SECTION VI

INTRODUCTION TO POLLUTION PREVENTION

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CHAPTER 1

INTRODUCTION TO POLLUTION PREVENTION

Pollution Prevention is generally defined as any in-plant process that reduces, avoids, or eliminates the use of toxic materials and/or the generation of pollutants and wastes so as to reduce risks to human health and the environment and to preserve natural resources through greater efficiency and conservation. The goal of pollution prevention is to minimize environmental risks by reducing or eliminating the source of risk (rather than reactively through treatment and disposal of wastes generated).

There are significant opportunities for industry to reduce or prevent pollution at the source through cost-effective changes in production, operation, and raw materials use. The opportunities for source reduction are not often realized because existing environmental regulations, and the industrial resources they require for compliance focus upon treatment and disposal, rather than source reduction. Source reduction is different and more desirable than waste management and pollution control.

A logical waste management hierarchy would be based on the principal that pollution should be prevented or reduced at the source wherever feasible, while pollutants that cannot be prevented should be recycled in an environmentally safe manner. In the absence of feasible prevention or recycling opportunities, pollution should be treated. Disposal or other release into the environment should be used as a last resort. This hierarchy is described in more detail in the next section.

1.1 WASTE MANAGEMENT HIERARCHY

In this section, a waste management hierarchy was developed as an approach to prioritize pollution control methods. This hierarchy assesses four types of pollution control methods based on their effectiveness in reducing the risks to human health and the environment from pollution.

Source Reduction

The most desirable option of the hierarchy and the most effective way to reduce risk is through source reduction. Source reduction is defined as any method that reduces or eliminates the source of pollution entirely. This includes any practice that:

- Reduces the amount of hazardous substances, pollutants, or contaminants entering a waste stream or otherwise released into the environment prior to recycling, treatment, or disposal; and

- Reduces hazards to public health and the environment associated with the release of such substances, pollutants, or contaminants.

The term source reduction includes equipment or technology modifications, process or procedure modifications, reformulation or redesign of products, substitution of raw materials, and improvements in housekeeping, maintenance, training, or inventory control. It is important to note that the term source reduction does not include any practice which alters the physical, chemical, or biological characteristics, or the volume of a hazardous substance, pollutant, or contaminant through a process or activity which itself is integral to, and necessary for, the production of a product or the provision of a service.

Recycling

Where pollution cannot be prevented through source reduction methods, the wastes contributing to the pollution should be recycled. Recycling is the use, reuse, or reclamation of waste after it has been generated (e.g., recycling spent solvents).

Treatment

Wastes that cannot be feasibly reduced at the source or recycled should be minimized through treatment in accordance with environmental standards and regulations that are designed to reduce both the hazard and volume of waste streams (e.g., adsorption of organic vapors onto activated carbon).

Disposal

Finally, any residues remaining from the treatment of waste should be disposed of safely to minimize their potential for release into the environment. Disposal involves the transfer of a pollutant to the environment in either air, solid waste, or water (e.g., landfilling metal scrap wastes).

Pollution control techniques include all four choices in the hierarchy. Pollution prevention techniques include only source reduction or closed-loop recycling, the first two choices in the hierarchy. Implementation of pollution prevention methods is the best way to reduce or control pollution considering their potential environmental and economic advantages which include:

- Energy and resources conservation;
- Raw material losses reduction;
- Treatment and disposal cost reductions;
- Reduction of long-term liabilities associated with environmental waste or cleanup;
- Improved worker health and safety; and
- Reduced regulatory requirements.

The waste management hierarchy establishes a set of guidelines to follow rather than a fixed set of rules. Practices such as treatment and proper disposal can be protective of the environment when performed properly. Industries can be expected to balance the costs and benefits when evaluating pollution control strategies. Specific factors which must be evaluated will be discussed in detail in a later section.

Many countries that are adopting pollution prevention as a national environmental program rely on voluntary efforts by industries and government to implement pollution prevention methods. These voluntary efforts have been quite successful due to several factors including the increasing costs of treating wastes, the increasing costs of transferring wastes to landfills, treatment plants, and hazardous waste management facilities; financial liabilities; and public pressure. These non-regulatory incentives are causing industries to realize the economic and environmental benefits gained from adopting pollution prevention control methods.

1.2 SOURCE CONTROL METHODS

Source control (pollution prevention) techniques can be grouped in numerous ways (as evidenced in the many manuals and guides prepared by EPA and other U.S. agencies). For this presentation, the techniques are grouped into the following eight classifications:

1. Process Changes
2. Material Substitution
3. Material Inventory and Storage
4. Waste segregation
5. Good housekeeping/Preventive Maintenance/Employee Education
6. Product changes
7. Water and energy conservation
8. Recycling/waste exchange

Process Changes

Process changes consist of changing one or more processes used by the facility, or changing the equipment used in the process(es). The changes can result in both reduced volume and/or toxicity of the waste generated. Process changes may not necessarily be extensive or costly to implement. Some examples of potentially simple and inexpensive process changes which are considered pollution prevention techniques include:

- Reducing drag-out (transfer) of pollutants from process solutions by slowing withdrawal speed of metal parts and allowing sufficient drainage time over process tanks (or over drip tanks). These procedures, along with other drag-out reduction techniques can reduce the waste of expensive chemicals, the quantity of pollutants in rinse waters, the toxicity of waste waters, and the quantity of sludge generated.

- Adjusting production schedules or dedicating process equipment to reduce the quantity of cleanup wastes generated (e.g., use of dedicated tanks in the paint formulating industry to eliminate intermediate washing).

- Use of still rinse techniques to reduce the volume of waste water generated in electroplating processes. Still rinses are static (no inflow or outflow) and are used to rinse metal parts after plating processes. When constituent concentrations become unacceptably high within the rinse tank, rinse waters may be used to replenish the upstream plating bath. Evaporative equipment may be used to concentrate rinse waters prior to replenishing the plating baths.

Material Substitution

Changes in the raw materials used in a process can result in pollutant source reduction by reducing or eliminating the hazardous materials that enter the production process. Examples of pollution prevention using material substitution techniques include:

- Substituting organic polyelectrolytes in place of traditional coagulation and flocculation agents (e.g., lime, alum) to reduce quantities of sludge generated;

- Substituting alkaline cleaners or citric acid cleaners for organic solvents; and

- Replacing environmentally hazardous hexavalent chromium electroplating solutions with trivalent chromium.

Material Inventory and Storage

Proper material inventory and storage refers to the purchasing, tracking, storage, and handling of hazardous materials. There are two facets of material inventory and storage:

- Using good inventory and tracking procedures of hazardous materials help minimize overstocking and contamination and reduces the need to dispose of expired or contaminated materials. These procedures should ensure that raw materials are purchased only when needed and in appropriate quantities. Expiration dates of materials should be tracked and a “first-in, first-out” (FIFO) policy (older materials used first) should be adopted.

- Developing procedures and obtaining appropriate equipment to prevent and respond to all potential sludge discharges including spills, leaks, bypasses, and upsets (e.g., utilizing secondary containment around tanks and containers of hazardous materials and process equipment to prevent discharge of hazardous materials and to reduce the quantity of waste generated from cleanup of spills or leaks).

Waste Segregation

Segregation of different types of wastes can be a simple and effective pollution prevention technique applicable to a wide variety of waste streams and industries. By segregating wastes at the source of generation and by handling hazardous and non-hazardous wastes separately, waste volume and management costs may be reduced. Additionally, uncontaminated or undiluted wastes may be reusable in the production process or may be sent off-site for recovery. Practices for segregating wastes include the following:

- Isolating hazardous waste from nonhazardous waste. Blending such waste makes all the waste hazardous and increases treatment or disposal costs.

- Segregating different types of solvents, particularly halogenated solvents from non-halogenated solvents, and aromatic solvent from aliphatic solvents. Solvents are harder to recycle and reuse.

- Avoiding contamination of wastes with water. Solvents and oils that are contaminated with water are harder to recycle and reuse. In addition, wastes and waste water that are mixed with large amounts of storm water require additional treatment steps and costs.

Good Housekeeping/ Preventive Maintenance/ Employee Education

These procedures are generally simple and inexpensive to implement and effectively reduce pollution at its' sources.

Good Housekeeping

Some examples of such procedures include:

- Reducing dripping and splashing from parts being dipped in process and rinse tanks. This prevents this waste water from entering drains to the sewer or waste water treatment system.

- Maintaining adequate distances between different chemicals to prevent cross contamination; and

- Keeping containers closed except when material is being removed.

- Providing funnels and other transfer equipment to reduce loss of material during transfer.

Preventive Maintenance

Preventive maintenance reduces malfunctions and leaks and can also reduce the quantity of waste generated. Preventive maintenance consists of regular inspection, cleaning, testing, and lubrication of process, storage, handling, monitoring and treatment equipment. A master preventive maintenance file which documents all maintenance work should be kept. Also, any parts that are worn or broken should be replaced before a problem occurs (e.g., regular replacement of seals and gaskets to prevent leaks from pumps, joints, valves, etc.).

Employee Education

Employee education may be the most basic pollution prevention technique and yet it is often overlooked. Pollution prevention education should be an integral part of the training normally given to employees when they begin a job and during regular refresher training. Two of the most important aspects of training include:

- Educating employees to know and understand the company's pollution prevention goals. It is important for employees to know and understand the benefits of reducing hazardous materials being handled and generated. To accomplish this task, many companies establish a facility-wide training program to educate employees on pollution prevention techniques used by the facility.

- Ensuring that all employees know and practice proper and efficient use of tools and supplies. This is especially important for cleaning operations.

Product Changes

Product changes that are considered pollution prevention techniques include any changes in the composition or use of an intermediate or end product which results in reducing waste from the manufacture, use, or ultimate disposal of the product. A life-cycle assessment of a product can be used as an objective tool to identify and evaluate opportunities to reduce the environmental impacts associated with its manufacture, use, or disposal. The three components of the assessment include:

- Inventory analysis—Identification and quantifying of energy and resource use and waste emissions;

- Impact Analysis—Assessment of the consequences those wastes have on the environment; and

- Improvement Analysis—Evaluation and implementation of opportunities to effect environmental improvements.

Water and Energy Conservation

Water and energy conservation should be considered as part of an overall pollution prevention strategy. Benefits to reducing water and energy use include reduced waste water generation and associated treatment/disposal costs and reduced pollution associated with producing potable water and the generation of energy. Examples of water and energy conservation techniques include:

- Employing timed automatic shutoff valves on equipment using water such as rinses on a metal finishing line. This technique is relatively inexpensive, but can result in substantial decreases in water use and waste water generated.

- Recirculating cooling waters through a cooling tower. Water used in cooling heavy machines, quenching hot metals, molding and forming processes, etc. should be recirculated to significantly reduce water use.

- Utilizing heat exchangers on high temperature discharges to heat incoming water. This practice is employed at many industrial laundries (including those at hospitals), chemical manufacturing, and power generating facilities.

**Recycling/
Waste Exchange**

Recycling can be used where further source reduction techniques cannot be implemented.

Recycling involves the use of a waste as an effective substitute for a commercial product or as a raw material in the manufacture of a product.

On-site Recycling

Recycling the waste on-site by returning the waste back to the process or another process (e.g., the use of waste acids and bases for pH adjustment in waste water treatment systems or the use of a small On-site still to purify degreasing solvents for subsequent reuse).

Off-site Recycling/ Reclamation

Recycling waste off-site by sending it to a recovery/reclamation facility for processing (e.g., sending metal-bearing sludges from industrial waste water treatment processes to Off-site reclamation facilities).

Waste Exchange

Advertising the sale or the availability of wastes through a private- or government-funded organization. Waste exchanges can help bring together generators of waste with companies that can use the waste in their production process.

1.3 IMPLEMENTATION OF POLLUTION PREVENTION TECHNIQUES

When industries are deciding whether to implement pollution prevention techniques in their facilities, several items must be examined.

First, it must be determined if the pollution prevention technique will result in cross medium transfer of pollutants. It is important to avoid transfer of pollutants from one media to another. The three types of media are air, land, and water. Most treatment or disposal methods transfer pollutants from one media to another. For example, wastewater treatment that uses coagulation and sedimentation to remove metals generates a sludge which is usually disposed in landfills. In this case, the metal pollutants are transferred from the waste water to the sludge placed in the landfill. Another example is the use of air stripping to remove volatile organic compounds (VOCs). In this case, the volatile organic compounds are removed from the waste water and released to the air.

Pollution prevention strategies can substantially decrease pollutant loads to the environment without transferring pollutants from one medium to another. An example includes substituting powder paints for water-based and solvent-based paints for example, eliminates cleanup wastes and emissions of VOCs.

A second consideration is worker health and safety. For example, the substitution of a coagulant chemical which generates less sludge in a pretreatment system may be more hazardous to workers handling it.

Finally, any pollution control technique utilized must comply with all applicable Federal, State and local laws and regulations. Some pollution prevention strategies may require obtaining a permit or license or making a special notification to the appropriate regulatory agency.

1.4 SELECTED POLLUTION PREVENTION CASE STUDIES

The United States Evironmental Protection Agency has established a voluntary pollution prevention program intiative called, the 33/50 Program. The program derives its name from its overall goals--an interim goal of 33% in 1992 and an ultimate goal of a 50% reduction by 1995 in releases and transfers of 17 high-priority toxic chemicals, using 1988 Toxic Release Inventory (TRI) reporting as a baseline. During 1988, 1.48 billion pounds of the target chemicals were either released to the environment on-site or transferred off-site to waste management facilities. The aim of the 33/50 Program is to reduce this amount by at least 50%-743 million pounds-by 1995, with an interim reduction target of more than 490 million pounds by 1992.

The Program is part of a broad group of EPA activities designed to encourage pollution prevention as the best means of achieving reductions in toxic chemical emissions. More than 16,000 facilites have reported 33/50 Program chemicals to the Agency since 1988. By contacting the chief executives of the parent companies of TRI facilities that report 33/50 Program chemicals, the Program seeks to instill a pollution prevention ethic throughout the highest echelons of American businesses.

In an effort to recognize companies making significant progress in reducing chemical releases and transfers, Company Profiles have been developed to provide detailed information about the reduction efforts companies have undertaken. The following case summaries represent 14 companies, of the more than 1200 companies participating in the Program, that have added to the success of the 33/50 Program.

PRINTED CIRCUIT BOARDS

HADCO Corporation is a manufacturer of custom printed circuit boards and backplanes for use in electronic components. Approximately 60% of the boards produced are used in computers, and an additional 30% are used in telecommunications equipment. The remaining 10% find end uses in various types of instrumentation, principally in medical devices and the automotive industry. HADCO is headquartered in Salem, New Hampshire, and operates six facilities.

From July, 1989 through August, 1990 the company implemented a $1.7 million process conversion and emission control project at its Derry facility. The project's goals were to eliminate use or minimize air emissions of chemicals used in the facility's manufacturing operations.

The cornerstone of the project was implementation of new aqueous-based chemicals in the cleaning and dry film processes. The dry film process was modified to include carbonate based developers instead of 1,1,1-trichloroethane, and hydroxide solutions instead of dichloromethane. A screen cleaning use of dichloromethane was also replaced with an aqueous cleaning solution at the Owego, NH facility.

HADCO's conversion project has resulted in the following source reduction of chemicals:

- Significant reduction in dichloromethane through conversion of six of the eight dry film and cleaning processes to water based chemistry;

- Elimination of 1,1,1-trichloroethane through conversion of the cleaning and dry film processes to water based chemistry; and,

- Elimination of methyl ethyl ketone as an additive to dichloromethane in cleaning (its only use at the facility).

Certain circuit board processes could not be replaced with this new water-based technology, however, because of user specifications. To reduce emissions of these chemicals, HADCO also installed a dual-bed activated carbon adsorption recovery system at its Derry, NH facility, which reduced remaining emissions of the three solvents by over 99%.

As an alternative to a recovery system, HADCO replaced both 1,1,1-trichloroethane and dichloromethane with a terpene solvent at its Owego, NH facility.

The recovery system was installed to further reduce air emissions. However, HADCO's process conversion and emission control program achieved significantly greater reductions than required by New Hampshire Air Toxics Regulations (adopted April, 1990). HADCO's state permit for dichloromethane allows emissions of no more than one pound per hour; however, the company estimates that its emissions level has been reduced to 0.3 pounds per hour. In addition, the State law did not require control of methyl ethyl ketone or 1,1,1-trichloroethane at the Derry site. Thus, HADCO has reduced air emissions by more than 270,000 pounds over the state requirements.

HADCO's efforts in pollution prevention and solvent recovery allowed the company to achieve its goals two years ahead of schedule. Company-wide releases and transfers of its' major solvents chemicals decreased 95% between 1988 and 1992, reflecting a reduction of almost 2.2 million pounds. In addition, according to company officials, the company achieved additional reductions in 1993 that have brought its total reductions to 99.5%.

STEEL PRODUCTS

Acme Metals Incorporated, based in Riverdale, Illinois, is the parent company of an integrated steelmaker and three steel fabricating subsidiaries. Although interrelated, each subsidiary is responsible for its own environmental programs.

Acme Steel Company, an integrated producer of steel products, operates coke and ironmaking facilities in Chicago, IL and a steelmaking plant in Riverdale, IL. Acme Packaging Corporation, a manufacturer of steel strapping tools, operates facilities located in Riverdale, IL, Leeds, AL, New Britain, CT, and Pittsburg, CA. These two subsidiaries are responsible for virtually all releases and transfers of selected chemicals and are the focus of this profile.

Acme Metals Incorporated reduced annual releases and transfers of selected chemicals by more than 833,000 pounds by 1992 from 1988 levels.

Acme achieved an 89% reduction in releases and transfers of these chemicals from 1988 to 1992, surpassing its pledged reduction of 70% by 1995.

Since 1988, Acme has implemented several programs aimed at further reducing releases and transfers of these chemicals. Acme has completed the following projects at its Chicago Coke plant:

- **Replace cooling system.** Acme replaced its contact gas cooling system with a non-contact, wet surface air cooler in the coke byproducts recovery process. The replacement of the cooling system resulted in reductions of releases of approximately 143,000 pounds of benzene, 276,000 pounds of cyanide, 28,000 pounds of toluene, and 6,000 pounds of xylene, as well as 1,450,000 pounds of ammonia, and 10,000 pounds of naphthalene.

- **Install emission collector headers.** Acme installed emission collector headers to remove volatile chemicals, such as benzene, toluene, and xylene, from the headspaces of process units and storage tanks. This process uses steam moving under negative pressure to sweep the volatile chemicals into the byproduct recovery system. Emission collector headers were installed at the light oil storage tank, the wash oil decanter, and the wash oil circulation tank and resulted in a 14,000 pound reduction in releases of benzene, as well as smaller reductions of toluene and xylene.

In addition, at Acme Packaging's Riverdale facility, spent lead dross from the steel strapping production process is now sent to an off-site recycler. Previously, the lead was landfilled. The increased recycling of lead resulted in a reduction of approximately 333,000 pounds of releases and transfers of lead. Small components of lead are still landfilled as a component of nonhazardous sludge generated from pollution control activities.

Acme reduced releases and transfers of other selected chemicals by nearly 2,600,000 pounds (75%) between 1988 and 1992.

Health Care Products

Johnson & Johnson is the world's largest health care company, with over 80,000 employees and manufacturing and sales locations in more than 50 countries. The company manufactures toiletries and baby care products, medical supplies, and pharmaceutical products.

To reduce releases and transfers of selected chemicals, Johnson & Johnson has undertaken several projects at its various facilities:

- Eliminating the use of methyl ethyl ketone, methyl isobutyl ketone, and xylene at the Consumer Products plant in North Brunswick, NJ. These chemicals were used in the manufacturing process for the company's Band-Aid™ Brand adhesive bandages. Vinyl extrusion and the use of a water-based emulsion has been substituted in the manufacturing process, resulting in a decrease of over 380,000 pounds in releases and transfers of these three solvents between 1988 and 1992.

- Equipment and procedure changes in several processes at the Noramco facility in Wilmington, DE, resulting in a combined reduction in releases and transfers of dichloromethane and toluene of over 131,000 pounds between 1988 and 1992. These changes by Noramco include: using dichloromethane and toluene as the seal fluid in liquid ring vacuum pumps, instead of water, thereby reducing wastewater transfers; implementing a leak detection and repair program to reduce fugitive emissions; and eliminating one product recovery step, further reducing dichloromethane transfers in wastewater. This facility has achieved reductions of 52% in releases and transfers of all these chemicals between 1988 and 1992.

- Material substitution at Ethicon plants in Somerville, NJ and San Angelo, TX, as well as the Advanced Materials facility in Gainesville, GA and the Vistakon plant in Jacksonville, FL, resulting in a decrease of over 66,500 pounds (73%) in releases and transfers of 1,1,1-trichloroethane between 1988 and 1992. A biodegradable cleaner was substituted for 1,1,1-trichloroethane.

As a result of Johnson & Johnson's pollution reduction efforts, releases and transfers of selected chemicals decreased 63% (469,981 pounds) between 1988 and 1992. The largest reductions were for xylene and methyl ethyl ketone, which decreased by 93% and 80% respectively. These reductions were due principally to the conversion of the adhesive carrier to aqueous emulsion in the Band-Aid™ manufacturing process.

Releases and transfers of 1,1,1-trichloroethane also fell by 74% (66,580 pounds), in conjunction with the company's goal of eliminating the use of this chemical and other ozone depleting substances.

Johnson & Johnson has stated that participation in a Pollution Prevention (P2) program has helped significantly in formulating reduction initiatives and in obtaining corporate support for their implementation. The requirement of reporting releases and transfers of hazardous chemicals to EPA initially made the company aware of the extent of its emissions and off-site transfers. The company began to develop strategies for reducing releases and transfers of hazardous chemicals as figures were first compiled company-wide. The P2 focus on a distinct set of chemicals then helped Johnson & Johnson to develop and choose among specific source reduction projects for these targeted chemicals.

Metal and Plastic Hardware

Aladdin Industries Inc. is a manufacturer of metal and plastic hardware for consumer and industrial use. Located in Nashville Tennessee, Aladdin produces a wide variety of products such as lunch kits, thermos bottles, hospital trays, coffee cups, lamps, and coolers.

Although Aladdin is a relatively small generator of toxic chemical emissions, the company has stated that, as a corporate citizen, it feels an obligation to reduce *any* emissions generated. Aladdin's ultimate objective is to eliminate the emissions of toxic chemicals completely, primarily through source reduction methods. However, in cases where source reduction is not possible, Aladdin is looking to other means of reducing emissions such as treatment and recycling.

In order to meet its goals, Aladdin designed in-house projects focusing on each of the chemicals to be eliminated, controlled, or replaced. For each of these projects, one staff member was appointed project leader and had primary responsibility for ensuring the project's completion. For each project, a goal, target implementation date, base year, and method for completion were articulated.

To date, Aladdin has completed the following projects:

- All trichloroethylene usage was eliminated during 1993. Trichloroethylene was required to remove petroleum oils from metal parts during metal forming processes. Synthetic lubricants are now used in place of petroleum oils and are removed from parts with an aqueous alkaline cleaner. The water from the alkaline cleaning process is treated on-site.

- Dichloromethane use was completely eliminated from the facility as of 1993 by replacing the polystyrene used in trays with polypropylene. Previously, the polystyrene trays were cut from a sheet and blemishes around the edges were removed using dichloromethane. Since the polypropylene trays are now injection molded, there are no blemishes to remove.

- Toluene and methyl isobutyl ketone were completely eliminated from the Aladdin facility as of 1993 by replacing a thinner containing toluene and methyl isobutyl ketone with a thinner containing 25% toluene and 75% 1,1,1-trichloroethane. This thinner was later replaced with a thinner containing acetone in place of the toluene. The company is currently investigating options to eliminate the 1,1,1-trichloroethane from this formulation.

- Aladdin eliminated all releases and transfers of chromium, along with phosphoric acid and sulfuric acid -- as of 1992. Using a newly installed on-site waste treatment facility, Aladdin removes toxic materials from a water mixture containing chromium, phosphoric acid, and sulfuric acid. Fifty percent of the water is recycled, while the remainder is of sufficient quality to discharge to the sanitary sewer. The sludge is of sufficient quality to be considered nonhazardous and is disposed of in a landfill. Prior to the installation of the on-site treatment facility, all of these wastes were transferred off-site for treatment or disposal.

- Aladdin eliminated its lacquer painting process by switching to a dry powder coating, thereby eliminating the use of lead, xylenes, and ketones. Small quantities of lead, xylenes, and ketones were previously used at Aladdin in its painting process for thermos bottles.

Rubber-coated Fabrics

Aldan Rubber Company is a manufacturer of rubber-coated fabrics that are used in a wide variety of applications, including protective clothing for fire fighting, flexible duct connectors, convertible tops, and baby products. Aldan is located in Philadelphia, Pennsylvania.

Aldan conducted a survey to identify areas in the manufacturing process where significant emissions were taking place. This allowed the company to focus reduction efforts on the largest emission sources. The survey followed the “solvent trail” through the entire manufacturing process, from unloading of solvent from tank trucks to post-manufacture disposal of rubber scrap. After completing the facility survey and evaluating the results, Aldan identified five major activities that would significantly reduce chemical emissions:

- **Totally enclose the rubber spreader.** In its 1976 project, Aldan installed a hood to capture solvent emissions over part of its spreader. The captured solvent was then routed to a recovery unit. Aldan recently enclosed the entire spreader so that all solvent emissions are captured and recycled, rather than just those under the partial hood.

- **Renovate the solvent recovery system.** In order to improve the efficiency of its solvent recovery system, Aldan renovated the system put in place in 1976. As part of the renovation, the recovery unit received a complete overhaul, including replacement of the carbon recovery media, cooling coils, and old seals and valves. Aldan reported the solvent recovery unit’s efficiency at 98% - 99% after the renovation, an increase of approximately 20% from the previous efficiency level.

- **Use an alternative cleaner for machinery clean-up.** Aldan traditionally used toluene in a hand-wipe application to clean its equipment on a periodic basis. This cleaning removes excess rubber, dirt, and other contaminants from production machinery. To eliminate this use of toluene, Aldan now uses a d-limonene cleaner in a similar hand-wipe application, with reduced but satisfactory performance, and somewhat higher but still acceptable cost.

- **Institute an employee awareness program.** Aldan recognized that a significant quantity of solvent emissions could be eliminated simply by improving the handling of process materials. An employee awareness program, mandatory for all employees who handle solvents, was implemented to achieve this goal. During the program, Aldan explained to workers the environmental problems associated with the solvent emissions and made suggestions for reducing emissions. Company officials believe that the employee awareness program has been a great success.

- **Improve management of rubber scrap.** Aldan developed a proprietary process by which it is able to reduce solvent emissions from rubber scrap. This process is one in which the scrap is processed to remove excess solvent prior to scrap disposal. Aldan has found that, not only does the process reduce emissions of solvent to the air, but it also renders the rubber scrap nonhazardous. The scrap can then be disposed of in a municipal landfill.

As a result of the efforts described above, by 1992 Aldan Rubber had reduced releases and transfers of selected chemicals by 73% from the 1988 baseline, almost reaching its goal of an 80% reduction. Reductions for toluene alone accounted for more than 1,000,000 pounds.

Specialty Fencing Products

Anchor Fence, Inc. is a manufacturer of high quality chain link fencing systems, gates, and specialty fencing products. The company has one facility located in Baltimore, MD, employing approximately 85 workers.

The company has undertaken the following activities to reduce releases of selected chemicals:

- Releases of methyl ethyl ketone have been reduced 93% (113,000 pounds) through substitution of water based formulations of primers for pipes and fittings. This action accounts for all of the observed decrease in releases of this chemical. In addition, all solvent based paint applications are being strictly monitored to determine which can be converted to water based products in the future.

- Improvements in the operation of the company's waste water treatment system have resulted in a 50% reduction in releases of lead, nickel, and zinc compounds between 1988 and 1992. These improvements consist primarily of adjusting the pH of the system to increase efficiency of metals removal.

- Eliminating the use of dichloromethane at the plant by shifting the PVC stripping process for off-quality products to an off-site cleaning company that uses a hot salt bath PVC removal process. This change resulted in cost savings for the company.

- Examination of solvent based cleaning processes using toluene and methyl ethyl ketone to determine where solvent evaporation can be reduced. The company intends to install a water-cooled component cleaning tank to further reduce releases of the solvents.

By 1992, Anchor Fence had reduced release of these chemicals by 87% from 1988 levels. Virtually all of this reduction was a result of substitution of methyl ethyl ketone-based primers with a water-based formulation.

Stainless Steel

Carpenter Technology Corporation manufactures stainless steel and other specialty metals for a variety of industries including aerospace, nuclear, and electronics. The company is headquartered in Reading, Pennsylvania and has four facilities that report emissions.

Its two largest facilities are in Reading, Pennsylvania and Orangeburg, South Carolina. The former produces a variety of bar wire and strip metal products while the latter produces fine wire. In addition, a small plant in Fryeburg, Maine and a plant in El Cajon, California also make metal products.

In 1988, as a first step in identifying source reduction opportunities, Carpenter set up a team dedicated to continuous environmental improvements. This team consisted of key staff from engineering, production, and research and development. The team identified several types of projects including solvent substitution, reduction in solvent emissions through process modifications, increased recycling of metal-bearing waste streams, and changes in operator procedures to reduce the amount of acid used for metal descaling.

Specific changes implemented by Carpenter to reduce solvent emissions include:

- Substituting mineral spirits (petroleum-based solvents) for trichloroethane for cleaning certain types of metal parts.

- Eliminating non-cleaning uses of 1,1,1-trichloroethane (e.g., as a lubricant).

- Improving vapor degreaser process control to minimize the amount of solvent needed to clean metal components, and reducing by 50% the number of vapor degreasers used.

- Improving process control to minimize the amount of waste acid generated and eliminate the need for sending acid bath wastes off-site for treatment.

Two additional changes resulted in the elimination of all releases of metals (1,608,250 pounds of chromium and nickel) to land and a significant reduction in the amount of metals transferred off-site for treatment:

- Improving sludge drying operations and recycling rolling mill sludges, resulting in a 400% increase in the amount of metal oxides that can be recycled. These wastes were previously transferred off-site for treatment.

- Adding chemical inhibitors to acid bath solutions to reduce the amount of dissolved metals being transferred to the acid waste streams.

In addition, for economic reasons, the company consolidated its operations in 1989 by closing the Bridgeport plant while maintaining similar company-wide production levels through operation of four other plants. Through this action, Carpenter was able to achieve a 35% reduction in releases and transfers of selected chemicals.

Shoes

Dexter Shoe Company is a manufacturer of shoes for men, women, and children. The company is headquartered in Dexter, Maine and has four facilities in Maine: two in Dexter, one in Skowhegan, and one in Milo.

Both the Headquarters and Skowhegan facilities are using a three-tiered approach to meet its reduction goals: reduction in chemical use, substitution with less hazardous chemicals, and solvent recovery.

The Skowhegan facility has had particular success in substitution and solvent recovery. The facility reports the following activities:

- Replacing two solvent-based waterproofing agents with aqueous-based products. These new products are more expensive than their solvent predecessors, but provide better coverage using less product.

- Replacing methyl ethyl ketone as a cleaning solvent with heptane. Because heptane still poses some risk, however, the company is continuing to investigate other alternatives.

- Employing solvent recovery for cleaning solvents, such as methyl ethyl ketone and heptane. Dexter uses solvent recovery both for reuse of individual solvents and for generalized recovery of mixed cleaning solvents. Some of the solvent recovery is done within the process for which the chemicals are used and, thus, can be considered source reduction.

A similar progress report from Dexter's Headquarters facility describes the following individual reduction accomplishments:

- Substituting solvents and cleaners containing methyl ethyl ketone, methylene chloride, and toluene with water-based products.

- Replacing a filler product containing 40% acetone with a cut insert material bonded to the upper part of the shoe with a hot melt adhesive.

- Installing a solvent recovery system for reuse of cleaning solvents.

Emissions of all reported chemicals at the company's two participating facilities have already decreased 47% from 1988 to 1992 through elimination of 209,471 pounds of emissions:

Automobile and Truck Components (seat and trim)

Douglas & Lomason Company is a manufacturer of automobile and truck components, primarily seat and trim parts. The company is headquartered in Farmington Hills, Michigan and operates 16 manufacturing facilities located in Alabama, Arkansas, California, Georgia, Iowa, Maryland, Mississippi, Missouri, Nebraska, Tennessee, and Texas.

To meet its reduction goals, Douglas & Lomason has undertaken a number of source reduction activities, primarily product and process reformulation. The company has completed projects to reduce chemical use in both the molding and painting processes.

- **Implementing a new mold-release agent formulation.** The Havre-de-Grace, MD, facility manufactures foam seat pads using a molding process. This process involves applying a wax mold-release agent to the mold to facilitate the removal of the finished molded product. Douglas & Lomason's traditional mold-release agent, which contained 1,1,1-trichloroethane as a solvent, was replaced with a water-based formulation. This substitution completely eliminated the use of 1,1,1-trichloroethane, a reduction of 350,000 pounds.

- **Using "high-solids" paint formulations**. At one facility, Douglas & Lomason manufactures metal trim parts which are painted. The amount of solvent, such as toluene, xylene, and methyl ethyl ketone, used in these paints was reduced through the use of reformulated "high-solids" paint. "High-solids" paint uses a reduced percentage of solvent in formulating the paint, thereby increasing the percentage of solids. This approach resulted in achieving reductions at the Phenix City, AL, facility.

- **Using water-based paint**. At several facilities, Douglas & Lomason manufactures metal seat frames which are painted for rust protection. The use of solvents in the paint has been eliminated by using water-reducible paints, in which the solvents (in this case toluene and xylene) are replaced with ethylene glycol. This approach was used at the Columbus, NE, facility, contributing to reductions of 86,454 pounds of toluene and xylene releases between 1988 and 1992.

- **Eliminating the use of paints**. Solvent use has also been reduced or eliminated through the implementation of two new processes that eliminate the need to paint certain parts. First, the spray-application of rust inhibitors has eliminated the need for painting, thereby reducing and in some cases eliminating the use of solvents. A second process implemented by Douglas & Lomason involves the chemical application of a coating to metal parts using a process that requires no solvents. The Red Oak, IA, facility used this process to eliminate releases and transfers of 61,000 pounds of toluene and xylene.

As a result of these and other efforts, Douglas & Lomason has made outstanding progress in reducing its releases and transfers of selected chemicals, including surpassing its 1995 reduction goal several years early. Douglas & Lomason succeeded in reducing its releases and transfers by 88% between 1988 and 1992, a reduction of 525,285 pounds. This reduction in releases and transfers was achieved despite an increase in production between 1988 and 1989.

As part of Douglas & Lomason's efforts, the Havre-de-Grace, MD, Red Oak, IA, and Columbus, NE facilities have completely eliminated their use of selected air toxic and other chemicals. The company as a whole has completely eliminated the use of 1,1,1-trichloroethane.

Specialty Chemicals and Metals

Olin Corporation is a Fortune 200 company, headquartered in Stamford, CT, with 29 facilities nationwide in 15 states. The company manufactures a wide variety of products, including specialty chemicals, metals, and other materials, as well as products for the defense, aerospace and sporting ammunition industries. Examples of significant projects at Olin facilities that have successfully reduced the emissions of these chemicals to the environment include:

Olin Corp., Rochester, NY. Olin's Rochester facility produces over 60 different types of specialty chemicals -- relatively low volume products tailored to the specific needs of individual customers, including biocides (zinc or sodium pyrithione), aniline dyes, and pharmaceutical ingredients. In 1988, the facility reported air emissions of 11,540 pounds of carbon tetrachloride, which is used as a non-reactive diluent. In order to recover carbon tetrachloride from air vents, the plant installed a scrubber and additional process vent collection equipment, and now reuses the reclaimed material in several of the facility's production processes. 1992 air emissions of carbon tetrachloride were reduced to 3,437 pounds at this facility, a reduction of 70%. This facility is also investigating the substitution of carbon tetrachloride and other chemicals with non-toxic raw materials.

Olin Ordnance, Red Lion, PA. The Red Lion facility produces various munitions for the military. In 1988, this facility reported air emissions of 122,535 pounds of 1,1,1-trichloroethane. This chemical is used as a multi-purpose cleaner and degreaser. The Red Lion facility took a number of steps to reduce the use of this chemical, including: restricting access and requiring employees to justify their use of the material; identifying material substitution options for products not required to use the chemical (e.g., by military procurement specifications); and modifying the chiller on a solvent degreaser to enhance vapor capture. As a result of these efforts, air emissions of 1,1,1-trichloroethane were reduced to 21,700 pounds in 1992, a reduction of over 80% from 1988 levels. The facility is currently investigating two additional actions to further reduce the use of 1,1,1-trichloroethane: installing a parts washer which will use water-based cleaners instead of chlorinated solvents, or altering the overall production process to completely eliminate the cleaning process.

Bridgeport Brass Co., Indianapolis, IN. In 1988 this facility reported air emissions of 37,000 pounds of 1,1,1-trichloroethane and dichloromethane, which were used as degreasers. By 1990, the facility had completely eliminated its use of these two chlorinated solvents by switching to the use of water-based soaps and hot water rinsing in its metal processing and maintenance operations.

Main Plant Facility, East Alton, IL. Olin's East Alton Main Plant facility used to landfill large quantities of lead wastes (off-site disposal of 815,853 pounds in 1988), primarily from bullets test-fired into sand traps at the Winchester sporting ammunition plant. The facility used to screen as much lead as possible out of the sand for reuse in their own production processes, and landfill the remaining lead-contaminated sand off-site. The facility began selling unscreened material to a battery manufacturer, and more recently began selling it to a lead smelter. The sand/lead mixture is used directly as a recycled raw material in the smelting process. The landfilling of lead wastes has thus been dramatically reduced to 39,673 pounds in 1992, for an overall reduction of 95%.

Between 1988 and 1992, Olin reduced its releases and transfers of selected chemicals by 67%, a reduction of 1,367,614 pounds. Much of this reduction was the result of eliminating or capturing 473,114 pounds of air emissions from solvents. In addition, Olin reduced off-site chemical disposal 876,904 pounds between 1988 and 1992, including shifting 776,180 pounds of lead from off-site disposal in a landfill to off-site recycling -- an action that represents a move up the pollution prevention hierarchy.

MOTION CONTROL PRODUCTS

Parker Hannifin Corporation manufactures a broad array of motion control products for industrial and aerospace applications. The company is headquartered in Cleveland, OH and employs nearly 26,000 individuals worldwide at 143 manufacturing plants and 87 administrative and sales offices, company stores, and warehouses. Parker's Industrial segment, which accounts for 75% of the company's sales, is comprised of five groups: Fluid Connectors, Motion & Control, Automotive & Refrigeration, Seal, and Filtration. The company's Aerospace segment is a single group with several divisions that account for the remaining 25% of Parker's sales.

To reduce releases and transfers of selected chemicals at its facilities in the United States, the company undertook the following activities between 1988 and 1992:

- Eliminated 756,000 pounds of releases and transfers of dichloromethane, tetrachloroethylene, 1,1,1-

trichloroethane, and trichlorethylene by switching to aqueous cleaning systems for degreasing operations. Because the aqueous cleaning process requires agitation of the parts, part of the conversion involved redesigning the racks used to hold parts during cleaning to accommodate agitation.

- Eliminated 453,000 pounds of releases and transfers of methyl ethyl ketone and toluene by substituting water-based solutions for solvent solutions used to carry cements in the manufacture of rubber hoses. This substitution required the addition of a drying step because of the relatively slow evaporation rate of water.

- Eliminated 109,000 pounds of releases and transfers of carbon tetrachloride, methyl isobutyl ketone, and xylene by substituting water-based adhesives and paints for solvent-based adhesives and paints.

- Eliminated 30,000 pounds of releases and transfers of chromium and chromium compounds used in coloring processes that are part of the metal finishing operations. This reduction was achieved through waste minimization techniques such as counter-current rinsing, reduced drag-out rates, and improved quality control.

- Reduced releases and transfers of cadmium and cadmium compounds by 15,000 pounds by substituting zinc plating for all of the cadmium plating process carried out in metal finishing operations. Cyanide releases and transfers associated with the cadmium plating operations have increased. This increase is due to the fact that the company switched approximately 50% of its cyanide treatment from on-site to off-site. (Waste treated on-site is reported only for quantities not destroyed or removed, while the full quantity treated off-site is reported as a transfer). Parker estimates, however, that releases and transfers of cyanide will be eliminated by 1994 when the conversion to zinc plating will be complete at all of its facilities.

In addition to these activities, Parker is working with steel suppliers to minimize emissions of metals during machining operations by developing raw material steel with a low or zero lead content. This effort is currently in the development stage, but promising results are expected in the future. In the meantime, Parker achieved reductions in metal emissions through improved scrap recovery and control methods. However, because these reductions are relatively small, they are not measured by the company and therefore cannot be quantified.

As a result of Parker's pollution prevention efforts, releases and transfers of selected chemicals decreased by more than 1,350,000 pounds between 1988 and 1992. This reduction of 71% exceeds the company's Program goal of a 50% reduction more than three years ahead of schedule.

Printed Circuit Boards

Printed Circuit Corporation, located in Woburn, Massachusetts, is a manufacturer of printed circuit boards. The company provides its products to companies in the electronics, instrumentation, telecommunication, and automotive industries.

In order to meet its program goals, Printed Circuit adopted a two-step approach. First, the company focused its efforts on eliminating all use of dichloromethane in its operations. To accomplish this goal, the company implemented a process that uses a water-based cleaner to strip away excess polymer from the etched circuit boards. In addition, Printed Circuit switched all solvent cleaning operations to 1,1,1-trichloroethane. These changes eliminated all use of dichloromethane at Printed Circuit by the end of 1991. As a result of the process change, the company also was able to minimize its use of methanol.

Although the switch to 1,1,1-trichloroethane for all solvent cleaning operations caused releases of the chemical to increase between 1990 and 1991, Printed Circuit showed an overall reduction in releases of selected chemicals between the two years. The company believed that by focusing its efforts on one chemical at a time, it would be able to make more rapid progress toward reducing emissions than if it were addressing several chemicals simultaneously.

To eliminate the use of 1,1,1-trichloroethane, the company undertook an evaluation of potential replacements. Printed Circuit worked with six vendors nationwide over a two-year period to identify replacements that would:

- be compatible with other chemicals and materials used in production;
- comply with environmental standards; and
- be economically feasible.

As a result of the study, the company has replaced its use of 1,1,1-trichloroethane as a developing agent with a water-based sodium carbonate solution. In addition, Printed Circuit now uses a mild detergent with water for the final cleaning of completed circuit boards, in place of dichloromethane and 1,1,1-trichloroethane.

As a result of these efforts, Printed Circuit Corporation reduced total releases of selected chemicals by 87% from 1988 to 1991 after the elimination of dichloromethane. Furthermore,the company completely eliminated releases of all 17 selected chemicals by 1993 after the elimination of 1,1,1-trichloroethane, far surpassing its goals.

AIRCRAFT, RESIDENTIAL AND COMMERCIAL APPLIANCES

Raytheon Company is a diversified organization whose major interests include manufacturing of aircraft, residential and commercial appliances (including refrigeration, cooking, and laundry equipment), electronics (including guidance systems, guided missiles, printed circuit boards, and communications equipment), and energy/environmental services (including power, transportation, logistics support, and road building equipment). Raytheon is headquartered in Lexington, Massachusetts and had twenty five facilities in the United States that reported releases and transfers of chemicals in 1988.

Raytheon's reductions of selected chemicals were achieved as a result of several on-going projects.

- Eliminate or reduce solvents in cleaning operations. Dichloromethane, 1,1,1-trichloroethane, tetrachloroethylene, trichloroethylene, and CFC-113 were all targeted by Raytheon's ODS and suspected carcinogen phaseout goals. In 1988, these solvents were used at 18 facilities for electronics cleaning and metal degreasing, and as general solvent cleaners.

  Terpene-based cleaners and mildly alkaline aqueous solutions were identified as alternatives to these solvent cleaners. Raytheon has successfully eliminated its use of dichloromethane, tetrachloroethylene, and CFC-113, and has significantly reduced its use of 1,1,1-trichloroethane and trichloroethylene as a result of the development of these alternate cleaners.

- Eliminate the use of dichloromethane for paint stripping applications. At the Wichita facility, dichloromethane was used to strip paint from aircraft. Raytheon implemented a dry media (wheat starch) blasting system for paint stripping that completely eliminated the need for dichloromethane at this facility.

- Reduce 33/50 Program chemicals in painting and soldering applications. Lead, chromium, toluene, and xylene are used at Raytheon facilities in painting and soldering operations. Raytheon has identified and implemented a powder paint system in some facilities which has resulted in a reduction of releases and transfers of these chemicals. For applications in which powder painting is not technically feasible, Raytheon is working with its coating suppliers to reduce the amount of solvent used in its coatings.

As a result of these and other efforts, Raytheon's releases and transfers of selected chemicals decreased over 2.5 million pounds between 1988 and 1992 — a 65% reduction from 3,883,820 pounds to 1,360,658 pounds. The major components of this reduction were the elimination of dichloromethane and tetrachloroethylene, and the significant reduction of releases and transfers of 1,1,1-trichloroethane and trichloroethylene.

The phaseout of the use of dichloromethane and tetrachloroethylene resulted in a reduction of 706,701 pounds of releases and transfers of these chemicals between 1988 and 1992. These reductions account for approximately 28% of total reductions of releases and transfers of these chemicals during that period. The replacement of 1,1,1-trichloroethane and trichloroethylene resulted in a reduction of 1,354,654 pounds of releases and transfers of these chemicals. This reduction accounts for approximately 54% of total reductions from 1988 to 1992.

INTEGRATED STEEL

U.S. Steel is a large, integrated steel manufacturer and also includes several smaller diversified businesses. USX Corporation also is involved in the oil and natural gas businesses through its Marathon Oil Group and Delhi Group. U.S. Steel has its headquarters in Pittsburg, Pennsylvania, and operates six wholly-owned plants which report releases and transfers of chemicals. In addition, U.S. Steel is involved in several joint ventures including USS/POSCO Industries and USS/Kobe Steel.

Four of U.S. Steel's six facilities are in Pennsylvania: The Clairton Works (Clairton), and the Edgar Thomson (Braddock), Irvin (West Miffin), and Fairless (Forest Hills) plants on the Mon Valley Works. The other plants are the Gary (Indiana) Works and the Fairfield (Birmingham, Alabama) Works.

U.S. Steel expected to achieve its reductions through material reuse/recycling, process modifications, and product changes. Based on its reported 1988 emissions data, the company's goal translates into an overall reduction of 2,250,952 pounds in total releases and transfers.

U.S. Steel achieved significant reductions in releases and transfers of selected Program chemicals through source reduction and recycling initiatives at several of its facilities. Examples of specific changes implemented by the company include:

- **Installation of inert gas blanketing systems.** These systems use nitrogen to confine air emissions of volatile toxic chemicals such as benzene, cyanide, toluene, and xylene. By maintaining a layer of inert gas over an open tank or container, toxic chemical vapors are unable to escape from the tank. U.S. Steel has installed blanketing systems on product and by-product storage tanks and decanters at both its Gary and Clairton plants.

- **Implementation of dust pelletizing process.** In the Steel making operations, pollution control dusts containing iron units and various metallic compounds are produced. Under normal circumstances, these dusts are landfilled. Because of the recoverable iron units in the dusts, the Edgar Thomson plant, U.S. Steel Mon Valley Operations has implemented a pelletizing operation. The pellets are recycled back into the steel making operations.

- **Modification of coke quenching process.** After the coke is removed from the Coke ovens, it must be cooled rapidly. Previously, the Clairton Works used contaminated water to quench the coke. Use of contaminated water, however, resulted in releases of 33/50 Program chemicals such as benzene and toluene. The facility switched to clean quench water 100% of the time, thus eliminating the releases of benzene and toluene from the quenching operations. The contaminated water is currently treated at the facility's waste water treatment plant where contaminants are removed to permitted levels.

As a result of these and a variety of other projects and initiatives, U.S. Steel has surpassed its goal of a 30% reduction in releases and transfers by 1992. The company successfully reduced its overall releases and transfers of selected chemicals by 6,582,277 pounds, amounting to a reduction of 88% from 1988 levels. In addition, although not an explicit part of U.S. Steel's goals, the company reduced annual releases and transfers of other selected chemicals by almost 14 million pounds from 20,148,876 pounds for a reduction of 69% since 1988.

Overall, U.S. Steel has reduced its annual releases and transfers of all chemicals by a remarkable 20,508,069 pounds since 1988. This represents a 74% reduction in all releases and transfers.