales, customer service, and distribution. In 1992, Polaroid modified PDP by integrating the process with Design for the Environment (DfE) elements and manufacturability efforts. To ensure a successful DfE integration, Polaroid secured support from senior management and held process personnel responsible for their contribution. For example, Polaroid allowed program managers to control their own program budgets, but held them accountable for the program's performance.

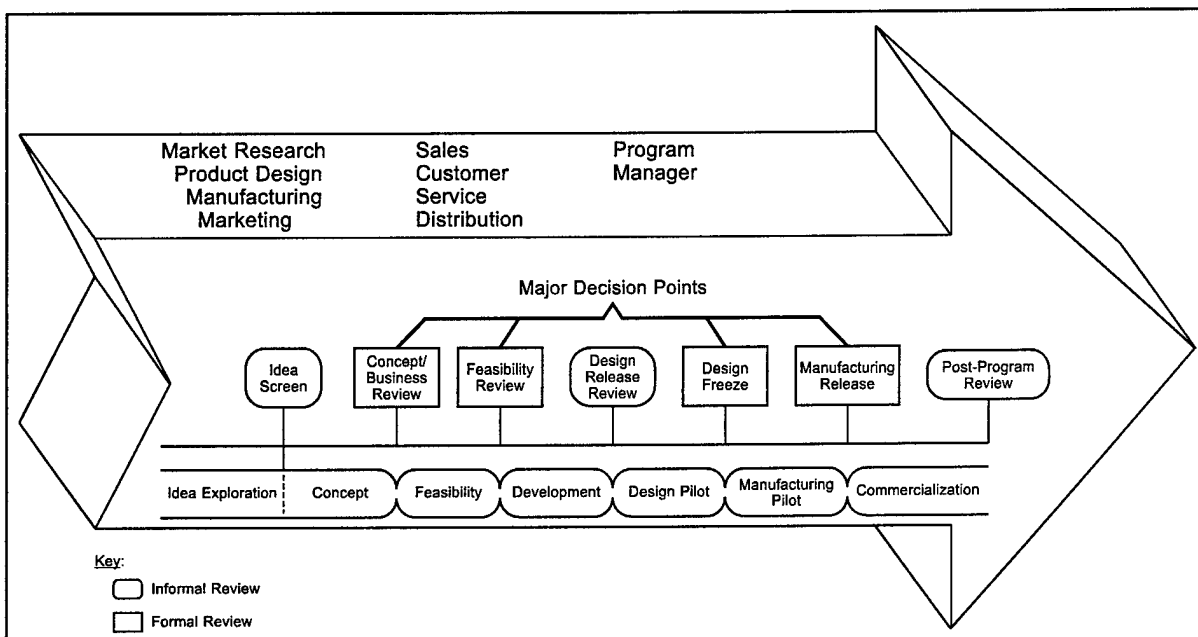


**Figure 2-6. The Product Delivery Process Team**

Specific DfE element changes to PDP were included in the concept and feasibility steps. Additions to the concept step included assessing environmental issues; examining environmental impact by the development program; identifying potential chemical, hardware, and packaging issues; and assuring that the product and its production comply with Polaroid's environmental goals. For example, Polaroid eliminated ozone depleting substances by removing the Teflon coatings on the friction points in its Captiva™ camera. Through its efforts to reduce the amount of silver needed for film processing, Polaroid developed a medical imaging product which was completely silver free. Additions to the feasibility step included specifically looking for opportunities to eliminate environmental problems; identifying substitutes for targeted chemicals to be eliminated (e.g., polyvinyl chlorides, chlorofluorocarbons); and examining the product for maximum usage of post-consumer waste (and reduction of the generation of consumer waste). For example, Polaroid was able to use approximately 63% of post-consumer waste content in its corrugated product packaging.

Polaroid continues to look for ways to improve its PDP. Current modifications underway include addressing additional environmental issues in the concept step and developing improved training methods for personnel who regularly use PDP in the workplace.

## Reinforcing Safety Values at Polaroid Program

Prior to 1989, Polaroid had an OSHA recordable incident rate of 2.4 while the average national manufacturers' incident rate was 8 to 9. In 1989, Polaroid established the Reinforcing Safety Values at Polaroid (RSVP) program. As a management tool, the RSVP program was designed and developed to reduce Polaroid's serious injury rate by 50% and to reinforce safety values. Polaroid's goal is to minimize accidents and eliminate hazards in the workplace and to enhance its leadership role in safety issues.

Initially used as a tool for safety audit team members, the RSVP program has expanded throughout Polaroid's divisions. The RSVP program is also used as the basis for auditing six important aspects of its management system, and for performing in-depth root causal analysis of accidents and illnesses. The program's effectiveness relies on the following six critical factors for safety performance:

- Knowledge, which identifies and communicates safety responsibilities, workplace hazards, and required precautions.
- Ability, which ensures employees have the necessary capabilities and skills to do their jobs and tasks safely.

- Motivation, which confronts deviations from and generally reinforces safety values, rules, and expectations.
- Design, which applies engineering design safety standards and performs hazards analyses.
- Maintenance, which establishes and implements equipment and facility safety inspections and maintenance.
- Actions of Others, which instruct employees who impact the workplace, inside or outside the organization, and ensure their actions do not create unsafe conditions.

As the governing components and foundation of the RSVP Accident Triangle, the six critical factors illustrate the relationship between accidents, injuries, injury causation, and injury prevention. These factors also show the underlying influences on individual behaviors and workplace conditions of safety performance. In addition, the six critical factors are part of the Evaluator, a tool to investigate and analyze accidents, and of the Preventor, a tool used for accident prevention. All these tools comprise the RSVP Pocketguide which employees receive as part of their safety training, along with the pocket-sized RSVP Polaroid Safety Guidebook and an in-house produced video. Risk Matrix is another part of the RSVP Program. This tool assesses hazard levels, establishes safety criteria, prioritizes opportunities for safety performance improvement, determines acceptable and unacceptable risks, and justifies expenditures for corrective action.

Safety management programs are successful only if a company establishes safety and employee well-being as one of its core operating values. Polaroid's safety and health policy is firmly committed to this principle. Through its RSVP program, Polaroid has established a proven track record for plant safety. In 1996, Polaroid had an OSHA recordable incident rate of 1.4.

### Safety Ambassador

In October 1985, Polaroid decided to enhance the plant safety program at its Battery Division because of a rise in accident rates. As a result, Polaroid established the Safety Ambassador program. The program enabled Polaroid to improve the Division's safety record by making each employee a contributing element of the process and incorporating safety with other aspects of production. When implemented, the program provided

meaningful measure and safety performance display metrics.

For the program to be successful, Polaroid's first step was to involve its employees. Initially, only salaried employees became safety ambassadors; however, the program eventually expanded to include all salaried and hourly employees within the Battery Division. Employees were not trained as law enforcers but rather as ambassadors for continual safety improvement. Ambassador routes were developed to find known problem areas, potential hazards, and possible risk areas. In addition, formal check-off lists were maintained to record compliant and problem areas. Those areas requiring attention were noted and received corrective measures.

Through its program, Polaroid reduced the Battery Division's injury rates by 50% and increased all employees' awareness on recognizing risk and problem areas (e.g., blocking exits, neglecting safety guards on equipment) which can affect safety within the plant. In addition, Polaroid operates the program as a recognition and reward system. Incentives for ambassadors include special designated parking spaces and "safety nickels" which allow employees to purchase film, cameras, and other company products.

Polaroid's Safety Ambassador program empowers employees to initiate improvement; recognize risk areas; and create and manage safety measures in their workplace. Polaroid's goal for its program is a zero-accident rate.

### Safety Values Process

Polaroid's Safety Values process works as a behavioral intervention program which reinforces the idea that health, safety, and well-being are every employee's personal responsibility. Begun in the early 1990s, the Safety Values process offered Polaroid a way to positively influence its employees' behavior by focusing on the motivations of an individual's action. The process' purpose was to reduce quantity and severity of personal injuries, as well as the associated pain and suffering.

Using the Total Quality of Life Model (Figure 2-7) as a starting point, the Safety Values process teaches employees to recognize and comprehend their behavioral motivation, identify the consequences from their actions, and take personal responsibility for their behavior. In addition, Polaroid uses a four-hour Safety Values Process Workshop as a first step to help its employees see their personal well being

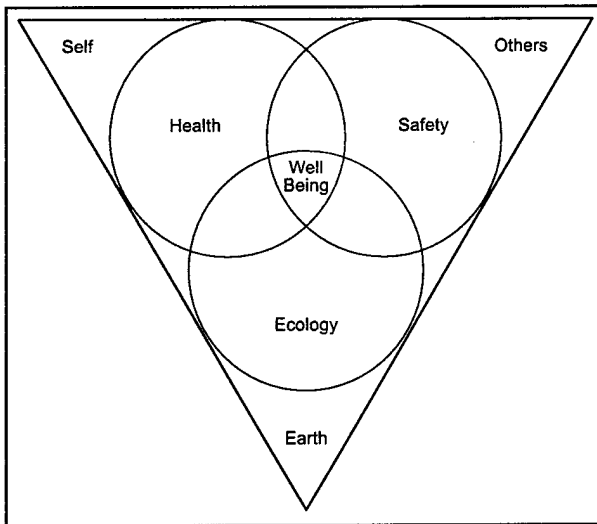


**Figure 2-7. The Total Quality of Life Model**

as an interrelated set of beliefs and values; behaviors; and consequences which extend beyond the workplace (Figure 2-8). The workshop seeks to drive these beliefs and behaviors in the "safe" direction, and focuses on situations that threaten the quality of life and the ability to perform. As a companion to the workshop, a course book furnishes specific, personalized, thought-provoking facts, models, and exercises which encourage employees to modify their behavior through understanding, willingness, and commitment. In addition, the course book provides a straightforward, logical progression through complicated concepts that are expressed in simple, amusing, and user-friendly examples.

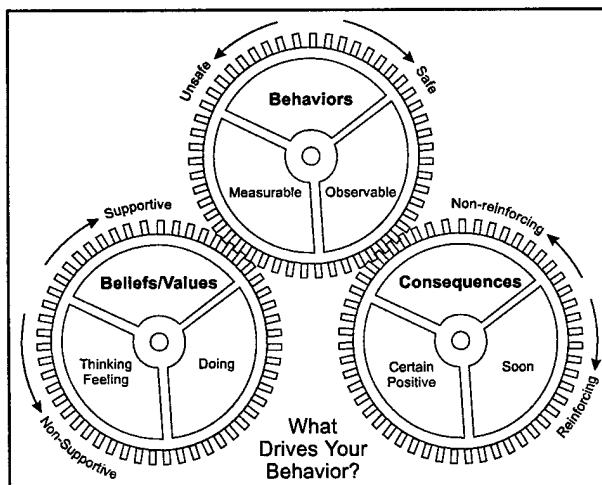


**Figure 2-8. Our Personal Well Being**

After completing the workshop, groups of volunteers establish safety values teams to examine those behaviors requiring change or improvement. The group determines how the behaviors should be altered, gets support from other team members, and periodically measures and demonstrates the success rate of the team's new behavior. Safety values team members receive specific, additional training (e.g., conflict resolution, risk assessment, incident investigative techniques) as issues arise.

Polaroid's Safety Values process uses a forward-thinking approach which goes beyond the traditional guidelines, instructions, and handbooks. Instead, the process strives to understand and alter the behavioral causes of accidents and injuries; uses a continuous improvement technique; addresses each employee's well being holistically; and achieves significant practical safety improvements. Currently, 900 employees have completed the Safety Values training. As a result, Polaroid has reduced its accident rate by 50%.

## Toxicity Bulletin

In 1965, Polaroid published its first Toxicity Bulletin as part of its Consumer Product Safety program. The bulletin provides general information on the toxicity of Polaroid products and answers potential health and toxicity questions raised by customers.

Polaroid's Customer Care Center representatives rely on the Toxicity Bulletin to answer customers' questions. The bulletin describes each Polaroid product, lists its hazardous ingredients, and specifies its toxicity. Recommendations are provided for appropriate treatment depending on the type of contact (e.g., eye, skin, oral) and for proper disposal. The bulletin also lists emergency contacts with office and home telephone numbers for those cases when more information is needed. These contacts are available to answer questions on a 24-hour basis. In addition, Polaroid distributes the Toxicity Bulletin to its security guards, telephone operators, and U.S. Poison Control Centers.

Polaroid's Toxicity Bulletin provides effective and timely responses to customers' concerns. In addition, Polaroid identifies trends and recurring problems by documenting and reviewing all customer inquiries.

## Facilities

### Cooling Tower Make-up Water Metering

Typically, sewer charges for industrial sites are based on the percentage of cubic feet of water metered to a company's site regardless of its usage (e.g., drinking, cleaning, cooling). Water consumption charges are based on meter readings placed at an entry point to the site. Allowing for a small percentage for lawn watering, the Water Department calculates sewer charges from these same meter readings based on the assumption that water entering a site will exit the site through the sewer. In industrial sites such as Polaroid where film processing and machinery generate vast amounts of heat, large cooling towers are required to maintain stable temperatures and humidity levels. Although these cooling towers consume large amounts of water for operation, only about 10% of the water returns to the sewer system while the remaining 90% evaporates from the towers. As a result, Polaroid negotiated with the City of Waltham's Water Department for an annual rebate of sewer charges for the water which evaporates from its cooling towers.

Until 1996, Polaroid paid full sewer charges for the evaporated water. Based on widely accepted engineering practices, on-site evaluations, and cooling tower blow-down cycles, Polaroid confirmed that an average of 90% of the water consumption volume for its 16 cooling towers evaporates, and the remaining 10% is discharged into the sanitation sewer system through the blow-down cycles. This breakdown equates to a 10:1 reduction of water consumed versus water entering the sewer system. Key to qualifying for the annual rebate was Polaroid's presentation and demonstration to the city that the Water Department's metering and sewer charging practices were inadequately reflecting the actual water discharged to the sewer system.

The city granted approval for the rebate, but required Polaroid to purchase and install new water meters at the intake of each of the water towers. The meters, which were compatible with the city's present metering system, registered in cubic feet and allowed for remote readout from a touchpad using a smart gun.

By using the new method to estimate sewer discharge, Polaroid established a reliable accounting method for determining how much water evaporates at the cooling towers and how much enters the sewer system. Sewer charges are no longer based on the assumption that all water entering a site will be discharged through the sewer system. Polaroid's annual sewer charge rebate for its 16 cooling towers is estimated at \$150,000 to \$200,000 with a hardware implementation cost of less than \$4,000.

### Free Cooling with Evaporate Fill Media Pads

Approximately 15 years ago, Polaroid's facilities engineers began retrofitting and installing new process, manufacturing, and office space heating, ventilating, and air conditioning (HVAC) systems using evaporative fill media pads. As a result, Polaroid achieved virtually free humidification and cooling year round while maintaining a 52°F dew point discharge temperature. Concurrently, the air handling units were redesigned and retrofitted to incorporate the advantages of a positive pressure, blow-through system. This modification reduced the possibility of chilled water coils freezing in the winter due to air stratification; eliminated the need for a preheater coil; and extended the life expectancy of equipment by housing the fan, motor, and drive in a dry, contaminant-free environment.

Before the retrofit, Polaroid's HVAC systems were installed with a draw-through design (Figure 2-9) in which the outside air and the return air were drawn into a plenum where the prefilter, preheat coil, chilled water coil, and steam humidifier were

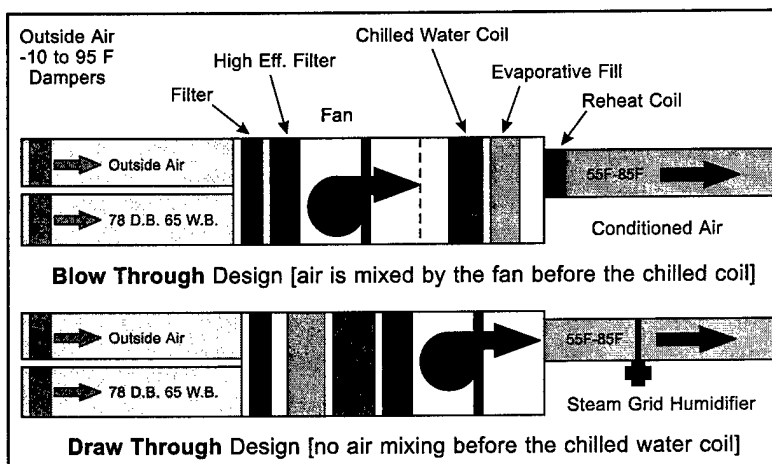


Figure 2-9. Heating, Ventilating, and Air Conditioning Systems

before the fan. This design allowed air to return from the conditioned space and mix with the minimum-required outside air make-up. As a result, portions of the chilled water coils became susceptible to freezing damage caused by the improper mixing of the cold outside air, warm return air, and warm air from the preheat coils (installed primarily to preheat the air and protect the chilled water coil). As the cold air and the warm air in the plenum stratified, pockets of cold air would pass over the surface of the chilled water coil, freeze on contact, and rupture the copper lines in the coil. This event not only shut down the air conditioning system for comfort cooling, but in most cases, shut down the process cooling and the production line in that area. The design is also inherently inefficient. On cold days, the air in the plenum is often preheated, and then cooled to a temperature required to condition the space, typically 55°F to 60°F. In addition, humidity requirements were satisfied by a steam humidifier located before the fan, motor, and drive which subjected internal parts to moisture and encouraged rust, dirt, bacteria formation, and long-term destruction of the fiberglass insulation in the plenum housing.

By retrofitting the units and incorporating the use of a 16-inch evaporative fill media pad, Polaroid eliminated the original design problems and provided virtually free cooling to the conditioned space. In the new blow-through design, the fan was placed before a high-efficiency filter, the chilled water coil, and the evaporative fill media. This design allows the stratified air to mix properly within the fan before reaching the coils which eliminates preheat coils and potential freezing hazards. By using evaporative fill media pads, the design allows the unit to be constantly saturated with recirculated and filtered water and provides the required cooling and humidity conditions to satisfy the controlling dew point of 52°F.

Benefits of Polaroid's new design are multiple and varied. Energy is saved through evaporative cooling by using the evaporative fill and a two-stage filtration, and eliminating the preheat coil. Other benefits include eliminating cost humidification; reducing the potential of the chilled water coil freezing in winter by allowing the stratified air to mix properly in the plenum housing; eliminating contamination into the unit via air leakage by placing the air under a positive pressure after the final filters; and housing the fan, motor, and drive in a dry environment by eliminating the direct steam injection into the air stream for humidification.

## Moving Crates

To accommodate the dynamics of its business structure, Polaroid has a constant movement of office employees. In the past, relocating employees required 15 corrugated moving boxes per employee for packing their office contents at a cost of \$11.75 per box. Employee relocation over a 12-month period typically averaged 4,600 boxes. Polaroid recognized that the practice of purchasing corrugated moving boxes, recollecting them after a move, and then recycling the used boxes was a waste of natural resources and an unnecessary budget commitment. To rectify the situation, Polaroid purchased 100 plastic stackable moving totes with hinged lids at \$20.00 each. These totes are loaned to employees and returned after each move.

Although it has been using the plastic totes for only six months, Polaroid has already paid for its original investment, and the concept has been well received by the employees. In addition to the cost savings, these commercial-off-the-shelf totes have also created a labor savings. Previously, when an employee finished unpacking, the empty corrugated moving boxes were often tossed in piles for custodial collection which created an unsightly nuisance. In addition, the recycling process of the corrugated boxes required an employee to collect, transport, and bale the boxes in another section of the facility to prepare them for the recycler. With the reusable plastic totes, employees can insert and neatly stack the totes for custodial collection and reuse. The savings from this environmentally-friendly method continues to accumulate and will fund the purchase of another 100 plastic totes to support Polaroid for the future.

## Power Factor Correction for Energy Conservation

In 1975, engineers at Polaroid's Norwood Plant initiated a project to add capacitance to its inductive electrical load to increase the total power factor on its electrical grid. Typically, electric utility companies penalize commercial and industrial customers with a kilovolt ampere demand charge for poor power factor performance. Although the defining point of poor performance varies depending on the utility, poor power factor performance generally is defined within a range of less than 80% to 95% efficiency. The local electric utility company charges a demand penalty for power factor readings of less

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than 80% efficiency. Additional negative impacts of a continued poor power factor might include panel and circuit overloading or reaching practical kilovolt ampere limits of a substation.

The easiest way to correct power factors usually involves installing some type of capacitor bank at the main substation used by the electric utility company to determine the kilowatt hour usage and demand charges. Effectively, poor power factor performance within the plant is then transparent to the electric utility company for billing purposes. However, this is not the best method.

On its own initiative, Polaroid's Norwood Plant raised its power factor and corrected any inefficiencies by installing capacitors on all motors greater than 25 hp at the motor, and capacitor banks in the motor control centers for all motors less than 25 hp. Capacitors were also added on all 15 kilovolt feeders within the plant.

Polaroid increased its power factor to more than 95% by installing capacitors on its inductive loads. In addition, this method efficiently uses Polaroid's purchased electrical energy, directly conserves electrical energy, and reduces reactive power problems for the surrounding electrical grid.

### Preheated Boiler Make-up Water

Approximately five years ago, Polaroid purchased two new air compressors for its production operations at the Integral Coatings Division and integrated the water lines for the aftercoolers on these compressors with the make-up water lines for the high-pressure steam boilers. Typically, industrial-application air compressors are installed with chilled water lines or once-through municipal water lines attached to the aftercoolers. This setup keeps the compressor, oil, and bearings at a safe operating temperature by dissipating the resulting heat that was generated through friction and motor energy in the compressing process. The result creates the situation that one source of energy is consumed to generate another source of energy. For example, if chilled water is used in the aftercoolers, then the discharged water would eventually be returned to the chiller where mechanical and electrical energy would be consumed to re-chill the water and begin the cycle again. For once-through municipal water, the discharged water would be directed to the sanitary sewer (and probably not reused) as the heat from the compressor is removed by the water in the aftercooler.

In Polaroid's situation, the proximity of the air compressors to the high-pressure steam boilers allowed the discharge water to be directed to the boiler as boiler make-up water to generate steam. Typically, boiler make-up water from a municipal source is approximately 50°F to 60°F. However, the boiler must consume more fuel than normal to counter the effects of the cooler water re-entering the system. To solve this problem, Polaroid preheated the make-up water entering the boiler to 95°F by consuming the heat energy dissipated via the air compressors.

Polaroid gained many benefits from its energy conservation technique: destructive heat is removed from the air compressor which allows the compressor to operate efficiently and reliably; additional mechanical and electrical energies are not sacrificed by using a chiller to generate another source of energy; preheated water from the compressor aftercoolers provides an excellent source of make-up water which does not compromise the efficiency of the high-pressure boiler; and expended water is not discharged into the sanitary sewer. Savings for the 750 hp air compressor system is \$66,000 per year for preheating the make-up water to the boilers. Eliminating the use of chilled water to cool the compressors resulted in an annual savings of \$94,000 in electric energy.

### Ultraviolet Light Treatment

Approximately eight years ago, Polaroid's Core Engineering Department began installing ultraviolet light water jackets for the humidifiers located in its air handling systems. These air handling systems service the comfort and health needs of the employee as well as the stringent production requirements for making instant print films. Treatment of the water used for humidification purposes is necessary to reduce the amounts of bacteria which would otherwise thrive in this constantly wet environment. Failure to condition the water would lead to poor indoor air quality, higher maintenance costs, and shorter life expectancy of equipment.

Conventional methods of water treatment rely on chemicals that are costly, require high maintenance, evaporate in the air stream, and typically need subcontractor support. The chemical delivery system to the humidifier also uses pumps or maintenance personnel which may result in spiking when the chemicals are first introduced at their highest concentrations.

Polaroid's ultraviolet systems have reduced the typical inlet condition from 200 to 10 colonies of bacterial growth per cubic meter. This improvement was accomplished by using a single pass through the ultraviolet water jacket before the water is introduced in the humidifier. In addition, Polaroid has reduced its humidifier maintenance by 75% since installing the ultraviolet systems.

### Variable Air Volume Heating, Ventilating, and Air Conditioning System

Approximately seven years ago, Polaroid began retrofitting the heating, ventilating, and air conditioning (HVAC) distribution systems at its Integral Coatings Division and installed energy-efficient, integrated, self-contained, thermally-activated diffusers on the variable air volume (VAV) distribution system for its comfort cooling applications. The modifications eliminated the need for zone thermostats and provided an energy-efficient way to maintain consistent, comfortable cooling.

Typically, VAV distribution systems are installed such that the air discharged from the HVAC unit is kept at a constant dew point temperature of 52°F; the static pressure in the duct is kept constant between 0.2 and 0.25 inches of water; and the volume of the air delivered through the diffuser is varied by a damper located in the respective branch distribution duct and controlled by a space thermostat. The result is an energy-efficient delivery system which requires no additional heat sources and makes optimal use of the sensible heat energy from the lights, equipment, and people in the conditioned space. The constant dew point temperature, cooled air is simply delivered variably. When the air is too hot, additional cool air is delivered to the space while conversely, when the air is too cold, less cool air is delivered. The drawback, however, is the higher capital costs and maintenance of the VAV boxes, and the need to install space air thermostats.

For Polaroid's needs, engineers installed integrated, self-contained, thermally-activated diffusers directly connected to the distribution branches which eliminated the need for mixing boxes and thermostats. The diffusers are designed with a hydraulic mechanism which drives the diffuser blades open or closed, depending on the ambient space air temperature. The mechanism contains a cylinder with a heat-sensitive wax material that reactively contracts or expands, thereby increasing or decreasing

the pressure in the cylinder proportionally. The result is an even, consistent, energy-efficient delivery of cool air without using thermostats that require constant calibration and adjustment.

Polaroid gained many benefits through its VAV HVAC system. By eliminating space air thermostats, Polaroid lowered its capital and recurring maintenance costs, and the need for constant calibration to ensure energy efficiency and comfort cooling. Other benefits include the elimination of higher capital costs associated with installing VAV boxes; increased diffusing performance which exceeds standard diffusers at equal cost; and greater energy savings associated with a maintenance-free VAV distribution system compared to standard VAV systems.

### Volatile Organic Compound Abatement System

To meet air pollution standards levied in 1984, Polaroid had to either revise its air emissions or face a shutdown. At the time, Polaroid had been releasing more than 2,500 tons of VOC emissions into the air annually. Emissions were generated from the drying ovens associated with film coating equipment. Direct-fired, continuous-burn incineration was a possible solution, but its associated high-energy consumption cost was a drawback. Polaroid needed a way to eliminate VOCs at a reduced energy cost. In response, Polaroid designed the specifications of the VOC Abatement system (Figure 2-10). The system's cost was \$5 million and went on-line in January 1985.

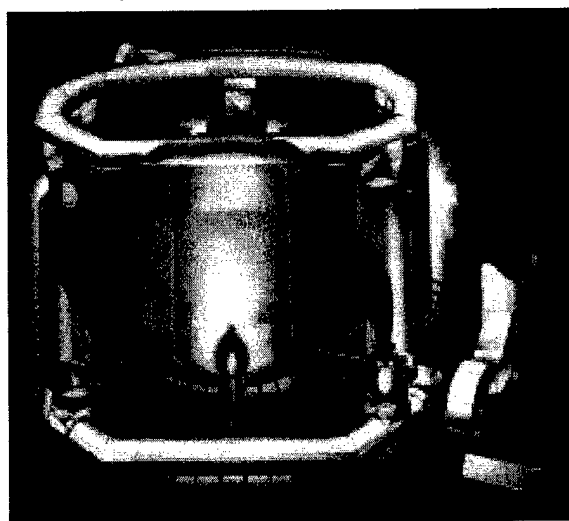


Figure 2-10. REECO Incinerator

Built by Regenerative Environmental Equipment Company (REECO), the VOC Abatement system was a high-efficiency regenerative cycling incineration system which abated the hydrocarbons contained in solvent laden process exhaust. Contaminated fumes enter the system through an upper ring-shaped manifold where inlet flow control valves direct the air from the manifold to the energy recovery stoneware beds. Fumes, progressively heated as they pass through the hot stoneware bed, move toward the incineration chamber. Upon leaving the stoneware beds, the fumes are very close to the incineration temperature. Oxidation is completed in the gas-fired central chamber which is maintained at 1500°F. VOCs, present in the fumes, autoignite while still in the stoneware beds which reduces auxiliary fuel requirements. When the incoming air contains enough VOCs, the energy released will provide enough heat to support the inner chamber ignition, allowing the burner to switch automatically to pilot mode. The purified air is then pulled from the central chamber through the stoneware beds and exits through the outlet control valves. The stoneware beds absorb the heat. The cooled air then exits to the exhaust fan at a temperature only slightly higher than that of the incoming air. Subsequently, the direction of flow reverses, the energy stored in the stoneware now preheats the incoming batch of air, and the inlet stoneware bed becomes the outlet stoneware bed. The VOC Abatement system's action is continuous cycling by taking advantage of the use and reuse of the heat energy stored in ceramic stoneware beds. With its high surface area for heat transfer and mass for energy retention, the stoneware beds' size and shape assure excellent air flow around, over, and under every element.

Polaroid's VOC Abatement system is virtually indestructible and has required minimal upkeep maintenance since its installation (only the valves have been redesigned). The system can receive more than 75,000 standard cubic feet of process exhaust streams per minute; destroy 2,800 tons of VOCs per year; produce a destruction efficiency greater than 98%; achieve a thermal efficiency greater than 95%; and operate in temperatures up to 1800°F. The 1996 annual operating cost of the VOC Abatement system was \$500,000, including \$45,000 for natural gas.

## Watershed Protection

In the mid-1980s, Polaroid and the Waltham community became aware of the need for coordinated watershed planning and a program to reduce the potential for liability. Since Polaroid sits on a steep hill, runoff water flows directly into a drainage area adjacent to Route 128, a major commuting highway, and then into a drinking water reservoir. Polaroid had spill response plans for specific buildings at its facility, but no unified site plan to accommodate a spill which might flow beyond the boundaries of a building. In response, Polaroid developed a watershed protection plan for minimizing site spill risks to the community.

Polaroid initiated a hazardous materials team which established a coordinated site spill response plan. In the event of a site spill, Polaroid can close, within seconds, a 42-inch storm water valve in the site's drainage system which will prevent 60,000 gallons of runoff water from flowing into the community reservoir. If a spill occurs during a sustained heavy rainfall, the storm water valve and drainage system can contain the spill for two hours. Even in a worst-case scenario, the valve will provide enough time for Polaroid to respond to an incident without impacting the community.

Polaroid improved the roadways around its site to provide multiple vehicular routes to its buildings and reduce the likelihood and impact of a transport vehicle spill. Other improvements include a holding bay to stage loaded trucks in inclement weather and a large storage tank to collect roof runoff water. The roof runoff water is then used for vacuum lines and cooling towers, eliminating the need to purchase water for this purpose. The Massachusetts Water Department has appreciated the steady discharge to the community water because it is now more manageable.

Another aspect of Polaroid's watershed protection program involves its community outreach efforts. These efforts include Polaroid's regular participation in the Waltham Earth Day festivities; assistance to the Cambridge Water Department by jointly developing informational brochures and hosting community meetings; voluntary stenciling of community water drains to discourage pollution; and open-line communication to the Massachusetts Water Department and the Waltham community.

Polaroid has gained many benefits from its watershed protection plan and activities. The risk in handling a site spill is now minimal. Increased

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community awareness of the issues and the spill response plan characterizes Polaroid as a company concerned with the health and safety of its community. By partnering with the Cambridge Water Department, Polaroid has also established credibility with the authorities and a strong line of communication for resolving issues.

## ***Management***

### **Beyond Environmental Compliance**

The environmentally-volatile era of the 1980s challenged Polaroid to comply with the numerous federal, state, and local regulatory requirements. Polaroid implemented compliance programs to reduce the potential liability associated with environmental non-compliance, while the company's drive for excellence in environmental stewardship led to the development of an internal pollution prevention program, the Toxic Use and Waste Reduction (TUWR) program, which went beyond compliance requirements.

In support of the TUWR program, a centralized measuring system called Environmental Accounting and Reporting System (EARS) was developed in 1987, using 1988 as the baseline, to integrate data collection throughout the corporate structure. EARS monitors and reports the rates of toxic use and waste generation for chemical materials (Categories I through V — refer to abstract on Establishment of Chemical Categories). In addition, EARS measures waste reduction per unit of production which is also the basis for the Massachusetts Toxic Use Reduction Act (MATURA), enacted in 1989. This calculation method normalizes the performance measurement and is relatively unaffected by changes in production volume. Environmental credits can be obtained through waste reduction efforts in all material categories and by reducing the use of Category I and II materials. These environmental credits are awarded to corporate divisions for achieving or exceeding TUWR goals.

Data collected in 1988 was used to establish the baseline under EARS for all categories in measuring toxic use and waste reduction per unit production. The 1988 totals were defined as 100% of the baseline amount (i.e., 1.00). A target goal of 10% reduction per year per unit of product was then set using the baseline measurement. Within the first five years, Polaroid achieved a corporate-wide reduction of greater than two million pounds per year

of usage/waste which translates to an overall reduction of nearly 25%.

In 1994, TUWR/EARS were expanded to include, among other aspects, energy reduction and water conservation. The systems' natural progression has also resulted in another expansion which provides data collections and reporting for the Superfund Amendment and Reauthorization Act via the Toxic Release Inventory's Form Rs and MATURA.

### **Community Outreach**

Although a very successful film-producing company in the early 1980s, Polaroid had not fully appreciated the surrounding community's increasing environmental concerns nor recognized the value of educating these neighbors on the company's business practices. In the middle 1980s, public interest groups, perhaps confused about the actual environmental practices embedded in Polaroid's manufacturing process, made public accusations against the company. Although these negative claims were often voiced without proper research, the public typically accepted the accusations. Polaroid's environmental leadership then realized they had very few avenues to disseminate correct data since the company had no formal method of educating the community. Recognizing the significant role which the local community had over industry through local environmental agencies, Polaroid responded to the situation with an open and honest effort by partnering with the local community.

Polaroid opened its doors to the public through facility tours, community meetings, communication links, a community newsletter, and an environmental report which listed specific environmental information about the company. Besides community education, Polaroid also began creating internal educational programs for its employees to inform them about environmental issues and processes within the company.

Polaroid now promotes community involvement and open communications within its facilities. Through community surveys and open meetings, Polaroid works with the community and recognizes that the residents' viewpoints and concerns may differ from those of the company. Polaroid receives several calls each year seeking its environmental leadership's assistance in interpreting environmental issues and recommendations. The trust

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created between Polaroid, its communities, and environmental groups has now become an asset to all involved.

## Environmental Reporting

Polaroid's corporate philosophy maintains that its business will be operated in an environmentally responsible and sustainable manner. One aspect of this responsibility entails keeping the company's stakeholders, including the local communities, informed on Polaroid's environmental efforts and performance. Polaroid has recently published its eighth annual report on the environment, the second of which follows the guidelines of the Coalition for Environmentally Responsible Economies (CERES).

In 1987, Polaroid decided to publicly report its environmental data and reorientate the company's environmental programs toward pollution prevention. As a result, Polaroid developed the Environmental Accounting and Reporting System (EARS) and the Toxic Use and Waste Reduction (TUWR) program in 1988. The TUWR/EARS program's first year results were used to create Polaroid's first environmental report in 1989. This document, the first modern, data-rich, corporate-environmental progress report in the United States, targeted an audience of pollution prevention leaders; environmental groups and committees; and Polaroid's employees and shareholders. The intended audience for these environmental reports was expanded between 1990 and 1992 to include the government, other companies, and investors who were interested in socially and environmentally responsible companies.

In 1992 and 1993, Polaroid was one of just ten U.S. companies that worked together to develop a set of guidelines which could be used by companies to publish corporate environmental reports. These guidelines, published in 1994 as the Public Environmental Reporting Initiative, were designed as a tool to assist organizations that voluntarily produce a balanced reporting perspective on their environmental policies, practices, and performances.

Continuing its environmental leadership role in 1994, Polaroid endorsed the CERES principles which encouraged companies to conduct business in a manner that protects the Earth and applies environmentally responsible practices throughout the world. These guidelines marked Polaroid's expanded commitment to actively collaborate with environmental leaders and investors on operating its business in an environmentally responsible and

sustainable manner. Polaroid's seventh and eighth reports on the environment are patterned directly after the CERES principles, including a clear cross-reference between the CERES report questions and applicable portions of Polaroid's annual report.

*Fortune* and *Tomorrow* magazines have recognized Polaroid for its leadership in corporate environmental reporting. Polaroid's internal efforts and external association with CERES and other U.S. premier environmental groups have enabled Polaroid to evolve its environmental program to a higher level.

## Ethics and Compliance Awareness Training

Polaroid's training directors recognized that a successful environmental training program required employee support not only from a compliance perspective, but also from an ethical awareness perspective. As a result, Polaroid has developed a unique training program which successfully instills personal ethical responsibility and stewardship concerning environmental compliance and behavior.

Like most corporations, Polaroid had established regulation-specific training modules which offered compliance awareness as required by the Resource Conservation and Recovery Act, the Department of Transportation, HAZCOM, and other local regulations. This training focused on the technical aspects of environmental issues but failed to inform the employee on the ethical aspects. Drawing on Polaroid's success from its business conduct module on ethics, the developers of the environmental awareness program established the training as a co-sponsorship between Corporate Health, Safety, and Environment and the Office of Ethics and Compliance under an umbrella of corporate ethical behavior.

The Ethics and Compliance Awareness Training successfully changed employees' way of thinking (e.g., question whether the environmental procedure was valid; influence the way decisions were made; determine the environmental impact). The training featured two hours of business significance and legal aspects of environmental compliance, which was customized for the local divisions. Polaroid used local environmental managers as the program trainers. These managers were able to have their employees share ownership and responsibility for their particular local work area.

Support for Polaroid's unique approach was built by enlisting the endorsement of top managers

throughout the company. A total of 29 trainers were trained to implement the program and were then allowed to develop specific guidelines unique to their areas. Polaroid initiated the Ethics and Compliance Awareness Training in September 1996 and has already trained more than 95% of its employees. Evaluation data indicates that 89% of the employees have a greater awareness of their own and the company's environmental responsibility; 86% have a better understanding of how the laws and regulations relate to their workplace; 82% will participate in identifying and correcting environmental problems; and 92% commended the program trainer on a well-informed session.

Polaroid's Ethics and Compliance Awareness Training has instilled its employees with a better awareness and greater sense of responsibility. The employees are more willing to impact environmental performance directly; identify risk areas that may have gone unnoticed; and contribute toward improving the company's environmental performance each year.

## Indoor Air Quality Management

Polaroid started its Indoor Air Quality (IAQ) program in 1987 and is taking an increasingly proactive approach to IAQ. Over the years, Polaroid has performed more than 29 separate investigations and studies at 17 different locations.

Since 1996, Polaroid has conducted 10 proactive IAQ investigations and studies. These studies involve sampling and testing the air inside buildings for volatile organic compounds, carbon dioxide levels, dust, bacteria count, relative humidity, and temperature. Polaroid performed the sampling over a four-hour period during the middle of a normal workday. Figure 2-11 shows the results from various facilities. Sampling methods include carbontrap activated charcoal tubes for volatile organic compounds; AQ502 for carbon dioxide, temperature, and relative humidity; and DATARAM for particulate matter (dust). All results of the studies were within the American Society of Heating, Refrigeration, and Air conditioning Engineers (ASHRAE) Guidelines. Polaroid plans to continue proactive routine IAQ studies throughout the corporation.

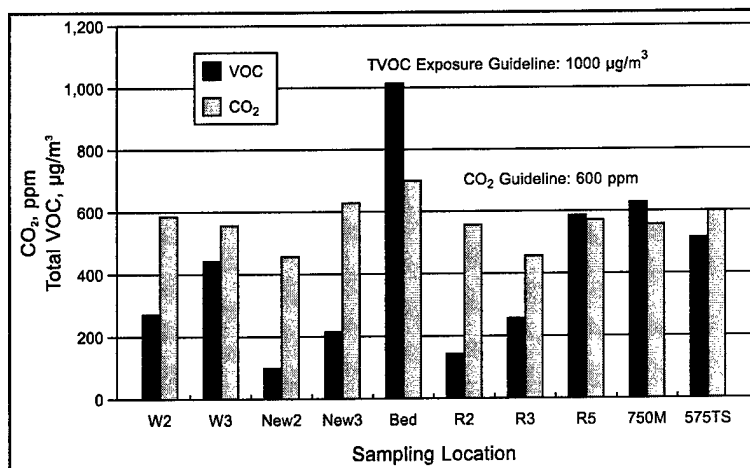


**Figure 2-11. Carbon Dioxide and Total Volatile Organic Compound Concentrations**

By using a proactive approach for its IAQ program, Polaroid has improved the working environment for its employees. Employee satisfaction and trust have also improved making the workplace more enjoyable, increasing production, and improving product quality.

## Occupational Medical Program

Dr. Edwin Land, the founder of Polaroid, envisioned complete healthcare for all employees and their families. Polaroid's Occupational Health Department began as a family practice health clinic for its employees and evolved into an occupational health clinic. Polaroid promotes and supports healthy work environments and healthy lifestyles for its employees.

Using an employee-oriented approach, the Occupational Health Department takes a major role in preventive medicine for Polaroid employees. The Department maintains three full-time doctors and 13 nurses for its five medical facilities throughout the company. Specialty services (e.g., orthopedics, psychology, and dermatology) are also provided by the Department once a week. Each medical facility is equipped with state-of-the-art medical equipment and laboratories. Polaroid's preventive medicine practice includes free complete physicals every three years for employees over the age of 40; gynecological exams and prostate exams for employees; and unlimited consulting for alcohol/drug abuse and stress. In addition, the Occupational Health Department offers wellness programs; informs

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employees of options such as living wills; and operates support groups for diabetic employees. Through their experience and understanding of Polaroid and its culture, the clinic doctors provide employees with quality medical services.

Polaroid's Occupational Health Department provides various benefits through its employee-oriented approach. Besides quality medical service, employees receive a sense of well being through an experienced and caring medical staff. In addition, Polaroid management supports the medical program as a top priority benefit for its employees. Overall, Polaroid increases employee moral and creates a better working environment.

### Polaroid Exposure Guidelines

In 1968, OSHA regulated permissible exposure limits (PELs) for almost 800 chemicals. These PELs, based on an earlier concept established by the American Conference of Governmental and Industrial Hygienists (ACGIH), identify safe worker exposure limits to air contaminants. However, detailed procedure requirements make regulation difficult to modify as new information becomes available. The National Institute for Occupational Safety and Health (NIOSH) proposes its own limits for chemicals known as Recommended Exposure Limits (RETs). These multiple exposure limits for a given chemical, combined with the trend of tightening environmental regulations, motivated Polaroid to establish its own, very conservative approach for identifying exposure limits.

In the late 1970s, Polaroid developed Polaroid Exposure Guidelines (PEGs) for materials handled in significant quantities based on current literature and toxicity test results from Polaroid-sponsored studies and existing established limits. PEGs are usually set at one-half of the lowest limit of an existing PEL or ACGIH, or less if the Polaroid review team deems it to be prudent. Although PEGs are self-imposed guidelines rather than federally-imposed limits, Polaroid strives to maintain that worker exposure is less than these guidelines. Polaroid's existing site evaluation and monitoring programs verify their compliance with PEGs. If exposures deviate beyond PEG limits, then Polaroid takes prompt corrective action.

If official or unofficial guidelines do not exist, then the PEG is based upon known and suspected toxic effects, governed by a rating system designed for this purpose. Among other advantages, conservative PEGs are used to anticipate downward shifts

in the OSHA PELs. Goal setting is straightforward since only one source exists for the guidelines, and no one needs to struggle to meet a more stringent requirement. Polaroid can quickly respond to new test data on exposure hazards as the company has an existing mechanism to incorporate that information with its company policy. This guideline program has existed for more than 15 years and has proven to be a satisfactory mechanism for practicing workers' health protection.

### Polaroid Foundation

Twenty-five years ago, the Polaroid Foundation was established with a mission to support non-profit organizations that provide services to those less advantaged. Beginning in 1997, Polaroid refocused that mission to include services which promote life skills development to those less advantaged. Geographically, the Polaroid Foundation concentrates its grants in Massachusetts, especially in those communities where Polaroid has its facilities. To evaluate submitted proposals, the Polaroid Foundation set up committees for culture, education, community, environment, and the New Bedford area. After the 1997 mission revision, the Polaroid Foundation regrouped its committees to include one for Greater Boston.

The Polaroid Foundation operates on an annual budget of approximately \$2 million which is provided by Polaroid. After an initial screening by the Polaroid Foundation for proper grant application requirements, the proposals are distributed to the appropriate committees. These committees of self-invested employee-owners decide which proposals should be funded.

In 1993, the Polaroid Foundation established an Environmental Committee because of Polaroid's values and potential impact on the environment. This would assure that environmentally-related proposals would receive priority when evaluated against criteria developed for this purpose. The Environmental Committee develops its own evaluation criteria based on outreach, education, organization stability, and program characteristics.

The Polaroid Foundation is one of many ways in which Polaroid demonstrates its involvement in the surrounding communities. The philanthropic activity promotes the well-being of the local area and its citizens; reinforces the support of the community; and allows Polaroid employees to select which community activities to support. Environmental grants totaling more than \$130,000 have

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been awarded over the last four years, ranging in amounts from \$1,000 to \$7,950.

### Proactive Roles with Public Groups, Boards, and Committees

Polaroid recognized that environmental-policy development by agencies benefits from full understanding of the nature of business and industry. In response, Polaroid's Environmental Leadership Group is actively involved in external environmental activities in addition to its complex reporting, planning, and maintenance duties on environmental compliance issues. The Group's members donate their time to participate proactively with public groups, boards, and committees which help influence public policy and environmental statutes and regulations.

Polaroid believes these regulatory actions are necessary for the long-term health of our planet. Through its participation, Polaroid offers its environmental and business expertise to these regulatory agencies to assist them in understanding the applicability and interpretations of regulations as they are being developed. Polaroid's commitment is evident throughout the corporation by offering business perspectives at the national, regional, state, and local levels. The opportunity to work closely within the surrounding communities of Polaroid's facilities has helped the company build trust and understanding with the communities, residents, and environmental groups.

Polaroid's proactive environmental leadership with public boards and committees has yielded many benefits between the company and the communities. Among them include more livable regulations and better interpretations of laws and regulations by agencies so industry and communities can obtain common goals.

### Product Safety Management Guidelines

Polaroid has always ensured customer safety by conforming with consumer protection laws. However, the Product Safety Committee, set forth by company policies and procedures in the 1970s, typically used a reactive approach and was subject to frequent membership turnovers. In addition, this reactionary and inconsistent approach to product safety made accountability difficult to track. No employee or manager felt personally responsible for the safety issues. In 1993, Polaroid began to

transform its Product Safety Committee from one that primarily reviewed information into a more proactive, comprehensive product safety program.

Polaroid established co-directors to lead the company in ensuring that all existing and new products meet Polaroid's product safety standards. To supplement the existing safety policy, the co-directors developed the Product Safety Management Guideline which is based on the elements of International Standards Organization (ISO) 9000 and 14000, although currently not audited. The Product Safety Management Guideline emphasizes that safety planning must address all stages of the product from concept, design, and development through customer use and disposal. The guideline targets safety strategies for employees who build the product, installers of the product, operators, maintenance personnel, and even bystanders. In addition, the guideline addresses product recall procedures; product testing for applicable national and international standards; establishment of responsibilities for managers, directors, and review committees; and annual reviews of management practices.

All managers are trained on Polaroid's philosophy. A risk assessment evaluation is required for each new or existing product, and a methodology for assessing risk is discussed. Critical definitions are explained to provide universal understanding of terms (e.g., substantial product hazard, safety, danger) which may have connotations other than those in the guideline. Employees have easy accessibility to the co-directors in case safety questions or issues arise after formal training. The frequent contacts indicate that Polaroid has a sound communication network in place.

In November 1996, Polaroid published its final version of the Safety Management Guideline which is auditable per ISO requirements. The practices set forth in the guideline save time and money because safety concerns are discovered and averted in the early stages of product design and development. Since implementing this guideline, Polaroid has not encountered any issues beyond the prototype development stage. In addition, company awareness has increased, and employees know a safety answer is only a telephone call away.

### Professional Development Committee

Polaroid has a tradition of helping employees improve their work-related knowledge and skills. To provide additional focus in the areas of health,

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safety, and environment, Polaroid established the Professional Development Committee (PDC) in 1994 which assists company HSE employees in their continued skill development.

Polaroid recognized that their HSE employees need a high level of technical competence, business insight, and personnel leadership. In addition, these employees face a continual learning challenge due to the day-to-day demands of their jobs and ever-changing regulatory requirements. As a result, their longer-term professional development tended to be neglected. To resolve this situation, Polaroid uses its PDC to update and educate HSE personnel on the skill requirements for promotion; standardize the HSE job family and job titles; offer ongoing professional training; and build a community of shared learnings on an HSE Intranet home page.

In 1994, Polaroid identified skills development as a top priority area within its corporate and matrix organizations which needed improvement, especially in the technical and leadership/management areas. Employee learning method preferences included coursework, on-the-job-training, and specific project assignments. Therefore, as part the PDC's focus on professional training, Polaroid developed a PDC Development Planning Kit. Based on the objective of helping HSE personnel, the Development Planning Kit clarifies their vision of career and/or personal achievement goals; develops a plan to reach those goals; identifies specific skills improvement activities with a timeline for accomplishing them; and enhances the supervisor's understanding of the PDC work and support for skill improvement. In addition, the Development Planning Kit provides details to the employees on how to conduct their own goal-setting effort. These goals are then reviewed with the employee's supervisor, and a skills assessment of the employee is conducted by a professional and the employee's supervisor. A portion of the skills assessment tool is the Checklist for Individual Development Planning which addresses knowledge areas such as environmental health; safety; leadership skills; communication skills; business environment; administration skills; community and professional engagement; and personal effectiveness skills. These efforts support employees in their pursuit of knowledge and skills through learning plans and management commitments.

Polaroid's PDC focus on HSE established a framework and guide for employees and supervisors to maintain and ensure skills development through

educational support, relevant monitoring, and successful progression. Employees who used Polaroid's PDC Development Planning Kit have benefited from self-assessment and achieved positive results from their learning plans. In addition, supervisors have gained a better understanding of HSE job responsibilities through the Development Planning Kit and regard it as a useful tool for supporting employee development.

## Project Bridge

Polaroid's Project Bridge began 15 years ago as a unique community human resource program with the local school board. Teachers take a one-year sabbatical from their academic responsibilities and work in a Polaroid facility. The experience allows the teachers to gain valuable life experiences which they take back to the classroom and enhance the educational teachings of the community's young people. In addition, Project Bridge has successfully helped teachers understand the relationship between their academic subjects and industry applications.

During the sabbatical, teachers continue to receive their school's employee benefits package, and the school system receives a reimbursement from Polaroid for the teachers' salaries. Project Bridge also complements Polaroid's intern program, another highly successful community outreach. Polaroid supplements its permanent workforce with students who work for the company while attending colleges and universities. The company pool of prospective applicants is derived from universities, environmental career organizations, minority programs, and resumes. Internships at Polaroid benefit the student's understanding of industrial and business processes, and identify real-world applications of academia requirements.

Project Bridge, the internships, and other human resource community sharing programs demonstrate Polaroid's interest and continued commitment to the surrounding communities. In return, Polaroid gains insight from experienced people who are eager to share their knowledge, and from students who bring an academic perspective on business. Teachers and students benefit from exposure to real-world business experiences and problems, which they can then apply to their classroom setting. These programs also offer a savings for Polaroid compared to the outsourcing of work to local subcontractors; improve its image by having com-

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munity members involved in daily operations; and add to the relationship between Polaroid and the local communities by openly sharing information.

### Regulatory Training Requirements

Several regulatory agencies require companies to provide environmental training for every employee. Although regulatory agencies may have similar training requirements, each agency involves specific topics to be addressed for compliance. In the past, Polaroid would conduct separate classes for each compliance which required employees to spend several hours per year away from their workplace. Since the regulatory requirements overlapped from class to class, employees often sat through redundant lectures. This technique also proved costly for the company as well. To remedy the situation, Polaroid developed a consolidated approach to its safety and environmental training.

Polaroid's consolidated approach streamlined its training effort by grouping similar requirements

into a package which met the criteria of several regulatory agencies at the same time. For example, one of the consolidated training packages groups the requirements for the Hazard Communication (HAZCOM) standard; the Occupational Safety and Health Administration (OSHA); the Resource Conservation and Recovery Act (RCRA); and the Department of Transportation (DoT). The HAZCOM, OSHA, RCRA, and DoT training package covers all necessary requirements at one time, creates a consistency in the level of understanding for the employees, and reduces the opportunity for non-compliance issues.

By consolidating regulatory training requirements, Polaroid decreased the number of training classes, reduced its employees' downtime from the workplace, and increased its employees' comprehension level. Polaroid's training program was developed on Microsoft PowerPoint, is readily available for use at various sites, and can be easily modified for specific site needs.

## Section 3

### Information

#### Design

##### Chiller Performance

Polaroid's production requirements made it necessary to operate the cool water chillers during the winter months. Each chiller, matched with a water cooled condenser that had a fixed fan and pitch, was controlled by a snap-acting thermostat ranging from 75°F to 85°F. The cold winter air would quickly cool the water in the condenser to 75°F and cause the chiller to turn off until the water's temperature rose to 85°F. With this situation occurring 20 times an hour, the inconsistent water temperature of the condenser caused the chiller to constantly load and unload, resulting in higher energy cost.

Polaroid implemented a short-term solution by installing a variable pitch fan blade on the water tower. The apparatus would sense the water temperature of the condenser and then adjust its blades according to the load of the system. This solution maintained a constant water temperature in the condenser, allowed the chiller to operate smoothly without constant loading and unloading, and reduced the energy consumption from 0.8 to 0.7 kilowatt per ton.

Next, Polaroid installed variable speed devices on the chiller and condenser pumps, and used a control system to modulate the devices according to the cooling load of the building. By adjusting speeds according to the demand, this new system reduced Polaroid's energy cost further from the initial starting point of 0.8 to 0.43 kilowatt per ton.

By retrofitting its cool water chillers with variable pitch fan blades and control systems, Polaroid saved \$30,000 a year in energy cost on a one-time investment of \$10,000. In addition, Polaroid saved almost 50% in energy by installing variable speed devices on its motors and pumps.

##### Variable Speed Chilled Water Pump

Polaroid let its Core Engineering Services Group investigate the chilled water problems at its new production facility in New Bedford. Built by a mechanical engineering subcontractor, the system

worked well under normal conditions, but failed during peak periods in the summer months when pumping demands increased. The heat load calculations confirmed the chillers were properly sized and large enough to handle the production requirements and the comfort cooling requirements of the facility. However, further investigation revealed that 800 feet of the main chilled water piping was improperly sized and causing excessive pressure losses and decreased chilled water flow (Figure 3-1). Polaroid's engineers calculated that an 18-inch piping system was needed to adequately deliver the chilled water during peak conditions instead of the 12-inch supply and return system installed by the subcontractor.

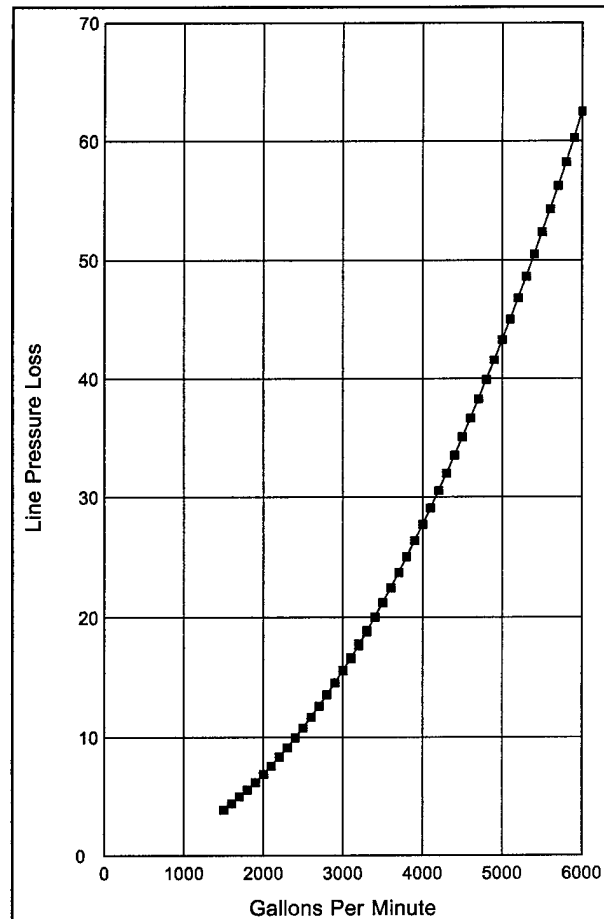


Figure 3-1. New Bedford Chilled Water Line Pressure Drop

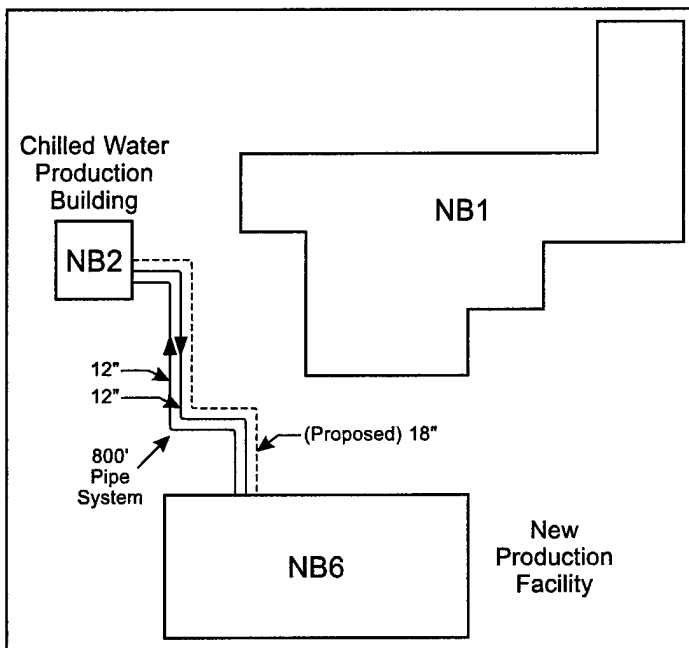


**Figure 3-2. New Bedford Complex**

The subcontractor suggested converting the two existing 12-inch pipes to supply lines and installing one new 18-inch pipe to serve as the return (Figure 3-2). The estimated installation cost for Polaroid was \$400,000. The Core Engineering Services Group suggested installing a variable speed booster pump in the existing 12-inch system to handle peak conditions. Polaroid engineers argued that the system design for the 52°F dew point discharge temperature could be met by turning off the chilled water system 65% of the time. During the remaining 35% of the time, the chilled water system would operate on a graduated scale, beginning with minimum cooling needs during moderate ambient conditions (194 hours out of the year) and ending in 100% full load requirements (three hours out of the year). Polaroid engineers reasoned that the small duration of running the booster pump under peak conditions did not justify the payback costs of installing a new 18-inch pipe line. Polaroid management agreed there would not be sufficient payback for the new pipe line investment and concurred with the Polaroid engineers to install only the booster pump.

Installing a variable speed booster pump when capacity demand increases is a cost-effective alternative to retrofitting an entire piping system. By installing the variable speed pump at \$77,945, Polaroid saved an avoidance cost of approximately \$320,000.

## Test

### Product Safety Testing

Polaroid's Product Certification Charter requires that products carrying the Polaroid name must comply with the product safety and certification laws of the countries where they will be marketed. Worldwide product safety regulations, voluntary standards, federal standards, and testing protocols must be met. Due to the chemistry and uniqueness of some Polaroid products, toxicity testing is performed to identify any health issues. In addition, testing and evaluation are required on all products purchased by Polaroid and repackaged for sale under the Polaroid name.

Test analysis and safety certification follows a product's lifecycle from concept to marketing. Involvement by development and production personnel is critical. The program manager ensures product safety by informing, educating, assisting, reviewing, testing, certifying, and monitoring product development. Safety critical items must be quantified, and safety certification and regulatory approvals must be obtained. In cases where design changes are unfeasible, labels and warnings must be developed. Alpha and beta testings confirm product safety analyses. The product must prove to be manufacturable with consistency and precision, and all documentation must be maintained for a minimum of ten years.

High product reliability and safety help Polaroid maintain a strong positive public image. By using an in-depth safety procedure, Polaroid meets its charter for global safety certification. Additionally, time is reduced between the concept and marketing phases by implementing the test analysis early in the product's lifecycle. Costs are also reduced by streamlining the certification stages and discovering necessary changes early.

### Safety Inspection Schedule

Polaroid's corporate policy requires that all facilities and equipment whose failure or malfunction could seriously endanger personnel or property shall be inspected regularly. The Corporate Safety Office established and documented periodic inspection intervals for common facilities and equipment

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throughout the company. Division managers established inspection programs for common facilities and equipment, and identified other equipment for inclusion in the inspection program (including the development of local inspection schedules) based upon hazards analysis. Each division has a recordkeeping system for managing inspections and reporting inspection results. Inspection results are then analyzed to determine if any program improvements are needed. Individuals performing the inspections are trained in the procedures and, where required, are certified or licensed. Upon finding a violation, inspectors immediately take the defective item out of service. Any items used to protect employees or property must be immediately repaired or replaced.

In January 1996, Polaroid conducted a safety audit of Divisional performance in implementing its Safety Inspection Schedule. Areas of strength included the existence of formal programs for scheduling the inspections and the inclusion of items to be inspected. Areas of average performance included the competency of the inspectors and the inspections themselves. Areas of weakness included management oversight and influence on the program; inspection postponements; inspections of portable electronic equipment and fire doors; recordkeeping and detailed documentation of inspections and findings; and examining the contracted inspectors' work.

With downsizing taking place over the past several years, special attention is needed in affected areas. Polaroid has had to hire contractors to perform some of its inspections. As a result, some inspections are not as adequately performed as Polaroid would desire. However, measures are being taken to address these issues.

## ***Production***

### **Corporate Safety Instructions**

In the 1950s, Polaroid developed its first set of safety policies which presented a traditional approach to safety issues and focused primarily on U.S. manufacturing plants. Polaroid's safety policies were based on national consensus standards and were above average for the current time period. In the late 1970s, Polaroid's safety policies were updated and transformed into formal instructions to comply with the newly-instituted OSHA standards. These updated safety policies were then

incorporated into a document entitled *Corporate Safety Instructions*. Known as the Green Book, the document was used by employees as a safety bible and reflected the U.S. laws and cultures as opposed to worldwide concerns.

Polaroid's current set of corporate safety instructions is divided into 11 sections including general instructions; environmental safety and health; fire protection; and technical area safety instructions. Each instruction contains several parts (e.g., scope, background, policy, definitions, responsibilities and procedures, appendices) which provide guidelines for the user. The key statement for each instruction can be found in the policy section.

The Green Book provides valuable, consistent health and safety standards to Polaroid's 40 operating divisions and eliminates the need for each division to develop its own standards. The document also serves as a standard for compliance audits. The Corporate safety team and division safety leaders meet monthly to discuss issues, problems, and concerns. Since the Polaroid facilities are located within a 60-mile radius of one another, these meetings provide an excellent opportunity for information exchange and keep all divisions updated.

Corporate safety instructions are not generally changed. However, the organization is constantly changing, and recent re-engineering efforts have resulted in the need to update the "who" portion of the policy. Polaroid also intends to globalize its policies and incorporate international standards and requirements for its non-U.S. plants. The document may be revised to comply with ISO-14000 standards.

### **Hazardous Materials Response Team**

Polaroid's corporate policy requires each division to establish emergency preparedness plans which are integrated with building, site, and community plans. Approximately three years ago, the Chemicals Division (and other Waltham site divisions) set up and began operating a Hazardous Materials (HAZMAT) Response Team. The HAZMAT Response Team not only complies with Polaroid's statutory requirements, but also promotes good business and community relations.

HAZMAT team members serve voluntarily and are selected based on their knowledge and experience with Polaroid's facilities, processes, and/or chemicals. Team members must pass an annual HAZMAT physical examination as prescribed by

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OSHA. Additionally, the members must undergo an initial 24-hour training session customized to the Waltham site's hazards, features, and equipment. New members attend company-sponsored HAZMAT technician courses (e.g., Basic Response Procedures; Personal Protective Equipment and Decontamination). Team members also participate in monthly training and drills, and in local, regional, and nationally-sponsored HAZMAT exercises.

Typically, HAZMAT team members are highly motivated individuals who genuinely want to use their specialized knowledge and skills to help Polaroid, their co-workers, and the community. To recognize the valuable contribution of these volunteers, Polaroid publicizes the HAZMAT team activities and provides training, equipment, and service awards. Like any emergency response effort, additional equipment requirements are uncovered as the nature and circumstances of incidents vary and as more technologically advanced tools for response/reaction emerge.

The HAZMAT Response Team continues to successfully respond to HAZMAT emergencies. Besides working closely with the local community to integrate their mutual efforts, the Response Team meets Polaroid's corporate policy for emergency preparedness plans.

## Health, Safety, and Environmental Audit Program

Polaroid considers its Health, Safety, and Environmental (HSE) Audit program as a value-added tool which helps drive its performance in HSE issues. However, a 1995 review convinced Polaroid that it needed to increase the effectiveness and overall value of its Corporate HSE audits of its manufacturing facilities. General concerns were that the Corporate Audit team did not always address the topic areas which the facility manager deemed most important; the time and date were revealed to the facility manager prior to the audit; and employees felt that the HSE resources were not being utilized most effectively between the corporate and manufacturing facilities. To address these concerns, Polaroid formed a Corporate Audit Effectiveness team in 1996 which conducted interviews with most plant managers and HSE representatives.

From the interviews, the Corporate Audit Effectiveness team identified specific areas for Polaroid to target: identify potential HSE risks; support

HSE compliance goals; facilitate corrective actions and follow-up; and communicate results, lessons-learned, and training needs. These areas were then grouped into five major themes which Polaroid is now addressing:

- **Identification of True Risk**—Polaroid has restructured its HSE audit program to conduct unscheduled audits; identify true HSE concerns and risks by working with plant managers in selecting audit topic areas; and pursue more in-depth analysis and auditing of topic areas.
- **Continuous Improvement**—The HSE audit will provide a road map to guide the plant toward better compliance; increase HSE awareness and competency by conducting more training and identification of the areas to be audited and why; and encourage shared learnings and improvements between plant and division operating managements.
- **Balanced Audit Reporting**—The HSE auditors will characterize and prioritize findings; cite deficiencies; and report and recognize improvements via rewards.
- **Verification of Corrective Actions**—The HSE audit team will provide more corporate consultation to the manufacturing plants which will supply the facility with the information it needs to take corrective action; and verify the HSE improvement via an annual customer satisfaction survey.
- **Providing a Clear Purpose**—The Corporate Audit Effectiveness team noted that an HSE audit program mission statement and vision needed to be developed.

Since 1996, the Corporate Audit team has worked on developing a mission and vision; identifying environmental compliance and community relations risks; developing individualized environmental risk assessment matrices for each manufacturing plant; and preparing instructions to identify the specifics on how to perform the different HSE audits. Polaroid began its initial revamped HSE audits in March 1997 and will perform its next customer satisfaction survey in November 1997. By upgrading its HSE Audit program and providing more consultation and follow-up services to its facilities, Polaroid expects to benefit by obtaining a truer risk-oriented picture of its manufacturing plants and more efficient measurement and balanced reporting methods for problem areas.

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## Ozone Depleting Substance Elimination

Prior to 1992, Polaroid cleaned more than 400 different part types for multiple camera assemblies using a freon material as a routine corrective action for any kind of parts cleaning or rework problem. As a result of the Clean Air Act, Polaroid began eliminating ozone depleting substances (ODSs), such as chlorofluorocarbons (CFCs), from three of its camera manufacturing processes (camera parts cleaning, camera parts coating, and shutterblade coating). In addition, Polaroid instituted a Just Say No More CFCs program and worked with its vendors to improve the cleanliness requirements for parts, and develop air and non-ODS solvent cleaning methods. As a result, Polaroid now receives cleaner camera parts with no negative cost impacts.

To reduce friction between parts, Polaroid used ODSs to coat camera and shutterblade parts with a Teflon material. The Teflon topcoat was applied in an agitated (ultrasonic) dip tank which contained Teflon suspended in a CFC 112 mixture. The new ODS-free process applies the Teflon topcoat to the camera parts in the same ultrasonic dip tank, but now the Teflon material is suspended in an aqueous solution and dried using heated, forced air. The shutterblade parts are now slot-coated by using the Teflon in methyl ethyl ketone. Although it requires a Reasonably Available Control Technology (RACT) Exemption, the process only needs to be performed twice a year to meet all production requirements.

Polaroid has eliminated ODS usage from its manufacturing processes and continually strives to improve its cleaning and coating methods. In addition, Polaroid has successfully used terpene materials to clean optic parts and has developed a no-clean nitrogen atmosphere wave soldering process for electronic assemblies.

## Supplier Principles of Conduct

Polaroid conducts its materials and services purchasing business based on seven global sourcing principles: Geographical Consideration, Risk Management, Materials Management, Supplier Relationships, Quality, Product Development, and Principles of Conduct. The first six are standard principles in industry. However, the seventh (Principles of Conduct) is somewhat unique to Polaroid and represents the key principle which guides Polaroid's procurement activities.

Polaroid's Principles of Conduct requires that excellent health, safety, environmental, social, ethical, and legal standards must be met or exceeded in all sourcing activities by both the company and all suppliers. As a result, Polaroid strives to have business relationships with those suppliers who comply with the Principles of Conduct. On a priority basis, suppliers are asked to complete a formal HSE survey. Polaroid then determines the supplier's performance in accordance with the Principles of Conduct based on the survey response, site visits, and outside data gathering. Since beginning this survey effort in mid-1996, Polaroid has certified a large percentage of its new vendors and continues to work with existing suppliers as well.

Through its Principles of Conduct, Polaroid has created a unique partnership between Corporate Purchasing; Corporate Health, Safety, and Environment; and its suppliers. Long-term benefits anticipated by Polaroid include minimizing company liability and enhancing environmental protection.

## Facilities

### Catastrophic Business Interruption Planning

Catastrophic Business Interruption Planning is aimed at assessing the vulnerability of Polaroid's facilities worldwide and developing disaster recovery plans to reduce business interruptions. These interruptions include catastrophic disasters and special fire hazard losses for items critical to producing and meeting end-user needs.

In August 1995, a battery plant fire triggered concerns at Polaroid that the potential for catastrophic disasters was very real and little formal planning existed for disaster recovery and pre-disaster planning. Polaroid's vulnerability rested in the uniqueness of its products and processes; the age of its buildings; and the dependency on the many special chemicals of its processes. The goal was to reduce the risk of catastrophic business interruptions by installing improved detection systems, improving structural materials, and developing disaster recovery plans among other improvements. Polaroid's approach consists of data collection, risk analysis, and disaster recovery for each of its major manufacturing divisions.

Data was gathered through questionnaires, plant visits, and interviews. Polaroid used the data to improve risk reduction measures; and assess facili-

ties and equipment vulnerabilities, business interruption effects, and hazard characterizations. Next, Polaroid reduced the data to classify the risk analysis or vulnerability to its various resources. Facilities, equipment, materials, and processes were analyzed to determine whether they could be replaced, what the cost would be, and how quickly it could be done. From this analysis, Polaroid developed a risk recovery scenario and established a degree of consequences. Polaroid has now assembled Divisional Disaster Recovery Coordinators set up a workshop which will offer guidance on how to perform disaster recovery and strategic planning. Plans are currently under development. Future efforts will identify items critical to production, document plans, and implement pre-disaster planning elements.

### Chlorofluorocarbons in Chillers

Chlorofluorocarbons (CFCs) were developed in 1930, specifically for air conditioning usage. Since 1974, scientists have theorized that CFCs were depleting the Earth's protective ozone layer and allowing ultraviolet light to penetrate through the atmosphere. As a result of CFCs and other ozone depleting material being released into the environment, government regulations were established in the 1990s to phase out all production use of ozone depleting materials. For years, CFCs have been used extensively as the prime cooling agent in mechanical cooling systems. Polaroid has 42 chiller systems, ranging in size from 150 to 2500 hp, of which 34 contain CFCs. In response to the stringent health and environmental issues associated with ozone depleting materials, Polaroid has taken corrective measures via replacement, conversion, and installation practices to eliminate CFCs from its chiller systems.

Polaroid's corrective measures include developing a strategy for containment and monitoring of all CFC chillers; replacing older chillers which leak; reclaiming refrigerants; converting medium pressure units to HFC-134A; purchasing refrigerant for future use; and certifying HVAC technicians. To date, Polaroid has replaced six units over the past five years, converted one medium pressure chiller to HFC-134A, and installed 27 new, high-efficiency purge units. Future plans include replacing an additional 12 purge units, converting one large 2500-ton chiller to HFC-134A, and replacing seven additional chiller systems.

Polaroid's efforts have been consistent with its environmental plan to comply with government regulations and reduce environmental impact. The installation of new mechanical cooling systems with variable flow controls has also reduced energy consumption by 20%. Modernization of a single cooling system, initiated in 1991, has resulted in a savings of four million kilowatt hours over a three-year period or \$300,000.

### New Bedford Power Plant Optimization Program

Polaroid Corporation's Negative Manufacturing and High Resolution Media Manufacturing Divisions in New Bedford, Massachusetts have commissioned an \$8 million Power Plant Optimization Program (PPOP) for its power plant and utility services building. PPOP will include upgrading two existing oil/gas fired boilers, upgrading four existing chillers, installing a new glycol chiller, installing a new process water chiller, installing a digital distributed control system, constructing two new cooling tower cells, rehabilitating the fuel storage facility, and upgrading or replacing peripheral equipment to support existing and future production demands.

In 1972, Polaroid established its Negative Manufacturing Division to produce color as well as black and white instant photographic negative media. The original site size was 500,000 square feet. In 1993, the New Bedford site increased in size when Polaroid built its High Resolution Media Manufacturing Division (250,000 square feet) to produce digital imaging media for medical and graphic arts markets. The combined sites cover 750,000 square feet and employ 550 people.

The existing power plant was originally designed to support the Negative Manufacturing Division. After the High Resolution Media Manufacturing Division was constructed, Polaroid anticipated that the power plant still had the capability to support the expanded production facility at full capacity. However, normal wear and tear; inefficient and unreliable controls; and various environmental-related issues combined to create a situation that prompted Polaroid to consider increasing the capability of the power plant. Reliable utilities for this facility are of critical importance and estimated manufacturing losses exceed \$1,000 per minute for an unexpected interruption of the production line.

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In 1995, Polaroid commissioned an engineering consultant to conduct a central utilities building study. The study consisted of four general considerations: power plant condition, power plant capability, environmental regulations, and feasibility of adding a co-generation facility. The consultant recommended replacement of the boiler tubes and controls; a low NO<sub>x</sub> upgrade for the boiler burner tips; replacement of the chiller refrigerants with compatible non-CFC refrigerants; repair of the existing cooling tower and the addition of two new cooling tower cells; replacement of the existing fuel oil storage tanks and rehabilitation of the storage facility; and upgrading or replacing peripheral equipment as necessary. For various reasons, the consultant determined that a co-generation facility is not feasible at this time.

All of the recommendations will be implemented. PPOP is on a three-year time line—engineering of the program began in June 1995, construction started in January 1996, and completion is expected to be on time and within budget in early 1998.

### Polychlorinated Biphenyl Elimination

In the late 1980s, Polaroid decided to remove polychlorinated biphenyls (PCBs) from the approximately 75 transformers located at six sites throughout the United States, or to replace them where possible. While the transformer replacement project was being completed, Polaroid then began replacing facility lights under its Green Light program. This action led to Polaroid's 1995 decision to locate and replace all PCB-containing capacitors, most of which were found in sensitometer testing units.

The PCB elimination and removal program was driven partly by cost and regulatory concerns. Transformer replacement was prioritized by age and sensitivity of location. The PCB elimination and removal plan emphasized minimal plant production disruption. In addition, the plan stressed minimal impact from possible spills at the plant, during transportation, or at the disposal site. The PCB elimination and removal program reinforces Polaroid's image as a leader in environmental stewardship.

### Side Skirts and Rails

In the late 1980s, Polaroid's Transportation Department entered into a lease agreement for heavy duty, over-the-road cargo vans for its transportation fleet. During the specification process, Polaroid

decided to include state-of-the-art side skirts and rails to each trailer as a safety feature to keep mirrors and trucks cleaner.

The side skirts and rails improved the driver's visibility and reduced wheel spray onto other motorists. In addition, the features increased the air flow over the wheels which reduced tire wear and heat build-up to the braking systems; decreased maintenance costs; and improved vehicle safety. Although this added margin of safety had not been factored into the original design, it has greatly contributed to the safety of the vehicles. Polaroid's heavy duty trailer construction has doubled the original estimated lifespan of each trailer, again reducing cost.

## Management

### Chemical Hygiene Program

In 1991, OSHA established chemical hygiene standards for laboratory safety. In response, Polaroid established its own stringent standards through its Chemical Hygiene program by augmenting OSHA's requirements.

Polaroid provides its laboratories with a generic chemical hygiene plan as a template and assigns a chemical hygiene officer to each geographic location. Employees who are newly hired or starting a new job assignment attend a two-hour, one-on-one orientation with the chemical hygiene officer and review the laboratory's chemical hygiene plan. In addition, employees must pass an examination before they are eligible to work in the laboratory.

All sites have a Safety Committee which guides the development and implementation of the site-specific Chemical Hygiene program. Each site's program includes standard operating procedures for specific operations; a checklist for the review of pilot projects before start-up; scheduled safety tours on a monthly basis; and routine Safety Committee meetings. Polaroid's Chemical Hygiene program provides active involvement by its laboratories and ownership for all activities of environmental, health and safety issues.

### Environmental Training Procedures

Prior to the early 1990s, standard training procedures for environmental professionals were not very formally established at Polaroid. Training plans in use at that time could have been consid-

ered somewhat haphazard. Documents in some cases were extensive while others lacked appropriate substance. In 1992, Polaroid began addressing the rapidly changing environmental regulatory arena by developing standardized environmental training procedures.

Polaroid's environmental training procedures encompassed all environmental regulatory areas and provided continuity for connecting training requirements, manufacturing procedures, and company policies. By developing a synergism between requirements, procedures, and policies, Polaroid enabled its managers and employees to grasp the reasons behind environmental training procedures; the method for maintaining current company information; and the insights to company goals and policies.

Polaroid also developed multi-purpose, standardized, evolutionary manuals for use as procedural or training manuals. To maintain current information and incorporate the latest requirement changes in the manuals, the environmental staff sends revisions to all trainers on a regular basis. Polaroid's training manuals have established the baseline for minimum environmental company policy and provide a readily-accessible reference and training tool.

## Health and Safety Management Systems Audit Procedure

Polaroid has developed a draft Health and Safety Management Systems Audit procedure based on the draft ISO-14000 standard. Most requirements already existed within the Corporate Health and Safety procedure, but did not meet the format requirements of ISO-14000. Polaroid's draft procedure originated with the October 1994 planning meeting for the 1995 Health and Safety Audit schedule. A committee to develop the procedure was formed in January 1995. Polaroid uses the Accident Triangle (Figure 3-3) as the foundation for developing procedures to audit an organization's preventive measures.

The Health and Safety Management Systems Audit procedure is organized in five sections: Roles, Responsibility, and Training; Safety, Goals, and Performance; Compliance with Regulations and Policy; Incident Review; and Hazard Assessment and Property Loss Prevention. Polaroid conducted and documented a pilot audit of its Battery Division which addressed operations; trades and engineering; and quality, laboratories, and material control.

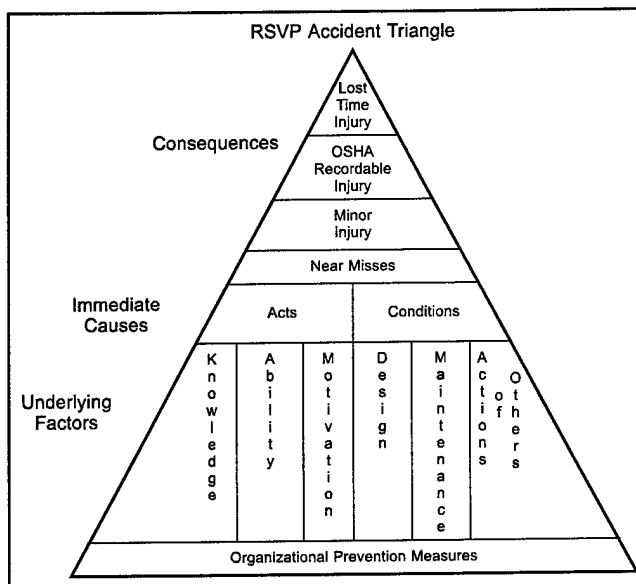


**Figure 3-3. The Foundation - The Accident Triangle**

Lessons learned from the pilot audit have been documented. Polaroid has placed this draft document on hold pending Corporate discussions on how best to align with the ISO-14000 standard.

## Informational and Alert Memos

Public media often raises issues to Polaroid on chemical issues or corporate-wide practices. This information is typically broadcast throughout the community via television, radio, and/or newspaper announcements. Unfortunately, these information stories were frequently inaccurate and caused undue anxiety in the surrounding Polaroid communities.

To allay any arising fears, the Corporate toxicology and health group researches the best available data on that particular topic and may contact experts in the field. Many times these media announcements are made in the early stages of research when knowledge is limited and not well documented. By focusing on risks to humans or other living organisms rather than on perceived risks, the toxicology and health group prepares Informational and Alert Memos as fact sheets for distribution throughout Polaroid. This factual account by a trusted organization helps reduce concern among employees, while further ensuring trust between corporate management and corporate workers.

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## Material Safety Data Sheets Management

Prior to OSHA requirements, Polaroid developed Material Safety Data Sheets (MSDSs) for all chemicals made by the company. The MSDS were distributed in hardcopy to all known users. Since its initiation, Polaroid has made various improvements to enhance the quality of the information and make it more accessible to its employees. Currently, Polaroid prepares MSDSs for all chemicals used in production, even if the chemicals were purchased from another manufacturer. This practice enables Polaroid to maintain a consistent format for all chemical information; provide standard terminology over a variety of chemical categories; write MSDSs for mixtures used by employees; and facilitate employee handling and spill response training.

In 1990, Polaroid began a project to transfer its hardcopy MSDS system into an electronic version. The new system provides access to the most recent version of an MSDS via computer and allows for database searches by various terms (e.g., chemical category, Chemical Abstracts Service number, chemical name). The system also contains the label text for hazard warnings and precautionary measures on Polaroid containers. Although Polaroid's MSDS system eliminated obstacles found in the hardcopy version such as difficult distribution and upkeep, employee accessibility of the system was limited.

In 1994, Polaroid established a Business Improvement Team (BIT) to improve the availability of the most up-to-date Corporate MSDSs. At the time, the MSDS system only had 50 on-line users. From its research, BIT discovered that employees had to obtain five separate account approvals which delayed access to the system by three to five weeks; passwords expired within 30 days unless used; employees had to maneuver through several screens before reaching the MSDS section; and the system lacked a correlation to Polaroid's chemical code number system which was how most employees identified chemicals. To revise the MSDS system, BIT focused on making the on-line system more accessible and easier to use.

As a result of BIT's recommendations, the revised MSDS system features many improvements: employees can establish accounts within one day; the easy-access, menu-driven system allows employees to reach the MSDS section faster; and the system now has a correlation with Polaroid's chemical code number system. The most significant improvement

of the system is its increased accessibility by employees. The MSDS system currently supports 1,466 on-line users.

## Noise Exposure Management

Occupational noise exposure is managed directly by Polaroid's Corporate Health, Safety and Environmental office. Readily-available exposure records date back to 1974, and audiograms are performed at Polaroid's medical facility. In addition, Polaroid implemented a lower level standard (85 dBA) for better protection compared to OSHA requirements (90 dBA). In 1995, Polaroid adopted the 1994-1995 American Conference of Governmental Industrial Hygienists' change to the 3 dBA exchange rate.

Adoption of the new 3 dBA standard and resurvey of Polaroid facilities have allowed a greater number of employees and shop areas to fall under the Hearing Conservation program. Additionally, the 3 dBA exchange rate will oblige Polaroid to develop new engineer controls in these shop areas and provide more training and lesson plans to its safety personnel. Audiometric testing and hearing conservation training is being provided for several hundred additional workers. A higher level of engineering controls is being sought, and the Corporate industrial hygiene group has developed a standard lesson plan and training materials for conducting hearing conservation training. The Corporate industrial hygiene group also periodically conducts training on noise exposure assessment and hearing conservation for its division safety and health representatives.

## Over-the-Road Emergency Response Plan

As an environmentally-responsible company, Polaroid has developed a comprehensive Over-the-Road Emergency Response Plan which addresses the responsibilities of the truck driver in the event of a hazardous material spill. Through extensive training, drivers gain knowledge and expertise for communicating any problems encountered; notifying the appropriate company personnel; and protecting themselves, the public, and the environment in an emergency situation.

All drivers are provided with radio and cellular telephone equipment for communicating with appropriate emergency personnel. Additionally, drivers are trained in procedures for spill containment;

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proper handling and controlling of their vehicle to ensure maximum public safety; and methods to protect themselves from hazardous material spills. Polaroid emphasizes safety first to its drivers for all emergency situations.

A standard checklist guides drivers through questions to capture the appropriate incident data. Corporate Emergency Response Teams use the data to determine proper response procedures. Polaroid provides a complete and in-depth emergency spill response training to its drivers, dispatchers, and emergency response personnel which enables them to react in a timely manner and to ensure the safety of personnel, the environment, and the public. Hazardous material documentation is readily available and can be provided to the proper authorities on request.

In 1994, a highway incident involving a non-hazardous material leak from a Polaroid truck served as an excellent test of the company's Over-the-Road Emergency Response Plan. Although the handling cost of the incident was \$20,000, Polaroid gained valuable experience and insight which it incorporated into its current procedure.

### Respirator Program Management

To protect its employees from hazardous substances, Polaroid established comprehensive programs to manage the application and use of respiratory protective equipment. Although engineering controls, such as ventilation, are the preferred methods of control, respirators are used as an extra precaution or for those situations where controls are infeasible or not yet in place. Polaroid uses a

wide variety of respiratory protective equipment including air purifying, supplied air, and self-contained breathing apparatus. Each division has a written respirator program modeled after a corporate generic document, and trains hundreds of employees through the respirator program.

In 1992, Polaroid formed a Respirator Council, composed of Division Respirator Program Administrators, which meets quarterly. Corporate-sponsored training is provided on-site to the Respirator Program Administrators. Over the past few years, Polaroid has stepped up efforts in its Respirator Program Management. For example, the company's facial hair policy for workers whose jobs may require them to wear respirators has been more firmly defined and enforced. Polaroid has purchased additional quantitative fit test equipment to meet its bi-annual fit test requirements, and has conducted studies of existing standards and regulatory requirements to ensure that the company maintains well-defined quantitative fit test procedures. The company also has provided recommendations to OSHA on draft respirator standards for fit testing use. Additionally, Polaroid shares its expertise in respirator protective equipment with the local community. Corporate staff members teach respiratory protection classes to graduate-level, industrial hygiene students at the nearby Harvard School of Public Health.

Although specific benefits of Respirator Program Management are difficult to quantify, Polaroid focuses on continuous improvement of its respirator programs. This approach enables Polaroid to provide a higher degree of safety for employees using respiratory protective equipment.

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# Appendix A

## *Table of Acronyms*

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| Acronym | Definition                                                                 |
|---------|----------------------------------------------------------------------------|
| ACGIH   | American Conference of Governmental and Industrial Hygienists              |
| ADD     | Actual Delivered Density                                                   |
| AMC     | Asbestos Management Council                                                |
| ASHRAE  | American Society of Heating, Refrigeration, and Air Conditioning Engineers |
| BIT     | Business Improvement Team                                                  |
| CERES   | Coalition for Environmentally Responsible Economies                        |
| CFC     | Chlorofluorocarbon                                                         |
| CTD     | Cumulative Trauma Disorder                                                 |
| DfE     | Design for the Environment                                                 |
| DoT     | Department of Transportation                                               |
| EARS    | Environmental Accounting and Reporting System                              |
| ESFR    | Early Suppression Fast Response                                            |
| HAZCOM  | Hazard Communication                                                       |
| HAZMAT  | Hazard Materials                                                           |
| HRS     | High Risk Situation                                                        |
| HSE     | Health, Safety, and Environment(al)                                        |
| HVAC    | Heating, Ventilating, and Air Conditioning                                 |
| IAQ     | Indoor Air Quality                                                         |
| ISO     | International Standards Organization                                       |
| LEPC    | Local Emergency Planning Committee                                         |
| MATURA  | Massachusetts Toxic Use Reduction Act                                      |
| MSDS    | Material Safety Data Sheet                                                 |
| MWRA    | Massachusetts Water Resource Authority                                     |
| NIOSH   | National Institute for Occupational Safety and Health                      |
| ODS     | Ozone Depleting Substance                                                  |
| OSHA    | Occupational Safety and Health Administration                              |

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| Acronym | Definition                                   |
|---------|----------------------------------------------|
| PCB     | Polychlorinated Biphenyl                     |
| PDC     | Professional Development Committee           |
| PDP     | Product Delivery Process                     |
| PEG     | Polaroid Exposure Guideline                  |
| PEL     | Permissible Exposure Limit                   |
| PHA     | Process Hazard Analysis                      |
| PPOP    | Power Plant Optimization Program             |
|         |                                              |
| RACT    | Reasonably Available Control Technology      |
| RCRA    | Resource Conservation and Recovery Act       |
| RDD     | Required Delivered Density                   |
| REECO   | Regenerative Environmental Equipment Company |
| RET     | Recommended Exposure Limit                   |
| RSI     | Repetitive Strain Injury                     |
| RSVP    | Reinforcing Safety Values at Polaroid        |
|         |                                              |
| TSDF    | Treatment, Storage, and Disposal Facility    |
| TUWR    | Toxic Use and Waste Reduction                |
|         |                                              |
| VAV     | Variable Air Volume                          |
| VOC     | Volatile Organic Compound                    |

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## Appendix B

### ***BMP Survey Team***

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| Team Member                            | Activity                                                                  | Function                |
|----------------------------------------|---------------------------------------------------------------------------|-------------------------|
| <b>Kip Hoffer</b><br>(812) 854-6446    | <b>Crane Division</b><br><b>Naval Surface Warfare Center</b><br>Crane, IN | <b>Team Chairman</b>    |
| <b>Cheri Spencer</b><br>(301) 403-8100 | <b>BMP Center of Excellence</b><br>College Park, MD                       | <b>Technical Writer</b> |
| <b>Caryl Lummis</b><br>(301) 403-8100  | <b>BMP Center of Excellence</b><br>College Park, MD                       | <b>Technical Writer</b> |

#### **Safety Team**

|                                             |                                                     |                    |
|---------------------------------------------|-----------------------------------------------------|--------------------|
| <b>Larry Robertson</b><br>(812) 854-5336    | <b>Naval Surface Warfare Center</b><br>Crane, IN    | <b>Team Leader</b> |
| <b>Maria Arner</b><br>(703) 271-9055        | <b>Production Technology, Inc</b><br>Arlington, VA  |                    |
| <b>Yvonne Lach</b><br>(301) 403-8100        | <b>BMP Center of Excellence</b><br>College Park, MD |                    |
| <b>Anne Marie SuPrise</b><br>(301) 403-8100 | <b>BMP Center of Excellence</b><br>College Park, MD |                    |

#### **Energy Team**

|                                       |                                                      |                    |
|---------------------------------------|------------------------------------------------------|--------------------|
| <b>Larry Halbig</b><br>(317) 306-3838 | <b>Hughes Air Warfare Center</b><br>Indianapolis, IN | <b>Team Leader</b> |
| <b>Tim Hanley</b><br>(206) 342-5322   | <b>The Boeing Company</b><br>Seattle, WA             |                    |

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### **Environment Team**

**Darrel Brothersen**  
(319) 295-3768

**Rockwell International**  
Cedar Rapids, IA

**Team Leader**

**Mike Downs**  
(904) 772-2200

**Naval Aviation Depot**  
Jacksonville, FL

**Mark Hancock**  
(301) 743-4956

**Naval Surface Warfare Center**  
Indian Head, MD

**Kip Hoffer**  
(812) 854-6446

**Naval Surface Warfare Center**  
Crane, IN

### **Health Team**

**Rick Purcell**  
(301) 403-8100

**BMP Center of Excellence**  
College Park, MD

**Team Leader**

**Pamela Beilke**  
(520) 794-8705

**Hughes Aircraft Company**  
Tucson, AZ

**Beth Cook**  
(205) 544-2545

**NASA Marshall Space Flight Center**  
Huntsville, AL

**Teri Rhodes**  
(904) 772-2200

**Naval Aviation Depot**  
Jacksonville, FL

## Appendix C

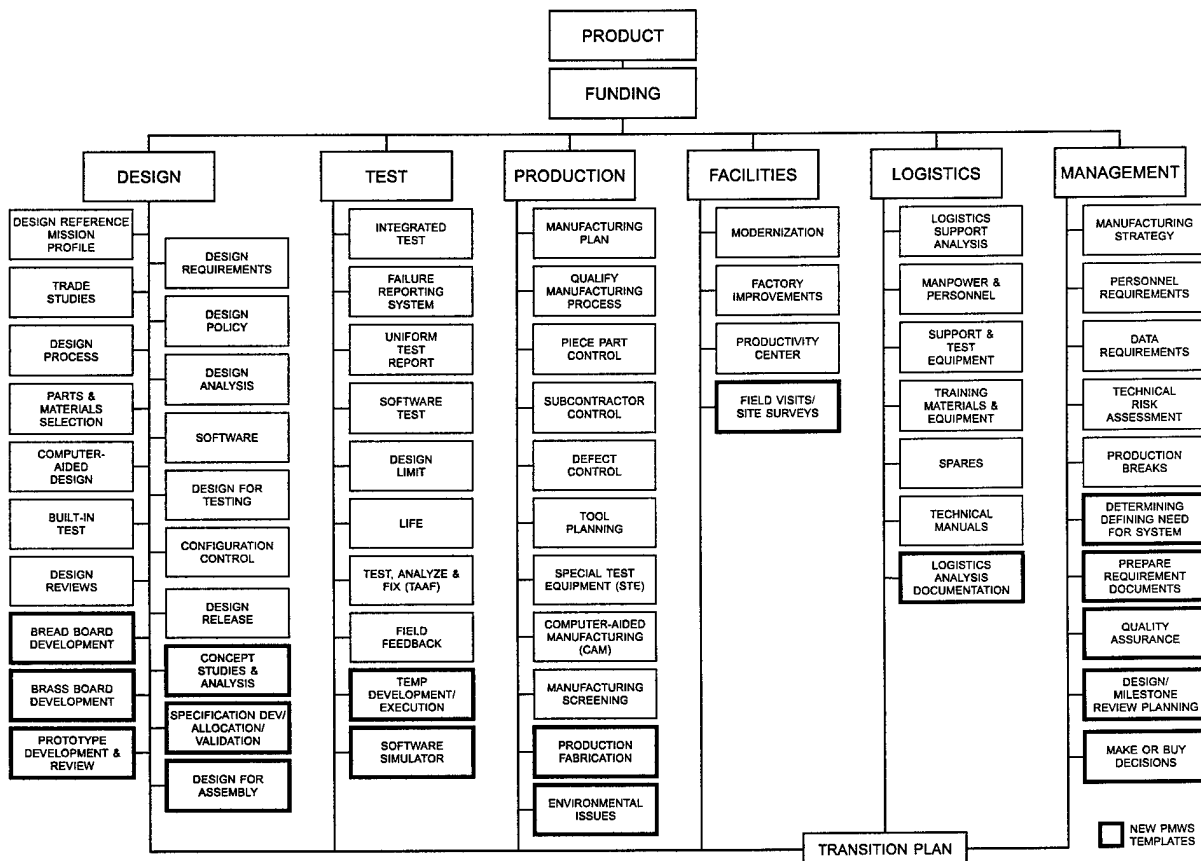
### *Critical Path Templates and BMP Templates*

This survey was structured around and concentrated on the functional areas of design, test, production, facilities, logistics, and management as presented in the Department of Defense 4245.7-M, *Transition from Development to Production* document. This publication defines the proper tools—or templates—that constitute the critical path for a successful material acquisition program. It describes techniques for improving the acquisition

process by addressing it as an *industrial* process that focuses on the product's design, test, and production phases which are interrelated and interdependent disciplines.

The BMP program has continued to build on this knowledge base by developing 17 new templates that complement the existing DOD 4245.7-M templates. These BMP templates address new or emerging technologies and processes.

### “CRITICAL PATH TEMPLATES FOR TRANSITION FROM DEVELOPMENT TO PRODUCTION”



## Appendix D

### *BMPnet and the Program Manager's WorkStation*

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The BMPnet, located at the Best Manufacturing Practices Center of Excellence (BMPCOE) in College Park, Maryland, supports several communication features. These features include the Program Manager's WorkStation (**PMWS**), electronic mail and file transfer capabilities, as well as access to Special Interest Groups (SIGs) for specific topic information and communication. The BMPnet can be accessed through the World Wide Web (at <http://www.bmpcoe.org>), through free software that connects directly over the Internet or through a modem. The PMWS software is also available on CD-ROM.

PMWS provides users with timely acquisition and engineering information through a series of interrelated software environments and knowledge-based packages. The main components of PMWS are KnowHow, SpecRite, the Technical Risk Identification and Mitigation System (TRIMS), and the BMP Database.

**KnowHow** is an intelligent, automated program that provides rapid access to information through an intelligent search capability. Information currently available in KnowHow handbooks includes Acquisition Streamlining, Non-Development Items, Value Engineering, NAVSO P-6071 (Best Practices Manual), MIL-STD-2167/2168 and the DoD 5000 series documents. KnowHow cuts document search time by 95%, providing critical, user-specific information in under three minutes.

**SpecRite** is a performance specification generator based on expert knowledge from all uniformed services. This program guides acquisition person-

nel in creating specifications for their requirements, and is structured for the build/approval process. SpecRite's knowledge-based guidance and assistance structure is modular, flexible, and provides output in MIL-STD 961D format in the form of editable WordPerfect® files.

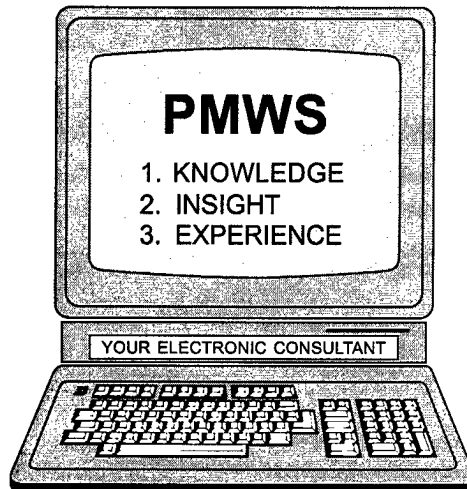
**TRIMS**, based on DoD 4245.7-M (the transition templates), NAVSO P-6071, and DoD 5000 event-oriented acquisition, helps the user identify and rank a program's high-risk areas. By helping the user conduct a full range of risk assessments through-

out the acquisition process, TRIMS highlights areas where corrective action can be initiated before risks develop into problems. It also helps users track key project documentation from concept through production including goals, responsible personnel, and next action dates for future activities.

The **BMP Database** contains proven best practices from industry, government, and the academic communities. These best practices are in the areas of design, test, production, facilities, management, and logistics. Each practice has been

observed, verified, and documented by a team of government experts during BMP surveys.

Access to the BMPnet through dial-in or on Internet requires a special modem program. This program can be obtained by calling the BMPnet Help Desk at (301) 403-8179 or it can be downloaded from the World Wide Web at <http://www.bmpcoe.org>. To receive a user/e-mail account on the BMPnet, send a request to [helpdesk@bmpcoe.org](mailto:helpdesk@bmpcoe.org).



# Appendix E

## ***Best Manufacturing Practices Satellite Centers***

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There are currently six Best Manufacturing Practices (BMP) satellite centers that provide representation for and awareness of the BMP program to regional industry, government and academic institutions. The centers also promote the use of BMP with regional Manufacturing Technology Centers. Regional manufacturers can take advantage of the BMP satellite centers to help resolve problems, as the centers host informative, one-day regional workshops that focus on specific technical issues.

Center representatives also conduct BMP lectures at regional colleges and universities; maintain lists of experts who are potential survey team members; provide team member training; identify regional experts for inclusion in the BMPnet SIG e-mail; and train regional personnel in the use of BMP resources such as the BMPnet.

The six BMP satellite centers include:

### **California**

#### **Chris Matzke**

BMP Satellite Center Manager  
Naval Warfare Assessment Division  
Code QA-21, P.O. Box 5000  
Corona, CA 91718-5000  
(909) 273-4992  
FAX: (909) 273-4123  
cmatzke@bmpcoe.org

#### **Jack Tamargo**

BMP Satellite Center Manager  
257 Cottonwood Drive  
Vallejo, CA 94591  
(707) 642-4267  
FAX: (707) 642-4267  
jtamargo@bmpcoe.org

### **District of Columbia**

#### **Margaret Cahill**

BMP Satellite Center Manager  
U.S. Department of Commerce  
14th Street & Constitution Avenue, NW  
Room 3876 BXA  
Washington, DC 20230  
(202) 482-8226/3795  
FAX: (202) 482-5650  
mcahill@bxa.doc.gov

### **Illinois**

#### **Thomas Clark**

BMP Satellite Center Manager  
Rock Valley College  
3301 North Mulford Road  
Rockford, IL 61114  
(815) 654-5515  
FAX: (815) 654-4459  
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### **Pennsylvania**

#### **Sherrie Snyder**

BMP Satellite Center Manager  
MANTEC, Inc.  
P.O. Box 5046  
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(717) 843-5054, ext. 225  
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### **Tennessee**

#### **Tammy Graham**

BMP Satellite Center Manager  
Lockheed Martin Energy Systems  
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M/S 8091  
Oak Ridge, TN 37831-8091  
(423) 576-5532  
FAX: (423) 574-2000  
tgraham@bmpcoe.org

## Appendix F

### ***Navy Manufacturing Technology Centers of Excellence***

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The Navy Manufacturing Sciences and Technology Program established the following Centers of Excellence (COEs) to provide focal points for the development and technology transfer of new manufacturing processes and equipment in a cooperative environment with industry, academia, and Navy centers and laboratories. These COEs are consortium-structured for industry, academia, and government involvement in developing and implementing technologies. Each COE has a designated point of contact listed below with the individual COE information.

#### **Best Manufacturing Practices Center of Excellence**

The Best Manufacturing Practices Center of Excellence (BMPCOE) provides a national resource to identify and promote exemplary manufacturing and business practices and to disseminate this information to the U.S. Industrial Base. The BMPCOE was established by the Navy's BMP program, Department of Commerce's National Institute of Standards and Technology, and the University of Maryland at College Park, Maryland. The BMPCOE improves the use of existing technology, promotes the introduction of improved technologies, and provides non-competitive means to address common problems, and has become a significant factor in countering foreign competition.

Point of Contact:  
Mr. Ernie Renner  
Best Manufacturing Practices Center of Excellence  
4321 Hartwick Road  
Suite 400  
College Park, MD 20740  
(301) 403-8100  
FAX: (301) 403-8180  
ernie@bmpcoe.org

#### **Center of Excellence for Composites Manufacturing Technology**

The Center of Excellence for Composites Manufacturing Technology (CECMT) provides a national resource for the development and dissemination of composites manufacturing technology to defense contractors and subcontractors. The CECMT is managed by the GreatLakes Composites Consortium and represents a collaborative effort among industry, academia, and government to develop, evaluate, demonstrate, and test composites manufacturing technologies. The technical work is problem-driven to reflect current and future Navy needs in the composites industrial community.

Point of Contact:  
Dr. Roger Fountain  
Center of Excellence for Composites Manufacturing Technology  
103 Trade Zone Drive  
Suite 26C  
West Columbia, SC 29170  
(803) 822-3705  
FAX: (803) 822-3730  
frglcc@aol.com

#### **Electronics Manufacturing Productivity Facility**

The Electronics Manufacturing Productivity Facility (EMPF) identifies, develops, and transfers innovative electronics manufacturing processes to domestic firms in support of the manufacture of affordable military systems. The EMPF operates as a consortium comprised of industry, university, and government participants, led by the American Competitiveness Institute under a CRADA with the Navy.

Point of Contact:  
Mr. Alan Criswell  
Electronics Manufacturing Productivity Facility  
Plymouth Executive Campus  
Bldg 630, Suite 100  
630 West Germantown Pike  
Plymouth Meeting, PA 19462  
(610) 832-8800  
FAX: (610) 832-8810  
<http://www.engriupui.edu/empf/>

#### **National Center for Excellence in Metalworking Technology**

The National Center for Excellence in Metalworking Technology (NCEMT) provides a national center for the development, dissemination, and implementation of advanced technologies for metalworking products and processes. The NCEMT, operated by Concurrent Technologies Corporation, helps the Navy and defense contractors improve

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manufacturing productivity and part reliability through development, deployment, training, and education for advanced metalworking technologies.

**Point of Contact:**

Mr. Richard Henry  
National Center for Excellence in Metalworking  
Technology  
1450 Scalp Avenue  
Johnstown, PA 15904-3374  
(814) 269-2532  
FAX: (814) 269-2799  
henry@ctc.com

**Navy Joining Center**

The Navy Joining Center (NJC) is operated by the Edison Welding Institute and provides a national resource for the development of materials joining expertise and the deployment of emerging manufacturing technologies to Navy contractors, subcontractors, and other activities. The NJC works with the Navy to determine and evaluate joining technology requirements and conduct technology development and deployment projects to address these issues.

**Point of Contact:**

Mr. David P. Edmonds  
Navy Joining Center  
1100 Kinnear Road  
Columbus, OH 43212-1161  
(614) 487-5825  
FAX: (614) 486-9528  
dave\_edmonds@ewi.org

**Energetics Manufacturing Technology Center**

The Energetics Manufacturing Technology Center (EMTC) addresses unique manufacturing processes and problems of the energetics industrial base to ensure the availability of affordable, quality energetics. The focus of the EMTC is on process technology with a goal of reducing manufacturing costs while improving product quality and reliability. The COE also maintains a goal of development and implementation of environmentally benign energetics manufacturing processes.

**Point of Contact:**

Mr. John Brough  
Energetics Manufacturing Technology Center  
Indian Head Division  
Naval Surface Warfare Center  
Indian Head, MD 20640-5035  
(301) 743-4417  
DSN: 354-4417  
FAX: (301) 743-4187  
mt@command.nosih.sea06.navy.mil

**Manufacturing Science and Advanced Materials Processing Institute**

The Manufacturing Science and Advanced Materials Processing Institute (MS&AMPI) is comprised of three centers including the National Center for Advanced Drivetrain Technologies (NCADT), The Surface Engineering Manufacturing Technology Center (SEMTC), and the Laser Applications Research Center (LaserARC). These centers are located at The Pennsylvania State University's Applied Research Laboratory. Each center is highlighted below.

**Point of Contact for MS&AMPI:**

Mr. Henry Watson  
Manufacturing Science and Advanced Materials  
Processing Institute  
ARL Penn State  
P.O. Box 30  
State College, PA 16804-0030  
(814) 865-6345  
FAX: (814) 863-1183  
hew2@psu.edu

• **National Center for Advanced Drivetrain Technologies**

The NCADT supports DoD by strengthening, revitalizing, and enhancing the technological capabilities of the U.S. gear and transmission industry. It provides a site for neutral testing to verify accuracy and performance of gear and transmission components.

**Point of Contact for NCADT:**

Dr. Suren Rao  
NCADT/Drivetrain Center  
ARL Penn State  
P.O. Box 30  
State College, PA 16804-0030  
(814) 865-3537  
FAX: (814) 863-6185  
[http://www.arl.psu.edu/drivetrain\\_center.html/](http://www.arl.psu.edu/drivetrain_center.html/)

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- **Surface Engineering Manufacturing Technology Center**

The SEMTC enables technology development in surface engineering—the systematic and rational modification of material surfaces to provide desirable material characteristics and performance. This can be implemented for complex optical, electrical, chemical, and mechanical functions or products that affect the cost, operation, maintainability, and reliability of weapon systems.

Point of Contact for SEMTC:  
Dr. Maurice F. Amateau  
SEMTC/Surface Engineering Center  
P.O. Box 30  
State College, PA 16804-0030  
(814) 863-4214  
FAX: (814) 863-0006  
[http://www/arl.psu.edu/divisions/arl\\_org.html](http://www/arl.psu.edu/divisions/arl_org.html)

- **Laser Applications Research Center**

The LaserARC is established to expand the technical capabilities of DOD by providing access to high-power industrial lasers for advanced material processing applications. LaserARC offers basic and applied research in laser-material interaction, process development, sensor technologies, and corresponding demonstrations of developed applications.

Point of Contact for LaserARC:  
Mr. Paul Denney  
Laser Center  
ARL Penn State  
P.O. Box 30  
State College, PA 16804-0030  
(814) 865-2934  
FAX: (814) 863-1183  
[http://www/arl.psu.edu/divisions/arl\\_org.html](http://www/arl.psu.edu/divisions/arl_org.html)

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- **Gulf Coast Region Maritime Technology Center**

The Gulf Coast Region Maritime Technology Center (GCRMTC) is located at the University of New Orleans and will focus primarily on product developments in support of the U.S. shipbuilding industry. A sister site at Lamar University in Orange, Texas will focus on process improvements.

Point of Contact:  
Dr. John Crisp  
Gulf Coast Region Maritime Technology Center  
University of New Orleans  
Room N-212  
New Orleans, LA 70148  
(504) 286-3871  
FAX: (504) 286-3898

# Appendix G

## Completed Surveys

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As of this publication, 90 surveys have been conducted by BMP at the companies listed below. Copies of older survey reports may be obtained through DTIC or by accessing the BMPnet. Requests for copies of recent survey reports or inquiries regarding the BMPnet may be directed to:

Best Manufacturing Practices Program  
4321 Hartwick Rd., Suite 400  
College Park, MD 20740  
Attn: Mr. Ernie Renner, Director  
Telephone: 1-800-789-4267  
FAX: (301) 403-8180  
ernie@bmpcoe.org

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| <b>1985</b> | Litton Guidance & Control Systems Division - Woodland Hills, CA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>1986</b> | Honeywell, Incorporated Undersea Systems Division - Hopkins, MN (Alliant TechSystems, Inc.)<br>Texas Instruments Defense Systems & Electronics Group - Lewisville, TX<br>General Dynamics Pomona Division - Pomona, CA<br>Harris Corporation Government Support Systems Division - Syosset, NY<br>IBM Corporation Federal Systems Division - Owego, NY<br>Control Data Corporation Government Systems Division - Minneapolis, MN                                                                                                                                                                                                                                                                                                                                                                      |
| <b>1987</b> | Hughes Aircraft Company Radar Systems Group - Los Angeles, CA<br>ITT Avionics Division - Clifton, NJ<br>Rockwell International Corporation Collins Defense Communications - Cedar Rapids, IA<br>UNISYS Computer Systems Division - St. Paul, MN (Paramax)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>1988</b> | Motorola Government Electronics Group - Scottsdale, AZ<br>General Dynamics Fort Worth Division - Fort Worth, TX<br>Texas Instruments Defense Systems & Electronics Group - Dallas, TX<br>Hughes Aircraft Company Missile Systems Group - Tucson, AZ<br>Bell Helicopter Textron, Inc. - Fort Worth, TX<br>Litton Data Systems Division - Van Nuys, CA<br>GTE C <sup>3</sup> Systems Sector - Needham Heights, MA                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>1989</b> | McDonnell-Douglas Corporation McDonnell Aircraft Company - St. Louis, MO<br>Northrop Corporation Aircraft Division - Hawthorne, CA<br>Litton Applied Technology Division - San Jose, CA<br>Litton Amecom Division - College Park, MD<br>Standard Industries - LaMirada, CA<br>Engineered Circuit Research, Incorporated - Milpitas, CA<br>Teledyne Industries Incorporated Electronics Division - Newbury Park, CA<br>Lockheed Aeronautical Systems Company - Marietta, GA<br>Lockheed Corporation Missile Systems Division - Sunnyvale, CA<br>Westinghouse Electronic Systems Group - Baltimore, MD<br>General Electric Naval & Drive Turbine Systems - Fitchburg, MA<br>Rockwell International Corporation Autonetics Electronics Systems - Anaheim, CA<br>TRICOR Systems, Incorporated - Elgin, IL |
| <b>1990</b> | Hughes Aircraft Company Ground Systems Group - Fullerton, CA<br>TRW Military Electronics and Avionics Division - San Diego, CA<br>MechTronics of Arizona, Inc. - Phoenix, AZ<br>Boeing Aerospace & Electronics - Corinth, TX<br>Technology Matrix Consortium - Traverse City, MI<br>Textron Lycoming - Stratford, CT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |

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| <b>1991</b> | <i>Resurvey of Litton Guidance &amp; Control Systems Division</i> - Woodland Hills, CA<br>Norden Systems, Inc. - Norwalk, CT<br>Naval Avionics Center - Indianapolis, IN<br>United Electric Controls - Watertown, MA<br>Kurt Manufacturing Co. - Minneapolis, MN<br>MagneTek Defense Systems - Anaheim, CA<br>Raytheon Missile Systems Division - Andover, MA<br>AT&T Federal Systems Advanced Technologies and AT&T Bell Laboratories - Greensboro, NC and Whippany, NJ<br><i>Resurvey of Texas Instruments Defense Systems &amp; Electronics Group</i> - Lewisville, TX                                                                                                                                                                                                                                                                |
| <b>1992</b> | Tandem Computers - Cupertino, CA<br>Charleston Naval Shipyard - Charleston, SC<br>Conax Florida Corporation - St. Petersburg, FL<br>Texas Instruments Semiconductor Group Military Products - Midland, TX<br>Hewlett-Packard Palo Alto Fabrication Center - Palo Alto, CA<br>Watervliet U.S. Army Arsenal - Watervliet, NY<br>Digital Equipment Company Enclosures Business - Westfield, MA and Maynard, MA<br>Computing Devices International - Minneapolis, MN<br><i>(Resurvey of Control Data Corporation Government Systems Division)</i><br>Naval Aviation Depot Naval Air Station - Pensacola, FL                                                                                                                                                                                                                                  |
| <b>1993</b> | NASA Marshall Space Flight Center - Huntsville, AL<br>Naval Aviation Depot Naval Air Station - Jacksonville, FL<br>Department of Energy Oak Ridge Facilities (Operated by Martin Marietta Energy Systems, Inc.) - Oak Ridge, TN<br>McDonnell Douglas Aerospace - Huntington Beach, CA<br>Crane Division Naval Surface Warfare Center - Crane, IN and Louisville, KY<br>Philadelphia Naval Shipyard - Philadelphia, PA<br>R. J. Reynolds Tobacco Company - Winston-Salem, NC<br>Crystal Gateway Marriott Hotel - Arlington, VA<br>Hamilton Standard Electronic Manufacturing Facility - Farmington, CT<br>Alpha Industries, Inc. - Methuen, MA                                                                                                                                                                                            |
| <b>1994</b> | Harris Semiconductor - Melbourne, FL<br>United Defense, L.P. Ground Systems Division - San Jose, CA<br>Naval Undersea Warfare Center Division Keyport - Keyport, WA<br>Mason & Hanger - Silas Mason Co., Inc. - Middletown, IA<br>Kaiser Electronics - San Jose, CA<br>U.S. Army Combat Systems Test Activity - Aberdeen, MD<br>Stafford County Public Schools - Stafford County, VA                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>1995</b> | Sandia National Laboratories - Albuquerque, NM<br>Rockwell Defense Electronics Collins Avionics & Communications Division - Cedar Rapids, IA<br><i>(Resurvey of Rockwell International Corporation Collins Defense Communications)</i><br>Lockheed Martin Electronics & Missiles - Orlando, FL<br>McDonnell Douglas Aerospace (St. Louis) - St. Louis, MO<br><i>(Resurvey of McDonnell-Douglas Corporation McDonnell Aircraft Company)</i><br>Dayton Parts, Inc. - Harrisburg, PA<br>Wainwright Industries - St. Peters, MO<br>Lockheed Martin Tactical Aircraft Systems - Fort Worth, TX<br><i>(Resurvey of General Dynamics Fort Worth Division)</i><br>Lockheed Martin Government Electronic Systems - Moorestown, NJ<br>Sacramento Manufacturing and Services Division - Sacramento, CA<br>JLG Industries, Inc. - McConnellsburg, PA |
| <b>1996</b> | City of Chattanooga - Chattanooga, TN<br>Mason & Hanger Corporation - Pantex Plant - Amarillo, TX<br>Nascote Industries, Inc. - Nashville, IL<br>Weirton Steel Corporation - Weirton, WV<br>NASA Kennedy Space Center - Cape Canaveral, FL                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |

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**1997**

Headquarters, U.S. Army Industrial Operations Command - Rock Island, IL  
SAE International and Performance Review Institute - Warrendale, PA  
Polaroid Corporation - Waltham, MA

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