United States
Environmental Protection
Agency

Office of Pollution
Prevention and Toxics
7408

EPA 745-K-95-004
June 1995

EPA

EPA's 33/50 Program Company Profile

UNISYS

Partnership in Prevention

Government-Industry-Community

This Company Profile is part of a series of reports being developed by EPA to highlight the accomplishments of companies participating in the 33/50 Program. The 33/50 Program is an EPA voluntary pollution reduction initiative that promotes reductions in direct environmental releases and offsite transfers of 17 high-priority toxic chemicals. The program derives its name from its overall goals -- an interim goal of a 33% reduction by 1992 and an ultimate goal of a 50% reduction by 1995. The program uses 1988 Toxics Release Inventory (TRI) reporting as a baseline. In February, 1991, EPA began contacting the parent companies of TRI facilities that reported using 33/50 Program chemicals since 1988 to request their participation in the 33/50 Program. As of April, 1994, a total of 1,216 companies had elected to participate in the Program, pledging to reduce emissions of the 17 target chemicals by more than 355 million pounds by 1995. Companies are encouraged to set their own reduction targets, which may vary from the Program's national 33% and 50% reduction goals. Company commitments and reduction pledges continue to be received by EPA on a daily basis.

17 PRIORITY CHEMICALS TARGETED BY THE 33/50 PROGRAM

BENZENE
CADMIUM & COMPOUNDS
CARBON TETRACHLORIDE
CHLOROFORM
CHROMIUM & COMPOUNDS
CYANIDES
DICHLOROMETHANE*
LEAD & COMPOUNDS
MERCURY & COMPOUNDS
METHYL ETHYL KETONE
METHYL ISOBUTYL KETONE
NICKEL & COMPOUNDS
TETRACHLOROETHYLENE
TOLUENE
1,1,1-TRICHLOROETHANE
TRICHLOROETHYLENE
XYLENES

* Also referred to as methylene chloride

The 1992 TRI data revealed that releases and transfers of 33/50 Program chemicals declined by 40% between 1988 and 1992, surpassing the Program's 1992 interim reduction goal by more than 100 million pounds. This accomplishment, together with evidence from analysis of facilities' projected releases and transfers of the 17 priority chemicals, reported to TRI under the Pollution Prevention Act, offers strong encouragement that the 33/50 Program's ultimate goal of a 50% reduction by 1995 will be achieved.

EPA is committed to recognizing companies for their participation in the 33/50 Program and for the emissions reductions they achieve. The Program issues periodic Progress Reports, in which participating companies are listed and highlighted. In addition, Company Profiles, such as this one, are being prepared to provide more detailed information about companies that have written to EPA describing significant emissions reduction initiatives. Information presented in these profiles is drawn from a number of sources, including the company's written communications to the 33/50 Program, extensive interviews with company representatives, the annual TRI reports submitted by the company's facilities (including Pollution Prevention Act data reported to TRI in Section 8 of Form R), and, in many cases, site visits to one or more of the company's facilities. All written company communications to EPA regarding the 33/50 Program are available to the public upon request.

EPA does not endorse the performance, worker safety, or environmental acceptability of any of the technical options discussed in this Profile. Mention of any product or procedure in this document is for informational purposes only, and does not constitute a recommendation of any such product or procedure, either expressed or implied, by EPA.

For information on the 33/50 Program, contact the TSCA Hotline at (202) 554-1404 or contact 33/50 Program staff directly by phone at (202) 260-6907 or by mail at Mail Code 7408, Office of Pollution Prevention and Toxics, U.S. EPA, 401 M Street, SW, Washington, D.C. 20460.

UNISYS CORPORATION

SUMMARY

Between 1988 and 1993, Unisys Corporation reduced releases and off-site transfers of targeted 33/50 Program chemicals from 852,443 pounds to 21,130 pounds, a reduction of approximately 98 percent. These reductions resulted largely from chemical substitutions and the elimination of a solvent cleaning process at the company's manufacturing operations, including the St. Paul, Minnesota facility. Reductions also occurred following decreased production and facility closures that occurred over the time period.

This case study highlights three 33/50 Program chemical reduction projects at Unisys:

- *Replacing a chromic/sulfuric acid etchant with an alkaline etchant;*
- *Replacing solvents used for degreasing with tacky rollers; and*
- *Replacing solvent-based developing and stripping processes with aqueous-based processes.*

These projects resulted in tremendous cost savings for Unisys. The first project yielded an annual cost savings of about $4.88 per circuit board, while the second and third projects yielded total annual cost savings of about $41,000 and $340,600, respectively.

COMPANY BACKGROUND

UNISYS

Unisys Corporation produces computer hardware, software, and information management services for commercial and military customers. The company also manufactures check sorters, postal sorters, and military radar units. Unisys provides its services to financial companies, airlines, telecommunication companies, and government agencies. Created in 1986 by the merger of Sperry and Burroughs, Unisys presently employs 48,000 people in 100 countries. The company is headquartered in Blue Bell, Pennsylvania, and has 20 manufacturing facilities across the United States.

Unisys Corporation has annual revenues of $8 billion. About 80 percent of this revenue is derived from commercial information systems and services, while the remainder comes from electronic systems manufacturing and services for the defense industry.

Environmental Strategy

The Unisys corporate environmental strategy, initiated in 1982, is outlined in a publication entitled *Environmental Stewardship Program*. As described in this document, Unisys is committed to a program of environmental stewardship, which entails managing all activities responsibly, with care and respect for the environment, and not merely complying with government regulations and requirements. This Profile highlights some of the company's environmental achievements and provides an overview of the company's environmental stewardship program.

In addition to participating in the 33/50 Program, Unisys is involved in numerous other environmental programs, including the following:

- *The company has established a program to reduce hazardous waste generated at their facilities. By re-engineering waste generating processes, Unisys has achieved its goal of reducing hazardous waste emissions by 85 percent between 1988 and 1994.*

- *Unisys has a program to eliminate the use of chlorofluorocarbons (CFCs) at its facilities. By the end of 1993, the company eliminated the use of CFCs in precision parts cleaning at their U.S. facilities. Unisys plans to eliminate CFCs from its refrigeration equipment by the end of 1999 through a phaseout program.*

- *Unisys has a proactive recycling program. The company recycles paper, plastic, and aluminum cans and promotes the use of environmentally acceptable packaging materials.*

- *The company participates in many voluntary EPA programs, including the following: Green Lights, a program that encourages the use of energy-efficient light fixtures; Energy Star computers, a program that encourages the computer industry to voluntarily manufacture energy-efficient products; and WasteWi$e, a program that encourages industry to reduce municipal solid waste.*

- *Unisys was a participant in the Minnesota-50 Project, which is similar to EPA's 33/50 Program and establishes a state-wide goal of a 50 percent reduction in releases and transfers of 33/50 Program chemicals by 1995.*

- *The company is an active participant in the Council on Office Products Energy Efficiency and in the International Standards Organization's effort to develop an international environmental standard to encourage companies to incorporate environmental management into their business plans.*

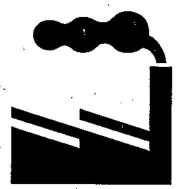
- *Unisys has begun auditing the environmental practices of some of its suppliers. Although this process is informal and conducted on a case-by-case* *basis, Unisys expects to implement a more formal auditing program in the future.*

Because of the company's commitment to environmental protection, Unisys and its facilities have received numerous awards for their efforts in pollution prevention. Some of the accolades received by Unisys include:

- *"Recycler of the Year" finalist, awarded in 1995 by the National Office Paper Recycling Project;*
- *The 1994 Governor's Award for Pollution Prevention from the Minnesota Office of Waste Management, awarded to the St. Paul facility;*
- *The 1994 Governor's Award for Pollution Prevention from the State of California;*
- *A Waste Minimization Award conferred to the Salt Lake City facility by the Department of Public Utilities for Unisys Corporation's efforts in pollution prevention in 1994;*
- *A 1993 Waste Reduction Award from the California Integrated Waste Management Board, which recognizes companies in California without standing programs to reduce, reuse, and recycle waste; and*
- *The Environmental Leadership Award from the Pueblo Area Council of Governments to the Unisys Corporation's Pueblo Colorado facility in 1993 for their efforts in the areas of waste reduction, recycling, reuse, and community service/education.*

At Unisys, environmental stewardship means designing, manufacturing, and selling environmentally acceptable information management solutions.
-Greg Fisher, Vice President Regulatory Affairs, Unisys Corporation.

OVERVIEW OF 33/50 PROGRAM AND TRI CHEMICAL RELEASES AND TRANSFERS



In 1988, Unisys reported total releases and transfers of TRI chemicals of 2,039,899 pounds, of which 42 percent were of 33/50 Program chemicals. Between 1988 and 1993, the following eight facilities reported releases and transfers of 33/50 Program chemicals to TRI: Roseville, St. Paul, and Eagan, Minnesota; Waterbury, Connecticut; Great Neck, New York; Salt Lake City, Utah; and San Diego, California (two facilities). Exhibit 1 presents company data on releases and transfers of TRI chemicals for 1988 and 1993. Exhibits 2 and 3 provide a breakdown of the company's 1988 data by chemical and by media. Additional data are provided in Appendices A through D at the end of this Profile.

Unisys reported releases and transfers of the following six 33/50 Program chemicals since 1988:

Chromium compounds are used primarily in the acidic solutions used to etch copper and clean metal surfaces in circuit board manufacturing processes, and are

Exhibit 1

Releases and Transfers of TRI Chemicals by Unisys Corporation (in Thousands of Pounds)

33/50 Chemicals (1000s lbs.)	1988	1993
Chromium Compounds	48	<1
Dichloromethane	285	NR
Lead & Compounds	5	NR
Methyl Ethyl Ketone	23	NR
1,1,1-Trichloroethane	378	21
Trichloroethylene	114	NR
33/50 Subtotal*	852	21
Other TRI Chemicals	1,187	173
TOTAL*	2,040	194

NR *Not reported to TRI; use below reporting threshold*

* *Columns do not sum to totals due to rounding.*

primarily transferred off-site for treatment and recycling.

Dichloromethane was used for stripping residual photoresist after etching and was released entirely as air emissions.

Lead compounds were principally used in solder plating of printed circuit boards and were transferred off-site to publicly owned treatment works (POTWs) and for recycling.

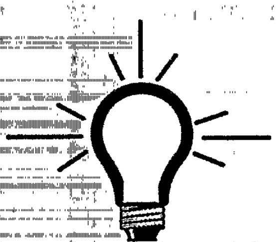
Methyl ethyl ketone (MEK) was a cleaner used in the manufacture of ceramic circuit boards and was released as air emissions.

1,1,1-Trichloroethane (TCA) is used to develop photoresist prior to etching and for cleaning circuit board inner layers prior to assembly, and is released primarily as air emissions.

Trichloroethylene (TCE) was used for cleaning circuit board inner layers prior to assembly, and was released as air emissions.

Unisys pledged a 90 percent reduction of releases and transfers of 33/50 Program chemicals by 1995.

The Unisys facility in St. Paul was the largest contributor to releases and transfers of 33/50 Program chemicals in 1988, and was responsible for 100 percent of MEK and TCE emissions, and 96 percent of dichloromethane emissions reported by the company. Several facilities (Waterbury, Great Neck, Roseville, and two in San Diego) reported releases and transfers of only one chemical, TCA.



33/50 Program Goals and Reduction Projects

Unisys pledged a 90 percent corporate-wide reduction of releases and transfers of 33/50 Program chemicals by 1995, using 1988 TRI levels as a baseline — a reduction goal of 767,199 pounds. The company stated that it intended to rely on source reduction measures to achieve reductions, rather than on recycling or treatment.

To achieve the 90 percent reduction, Unisys established specific waste-reduction goals for its facilities that would result in a 90 percent reduction of

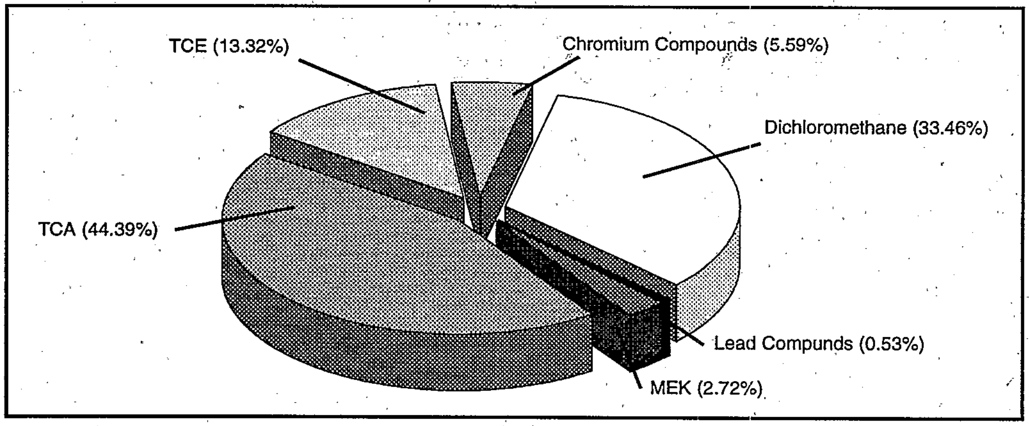


Exhibit 2

Percentage Breakdown of 33/50 Program Chemical Releases and Transfers for 1988 (by Chemical)

TCA, a 100 percent reduction of both TCE and dichloromethane, and a 70 percent reduction in chromium. Releases and transfers of MEK and lead were expected to remain the same, but opportunities for reducing releases and transfers of these chemicals would be evaluated. In July, 1993, Unisys revised its goals for chromium by committing to a 95 percent reduction.

The 33/50 Program at Unisys is administered at the corporate level. The program is directly implemented at the facility level by the environmental and production management at each facility, along with staff members who decide which chemicals to reduce or eliminate and the methods for achieving the reductions.

The pollution reduction efforts at the St. Paul facility account for a majority of the company's total reductions.

This Profile focuses on three projects undertaken at the company's St. Paul facility to reduce or eliminate the use of 33/50 Program chemicals. The St. Paul facility, which employs about 800 workers, manufactures printed circuit boards for the U.S. military. Because the St. Paul facility accounts for the largest quantity of 33/50 Program chemical releases and transfers of any Unisys facility, the pollution reduction efforts at this facility resulted in the majority of the company's reductions of 33/50 Program chemicals. Appendix B at the end of this Profile contains data on releases and transfers of TRI chemicals at the St. Paul facility.

All three projects involved modifying the production process for manufacturing printed circuit boards. Generally, circuit boards consist of multiple

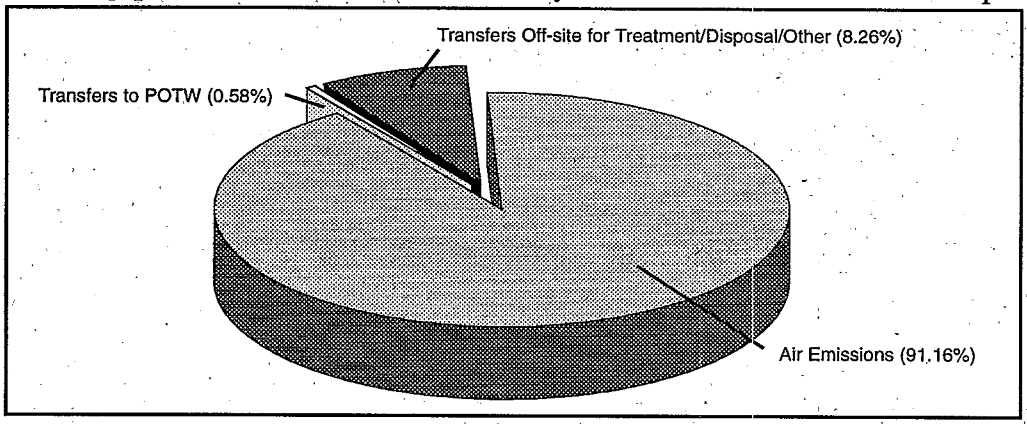
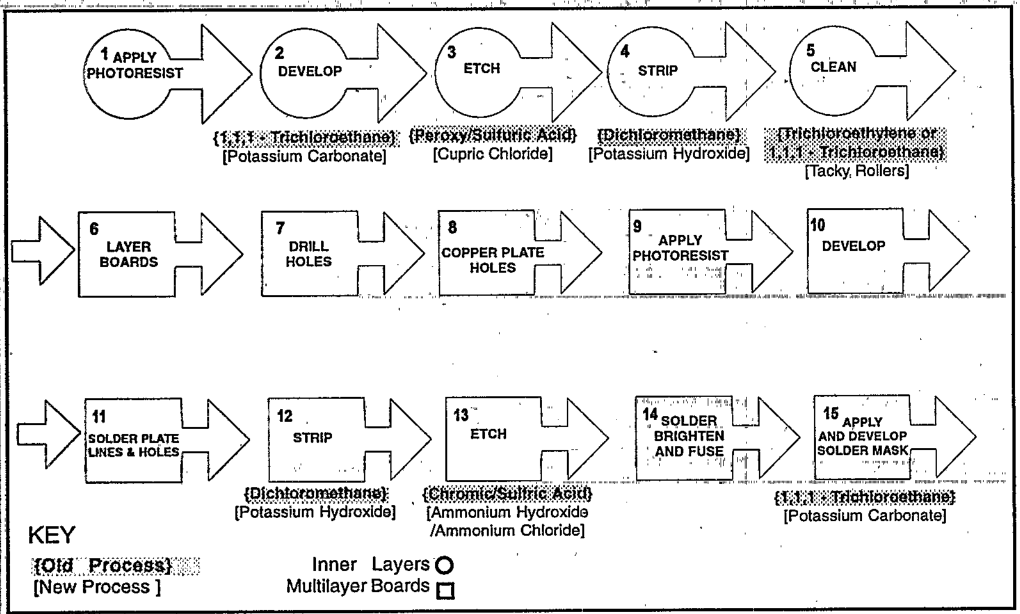


Exhibit 3

Percentage Breakdown of 33/50 Program Chemical Releases and Transfers for 1988 (by Media)

Exhibit 4

Diagram of Printed Circuit Board Manufacturing Process



"inner" layers that are laminated together. "Outer" or "final" layers are then placed on the top and bottom of the stack of inner layers to form a printed circuit board. A schematic of the process for manufacturing printed circuit boards is shown in Exhibit 4 and is referred to in the detailed process description that follows. This schematic also indicates the chemicals used in each of the processes discussed in this Profile.

Circuit boards are manufactured using a complex, multi-step process.

First, a copper-coated inner layer board is covered with a light-sensitive polymer and the circuit board pattern is imprinted on the polymer using ultraviolet light (step 1, apply photoresist). The polymer that is not exposed to light is then removed (step 2, develop). The bare copper is etched away (step 3, etch) and the circuit pattern is cleaned of residual resist (step 4, strip). The inner layers are cleaned and layered on top of each other, final layers of copper-coated board are placed on the top and bottom, and the package is pressed to produce a board (steps 5-6). Holes are then drilled in the board and a two-step plating process is used to coat the holes with copper (steps 7-8).

The circuit pattern is placed on the final layers using analogous steps described for the inner layers. The final layer copper board is coated with a light-sensitive polymer (step 9, apply photoresist) and the area surrounding the circuit board pattern is imprinted on the board using ultraviolet light. The polymer that is not exposed to light (i.e., the circuit board pattern) is removed (step 10, develop). The circuit board pattern and holes are solder-plated (step 11) and excess polymer is removed (step 12, strip). The circuit pattern is then created by etching away all copper except the circuit pattern (the solder plating protects the copper of the final layer circuit pattern from being removed by the stripping process) (step 13, etch).

The circuit board is cleaned with acid to remove metal oxides, dried in an oven, and placed in hot oil to allow the solder to flow, which enhances the electrical connections (step 14, solder brighten and fuse). A permanent, protective layer of polymer, which acts as an insulator, is then placed on the board using similar steps described for the inner and final layers. The polymer is placed on the final layer board, cured on the board using ultraviolet light, and excess polymer is removed (step 15, apply and develop solder mask). The final circuit board is now ready for the assembly process in which components are attached.

Three projects undertaken at the St. Paul facility that reduced or eliminated the use of 33/50 Program chemicals are discussed in this Profile:

- *Replacing a chromic/sulfuric acid etchant for final layer boards with an alkaline etchant;*
- *Replacing solvents for cleaning inner layers (TCE or TCA) with tacky rollers; and*
- *Replacing solvents for developing and stripping (TCA and dichloromethane, respectively) with aqueous processes.*

Project #1: Replacing Chromic/Sulfuric Acid Etchant with an Alkaline Etchant

Chromic/sulfuric acid was used to etch copper from final layers of circuit boards (step 13 in Exhibit 4) resulting in approximately 25,000 pounds of chromium waste in 1988, which the company transferred off-site. Because of the high cost of purchasing and disposing of the chemicals used in this process, Unisys decided to reduce, and if possible, eliminate the use of chromic/sulfuric acid in the final sulfuric etching process. At the time, the disposal cost for chromic acid was one of the largest environmental costs at the facility.

As an initial step in reducing the use of chromic acid, the facility invested about $400,000 in an electrodialytic regeneration system in 1987. This system was designed to regenerate the chromic/sulfuric acid etchant for reuse and to recover the copper etched from the boards for recycling. However, the system malfunctioned almost immediately after installation and was shut down for repairs. In late 1992, after repeated problems and attempts to test and repair the system, Unisys realized the system was unreliable and would not provide the expected cost savings, and shut the system down. The electrodialytic regeneration system was later dismantled and disposed of.

Unisys replaced chromic/sulfric acid etchant with alkaline etchant for 90 percent of its products.

In 1993, a team of operators, production engineers, maintenance personnel, environmental managers, and occupational, safety, and health personnel were assembled to select an etchant that would be more cost effective and reliable, less toxic, generate less waste, and use less rinse water than the chromic/sulfuric acid etchant.

The team considered three alternative etchants: ammonia-based alkaline etchant, peroxy/sulfuric acid, and cupric chloride. These etching chemistries rep-

1

resent those most widely used in the industry. Peroxy/sulfuric acid was very expensive and extremely volatile, while cupric chloride could not be used on final layer boards since it corrodes the solder coating on the boards (step 11 in Exhibit 4). Thus, these two alternatives were eliminated from further consideration. The team compared the costs of using the third alternative, an alkaline etchant, with that of chromic/sulfuric acid, and considered such factors as water use, worker exposure, purchase and disposal costs, and ease of maintenance. The team determined that the alkaline etchant was the more cost-effective (costs are discussed in greater detail below).

Implementation of the alkaline etchant also required a change in the equipment used. Chromic/sulfuric acid is used in an enclosed conveyorized system through which the items being etched pass. However, the equipment used with the chromic/sulfuric acid is not suitable for the ammonia-based alkaline etchant because the entrance and exit openings are large, and ammonia vapors escaping through these openings would be too strong for workers to tolerate. Unisys had to purchase equipment that could transport the items to be etched through the etchant in a closed and automated system.

The team selected etchant equipment based on information gathered a year earlier when another etchant system at the facility was replaced, and used the same manufacturer as had been used before. In July 1993, an alkaline etchant machine was purchased. This machine has rinse modules designed to keep virtually all of the etched copper in the etchant. The copper laden waste etchant is given to the vendor from whom the etchant is originally purchased. The vendor removes the ammonia from this etchant, and the copper oxide that is generated is sold to the wood preservative industry for use as a feed stock in the wood preservative chromated copper arsenate. Because the waste etchant is transferred as a product, it does not require treatment as a RCRA hazardous waste, thereby reducing the costs associated with waste disposal.

The implementation of the alkaline etch system reduced cost by $4.88 per circuit board.

Although the company wanted to eliminate the use of chromic/sulfuric acid as an etchant, it determined that the alkaline etchant was not suitable for certain Unisys products. In particular, the alkaline etchant was not strong enough to cleanly etch copper layers greater than four ounces per square foot. Unisys manufactures several products that use copper layers greater than this thickness, for which it continues to use chromic/sulfuric acid as an etchant. In addition, a flexible cable product that requires etching will not fit through the closed alkaline etch machines and, therefore, must be etched in the open system with chromic/sulfuric acid. Approximately 10 percent of the production at the St. Paul facility is still etched with chromic/sulfuric acid.

Implementing the alkaline etchant system resulted in a considerable cost savings for Unisys. Exhibit 5 compares the costs of the two processes. The company incurred about $95,000 in initial capital costs for the alkaline etchant equipment and $1,000 for disposal of the old chromic etch equipment. The purchase and disposal costs for the alkaline etchant, however, are substantially less than that of the chromic/sulfuric acid etchant. In the first half of 1993, Unisys used

11,015 gallons of chromic acid etchant per year at a cost of $2.14 per circuit board produced. Disposal of spent etchant waste (24,695 gallons generated per year) cost $4.71 per circuit board. In addition, disposal of waste sludge, consisting of chromium, copper, lead, nickel, sulfate, and sodium salts, cost $0.29 per board.

In the second half of 1993, after implementing the alkaline etch system, the company used 2,020 gallons of chromic/sulfuric acid etch and 4,345 gallons of alkaline etch per year, which cost about $1.12 per circuit board produced — a 50 percent reduction in this cost component. Unisys disposed of 3,355 gallons of spent chromic/sulfuric acid etch and alkaline etch waste, costing $0.88 per printed circuit board — an 81 percent reduction in this cost component. Disposal of sludge generated from the chromic/sulfuric acid etch and alkaline etch cost $0.25 per board — a slight decrease from previous sludge disposal costs.

Exhibit 5

Comparison of Costs for Project #1 (Etching)

COST ELEMENT	100% CHROMIC ETCH	90% ALKALINE ETCH 10% CHROMIC ETCH
Fixed Costs:		
Purchase new equipment	Sunk cost	$95,000
Dispose of old equipment		$ 1,000
Annual Costs (per circuit board):		
Chemical purchase	$2.14	$1.12
Disposal of waste entchant	$4.71	$0.88
Disposal of sludge	$0.29	$0.25
Total Annual Cost (per circuit board)	$7.13	$2.25

By implementing the alkaline etching system and using chromic sulfuric acid etchant only for special applications, the company's annual costs dropped nearly 70 percent, from $7.13 per board to $2.25 per board. In addition, the company's water consumption decreased considerably; however, this cost savings can not be calculated separately for this process change.

Unisys now uses chromic/sulfric acid etchant only where necessary.

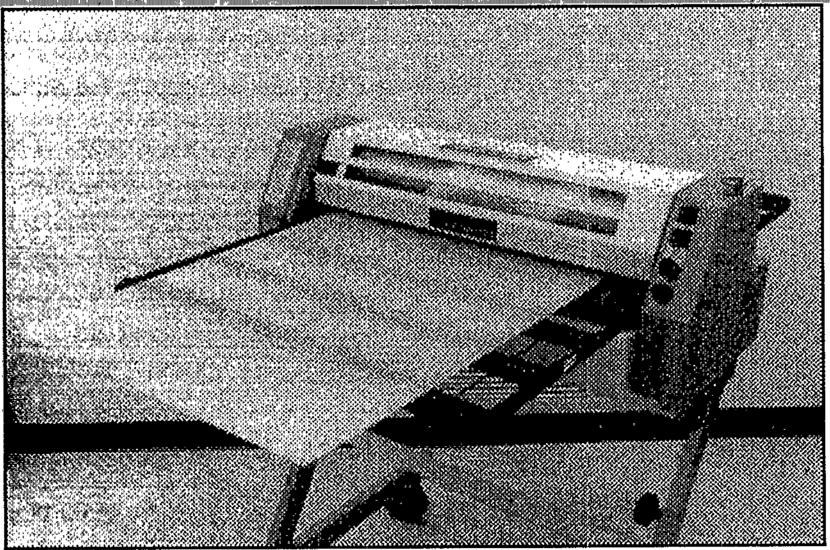
Although Unisys had been aware of the technical feasibility of using alkaline etchant since the 1970s, the decision to convert had been delayed because the etchant could not be used on all products. However, because of the high cost of the chromic/sulfuric acid etchant, and the company's wish to eliminate using 33/50 Program chemicals, Unisys decided to split the production line and use the chromic/sulfuric acid only where it was essential.

Project #2: Replacing Solvents for Degreasing with Tacky Rollers

Chlorinated solvents (TCE and TCA) were used as degreasers to clean the inner layers of the printed circuit boards prior to assembly (step 5 in Exhibit 4). In 1988, this cleaning process released approximately 113,000 pounds of TCE to

Exhibit 6

Tacky Roller Machine



the air. TCE was used for this purpose until 1989, when it was replaced with the less toxic solvent, TCA.

Inner layers were cleaned prior to assembly to remove organic matter like finger prints and loose debris like dust. These contaminants collected on the inner layers, between the time the inner layers were produced and the time they were assembled into circuit boards.

Unisys eliminated the need for solvent cleaning by improved materials handling and use of tacky rollers.

Unisys eliminated the need for solvent cleaning by changing two processes. First, in 1987, Unisys began requiring that employees wear gloves when handling the inner layers. This process change reduced the amount of organic matter that was deposited on the inner layers. Second, about two years later, the company introduced a new process to remove loose debris from the boards.

In 1989, a Unisys employee suggested using tacky rollers instead of solvents to remove loose debris from the inner layers. She had used hand-held rollers covered with tacky paper to remove loose debris while working at another Unisys facility, and had discovered that tacky rollers cleaned the boards better than did TCA. To test this process change, the St. Paul facility purchased a hand-held tacky roller from the manufacturer. About six months later, the manufacturer of the tacky roller produced a completely automated machine, which the St. Paul facility purchased. In January 1990, the use of solvents for inner layer board cleaning was completely eliminated with the implementation of tacky rollers.

The tacky roller machine (Exhibit 6) contains two rollers coated with a tacky substance. A technician manually inserts the board into the machine between the rollers. The rollers pull the board through the machine and roll it back, returning it to the technician. The tacky coating on the rollers removes debris from both sides of the board. The technician then removes the board from the machine and layers the clean boards on top of each other.

Tacky rollers produce a cleaner inner layer board than the solvent degreasing machine.

The tacky rollers produce a cleaner inner layer board than the solvent degreasing machine, which decreases the probability of producing a damaged product. The rollers also reduced the labor required to clean and assemble the boards. Before using tacky rollers, different workers performed the degreasing

Exhibit 7

Comparison of Costs for Project #2

	COST TO CONTINUE SOLVENT CLEANING		COST TO IMPLEMENT TACKY ROLLERS	
Fixed Costs:				
	Sunk Costs		Purchase of 8 tacky roller machines	$24,000
			Disposal of 3 degreasers	$60,000
Annual Costs:				
	Purchase solvents	$46,000	Roller refills	$5,000
	Dispose of waste solvents	$0	Dispose of roller refills	$0
Total Annual Cost		$46,000		$5,000

and the layering of the boards (steps 5 and 6 in Exhibit 4). Using tacky rollers, however, the same worker who layers the boards performs the cleaning.

Using tacky roller machines resulted in cost savings for Unisys. Exhibit 7 compares the costs of the two processes. The initial capital cost to purchase the tacky roller machines was $24,000, while the cost to dispose of the solvent degreasers was $60,000. The annual cost to use tacky rollers for cleaning is considerably less than the cost of using solvents. The annual cost to purchase solvents was approximately $46,000 per year (this cost varies depending on the quantity of solvent used and the price of the solvent). Because Unisys reclaimed most of the solvent, there were usually no waste solvent disposal costs. The annual cost of using the tacky roller machines is about $5,000 per year, the price of roller refills. Each machine has two sets of rollers: one permanent set and one replaceable set that can be thrown in the trash. Additionally, converting to tacky rollers reduced labor and energy costs. Those costs were not quantified by the company. Even ignoring labor and energy cost savings, Unisys achieved annual savings of $41,000, which provided a payback period of just over two years on their capital investment for the new solvent-free cleaning system.

Using tacky roller machines resulted in cost savings for Unisys.

Project #3: Replacing Solvents for Developing and Stripping with Aqueous Processes

TCA and/or dichloromethane were used in three distinct processes in the manufacture of printed circuit boards: to develop and strip inner layer boards (steps 2 and 4 in Exhibit 4); to develop and strip final layer boards (steps 10 and 12); and to develop the solder mask (step 15). In 1988, these develop and strip processes resulted in air emissions of 139,000 pounds of TCA and 274,000 pounds of dichloromethane.

Initially, the decision to replace the developer and the stripper was based on the need to eliminate the use of dichloromethane. In the early 1980s, dichloromethane was found to be carcinogenic, which led to public health concerns about the large quantity of dichloromethane emissions to air from the facility. Because the developer and stripper had to be compatible with each other, eliminating the dichloromethane stripper meant that an alternative developer needed to be found as well.

Production engineers decided to switch to a completely aqueous process to eliminate the use of all solvents.

Replacing the chlorinated solvents used as developers and strippers also required finding photoresist polymers that were compatible with the alternative chemicals. As described previously in the circuit board manufacturing process, the developer is used after the photoresist has been exposed to light to fix the exposed polymer and to remove the unexposed polymer. The stripper removes the exposed polymer after the etching process. The primary barrier to switching develop and strip chemistries was finding a polymer that met the necessary standards and was compatible with the alternative chemistries.

In the early 1980s, Unisys began a program to replace TCA (in developing) with potassium carbonate, and replace dichloromethane (used in stripping) with potassium hydroxide. Substituting these solvents with aqueous solutions was a three-step process. The replacement for inner layer boards occurred in the early 1980s, the replacement for final layer boards occurred in the late 1980s, and the replacement for the solder mask occurred in 1993. The timing of the conversions was determined by the availability of alternative photoresist polymers for each of the three steps, since each consecutive step had increasingly rigorous requirements for the polymer.

For the first conversion (steps 2 and 4 in Exhibit 4), the production engineers at the facility had the option of replacing TCA and dichloromethane used for the inner layer boards with either a semi-aqueous or aqueous developer and stripper. The production engineers decided to switch to a completely aqueous process in order to eliminate the use of all solvents. A team of workers was formed to select the equipment needed to implement the process changes. The team initially reviewed equipment that was available on the market, sent sample circuit boards to manufacturers to test the processes, and selected an equipment manufacturer.

While changes were made to the inner layer process, Unisys tried to replace the developer and stripper used on the final layer boards (steps 10 and 12). However, the company was unable to find a polymer compatible with the aqueous developer and stripper that met the requirements for outer layers. The polymer coating cured on the final layer board must be more durable than that used on the inner layers because the final-layer coating must withstand exposure to more chemicals than the inner-layer coating. It wasn't until the late 1980s, when better methods became available, that the facility could replace the chlorinated solvent developer and stripper with aqueous solutions.

It took a long time to develop processes that were acceptable for military purposes and compatible with the company's production process.

In the late 1980s, Unisys began testing aqueous-based systems for the final solder mask (step 15). However, it took a long time to develop a process that was both acceptable for military purposes and compatible with the company's process. Because the solder mask is a permanent coating that remains on the board, military standards (mil specs) for this process were more rigorous than for polymers used in earlier processes. At the time, there were products available that met the mil specs, but these products were not compatible with the Unisys process. The company did not want to invest the money to research and develop a new process. In 1993, the manufacturer of the solvent-compatible solder mask used by Unisys discontinued production and the facility was forced to find an alternative solder mask. By this time, products had been developed that were compatible with the Unisys process and with the mil specs. By converting to an aqueous-compatible solder mask, Unisys replaced TCA with potassium carbonate, which completely eliminated the use of TCA at the St. Paul facility.

Replacing the solvents used for developing and stripping with aqueous processes required a large capital investment for equipment for each process change (see Exhibit 8). The developer and stripper equipment for the inner layer boards cost about $330,000. The developer and stripper equipment for the final layer boards cost about $160,000, and the solder mask developer equipment cost about $87,000. The annual purchase cost of chemicals, however, has dropped considerably following the implementation of the aqueous processes. The annual cost of chemicals for developing inner and final layer boards dropped from $63,000 when using TCA to $4,900 when using potassium carbonate. In addition, the annual cost of chemicals for stripping inner and final layer boards declined from $266,500 when using dichloromethane to $9,100 when using potassium hydroxide. With the solder mask developer, annual chemical costs dropped from $27,400 when using TCA to $2,300 when using potassium carbonate.

Exhibit 8

Comparison of Costs for Project #3

COST ELEMENT	CONTINUE USE OF SOLVENTS	IMPLEMENT AQUEOUS PROCESSES
	develop and strip inner and final layer boards	
Fixed costs:		
Purchase new equipment	**Sunk costs**	**$490,000**
Annual costs:		
Chemical purchase	**$329,500**	**$14,000**
	develop solder mask	
Fixed costs:		
Purchase new equipment	**Sunk costs**	**$87,000**
Anuual costs:		
Chemical purchase	**$27,400**	**$2,300**

Conversion to aqueous processes required large capital investments but resulted in lower annual costs.

The replacement of solvents for developing and stripping with aqueous processes resulted in tremendous savings for Unisys. Substituting solvents for developing inner and final layer boards with aqueous processes resulted in an annual savings of $316,000, on a capital investment of $490,000. Replacement of solvents with aqueous processes for solder mask developing resulted in an annual savings of $25,000 on an $87,000 capital investment.

In addition to the costs discussed above, other significant costs included chemical disposal costs, equipment disposal costs, and changes in wastewater treatment costs. However, Unisys was not able to provide quantitative estimates of these costs. The company also incurred significant costs developing new waste treatment methods for wastes from the aqueous system. The most significant issue was developing a process for removing the heavy metals from the aqueous waste. The aqueous chemicals made the wastewater treatment process more difficult because they chelate metals, thereby making these metals more difficult to separate from the cleaning solution in the treatment process. It took Unisys nearly a year to develop a waste treatment method that worked consistently and economically.

33/50 Program Progress and TRI Data Summary

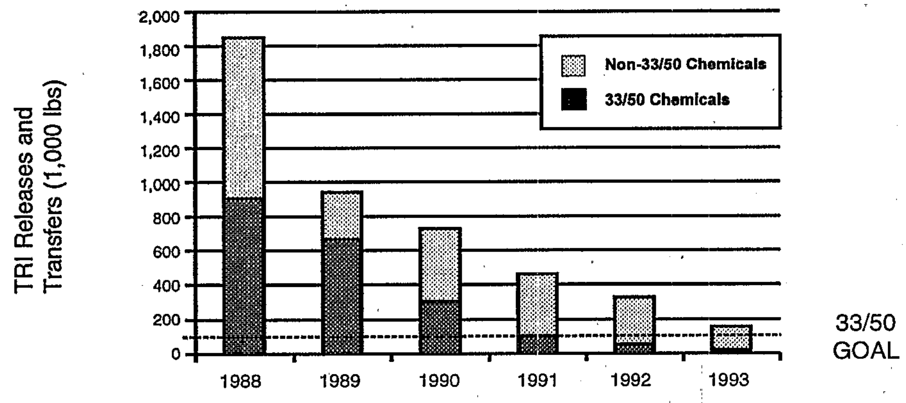
Unisys reduced releases and transfers of 33/50 Program chemicals by over 831,313 pounds between 1988 and 1993 — a 98 percent reduction from 852,443 pounds to 21,130 pounds. As shown in Exhibit 9, the company has surpassed its goal of a 90 percent reduction in releases and transfers of 33/50 Program chemicals. Of the six 33/50 Program chemicals used by Unisys, the largest reductions were from chromium compounds, dichloromethane, TCA, and TCE. Use of dichloromethane and TCE has been completely eliminated. Releases and transfers of TCA have decreased by 95 percent since 1988. The use of chromium compounds dropped below the 10,000 pound reporting threshold. Exhibits 10 and 11 show the percentage breakdown of 1993 33/50 Program chemical releases and transfers by chemical and by media, respectively.

Unisys reduced releases and transfers of 33/50 Program chemicals by 98 percent.

The sources for the company-wide reductions of 33/50 Program chemicals are illustrated in Exhibit 12. Of the total reductions, 65 percent were achieved by process changes made at the St. Paul facility, and one percent resulted from process changes made at other facilities. The remaining 34 percent of reductions resulted from decreases in production and closure of manufacturing operations. The company has significantly reduced its size, from 120,000

Exhibit 9

Unisys Corporation's Progress Towards Meeting its 33/50 Program Goals



33/50 Goal: 90% reduction in releases and transfers of 33/50 chemicals by 1995

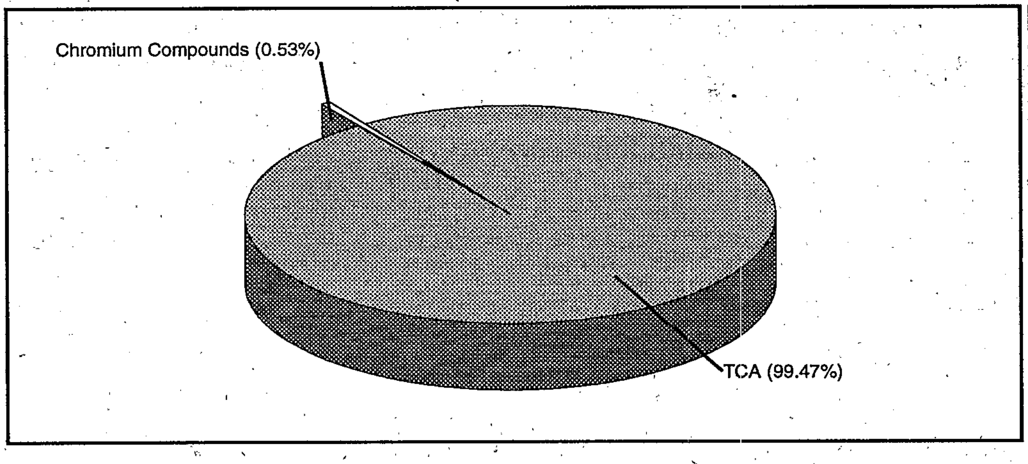


Exhibit 10

Percentage Breakdown of 33/50 Program Chemical Releases and Transfers for 1993 (by Chemical)

employees and $10 billion of revenue in 1988, to 48,000 employees and $8 billion of revenue in 1993.

At the St. Paul facility, the majority of reductions in releases and transfers of 33/50 Program chemicals resulted from process changes. At this facility, the use of dichloromethane and TCE decreased by 100 percent since 1988. Releases and transfers of TCA at this facility decreased 91 percent, while use of chromium compounds dropped below the reporting threshold.

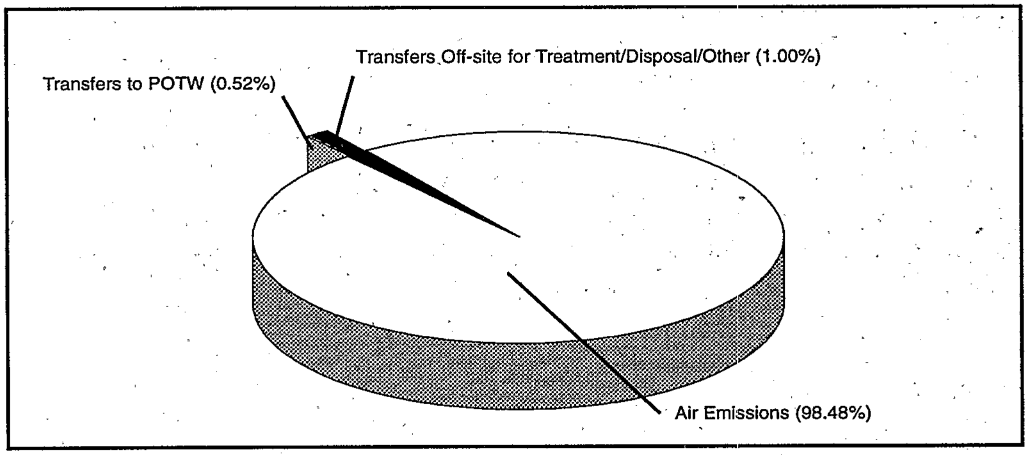


Exhibit 11

Percentage Breakdown of 33/50 Program Chemical Releases and Transfers for 1933 (by Media)

Exhibit 13 presents data on the sources of reductions in releases and transfers of 33/50 chemicals at the St. Paul facility. Seventy-one percent of the reductions were achieved by substituting aqueous processes for TCA as the developer and dichloromethane as the stripper. Twenty percent of the reductions resulted from replacing TCE with tacky rollers, and five percent were achieved by replacing chromic acid etchant with an alkaline etchant.

Although not a part of its 33/50 Program goal, Unisys has reduced emissions of TRI chemicals not targeted by the 33/50 Program. Releases and transfers of non-33/50 TRI chemicals decreased by 85 percent, from 1,187,456 pounds in 1988 to 173,297 pounds in 1993. At the St. Paul facility, releases and transfers of

Exhibit 12

Sources of Reductions in Releases and Transfers at Unisys (1988 - 1993)

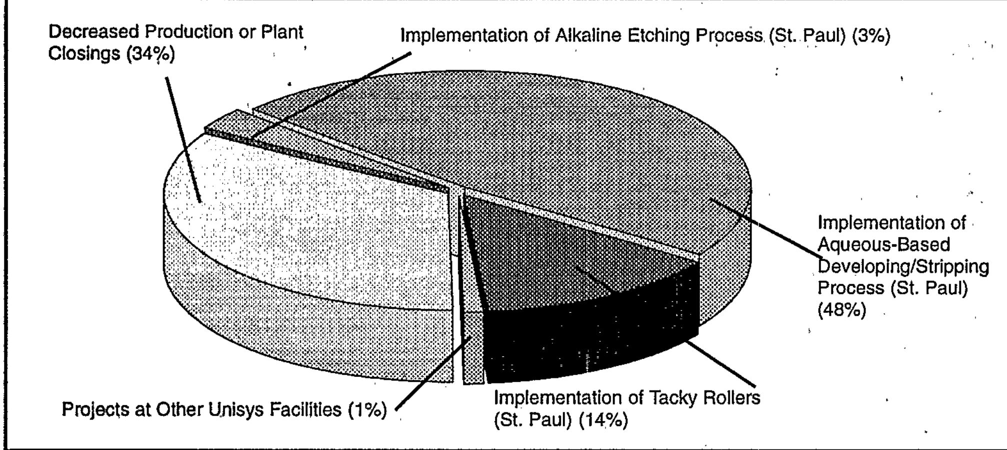
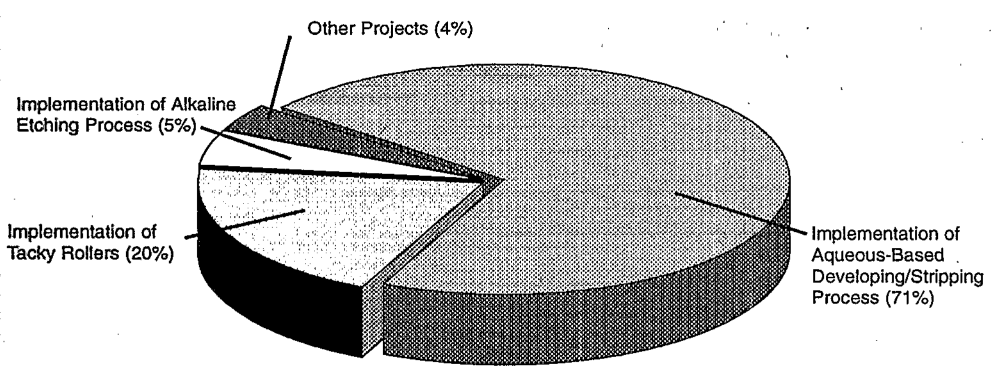


Exhibit 13

Sources of Reductions in Releases and Transfers at the St. Paul Facility (1988 - 1993)



Total St. Paul facility reductions in releases and transfers = 562,207 pounds

non-33/50 TRI chemicals have decreased by 86 percent, from 495,589 pounds in 1988 to 70,575 pounds in 1993. The largest reductions in releases and transfers at the St. Paul facility are for copper, CFC-113, and sulfuric acid, which decreased 97, 88, and 85 percent, respectively, since 1988. These reductions may be attributed to several factors: copper use has declined due to reduced production, CFC-113 is being phased out under the Montreal Protocol, and sulfuric acid used in etchant processes has been replaced.

FUTURE CHALLENGES

Despite the success of Unisys in reducing the use of 33/50 Program chemicals, the company continues to investigate methods to eliminate the use of 33/50 Program and other TRI chemicals. Company-wide, Unisys plans to eliminate CFCs by 1999 and is currently phasing out CFC-refrigerants from its facilities by converting to non-CFC refrigerants in existing equipment or by replacing outdated equipment. The company's Roseville facility recently replaced lead used in soldering with tin and bismuth in some processes. At its St. Paul facility, several projects are being planned to further reduce the use of 33/50 Program chemicals. The need to completely eliminate the use of chromic acid as an etchant is under discussion, and methods to reduce the use of methyl ethyl ketone needed for the manufacture of ceramic circuit boards are being researched.

CONTACT FOR FURTHER INFORMATION

For additional information on any of the information provided in this case study, please contact the following individual:

Greg Fischer
Vice President Regulatory Affairs
Unisys Corporation
25725 Jeronimo Road
Mission Viejo, CA 92691
Tel: (714) 380-5532
Fax: (714) 380-6634

Appendix A
Unisys Company
Releases and Transfers of TRI Chemicals, 1988-1993

Chemical	Year	Total Air Emissions (pounds)	Surface Water Discharges (pounds)	Underground Injection (pounds)	Releases to Land (pounds)	Transfers to POTW (pounds)	Transfers Off-site for Treatment/ Disposal/Other (pounds)	Total Releases and Transfers (pounds)(1)	Percent Change 1988-1993 Total Releases and Transfers
Chromium compounds	1988	0	0	0	0	1,322	46,298	47,620	
	1989	0	0	0	0	797	32,422	33,219	
	1990	0	0	0	0	1,857	28,649	30,506	
	1991	0	0	0	0	338	6,070	6,408	
	1992	0	0	0	0	81	27	108	
	1993	0	0	0	0	109	2	111	-100%
Dichloromethane	1988	285,229	0	0	0	0	0	285,229	
	1989	89,733	0	0	0	0	0	89,733	-100%
Lead	1991	0	0	0	0	96	169	265	
Lead compounds	1988	0	0	0	0	250	4,300	4,550	
	1989	0	0	0	0	250	3,500	3,750	-100%
Methyl ethyl ketone	1988	23,154	0	0	0	0	0	23,154	
	1989	17,045	0	0	0	0	0	17,045	
	1990	9,613	0	0	0	0	0	9,613	
	1991	22,142	0	0	0	0	0	22,142	
	1992	14,066	0	0	0	0	0	14,066	-100%
1,1,1-Trichloroethane	1988	355,143	0	0	0	3,380	19,855	378,378	
	1989	456,523	0	0	0	1,407	4,862	462,792	
	1990	216,324	0	0	0	250	7,095	223,669	
	1991	77,142	0	0	0	0	0	77,142	
	1992	42,686	0	0	0	0	44	42,730	
	1993	20,809	0	0	0	0	210	21,019	-94%

Appendix A
Unisys Company
Releases and Transfers of TRI Chemicals, 1988-1993

Chemical	Year	Total Air Emissions (pounds)	Surface Water Discharges (pounds)	Underground Injection (pounds)	Releases to Land (pounds)	Transfers to POTW (pounds)	Transfers Off-site for Treatment/ Disposal/Other (pounds)	Total Releases and Transfers (pounds)(1)	Percent Change 1988-1993 Total Releases and Transfers
Trichloroethylene	1988	113,512	0	0	0	0	0	113,512	
	1989	73,929	0	0	0	0	0	73,929	-100%
33/50 Program Chemicals	**1988**	**777,038**	**0**	**0**	**0**	**4,952**	**70,453**	**852,443**	
	1989	**637,230**	**0**	**0**	**0**	**2,454**	**40,784**	**680,468**	
	1990	**225,937**	**0**	**0**	**0**	**2,107**	**35,744**	**263,788**	
	1991	**99,284**	**0**	**0**	**0**	**434**	**6,239**	**105,957**	
	1992	**56,752**	**0**	**0**	**0**	**81**	**71**	**56,904**	
	1993	**20,809**	**0**	**0**	**0**	**109**	**212**	**21,130**	**-98%**
Copper	1988	0	0	0	0	1,146	23,768	24,914	
	1989	0	0	0	0	1,070	13,571	14,641	
	1990	0	0	0	0	2,083	18,583	20,666	
	1991	0	0	0	0	676	3,900	4,576	
	1992	0	0	0	0	288	541	829	
	1993	0	0	0	0	674	0	674	-97%
Freon 113	1988	616,415	0	0	0	4,619	21,708	642,742	
	1989	522,782	0	0	0	1,000	26,250	550,032	
	1990	417,578	0	0	0	5	20,130	437,713	
	1991	268,215	0	0	0	0	1,896	270,111	
	1992	188,765	0	0	0	0	2,328	191,093	
	1993	98,094	0	0	0	0	5,033	103,127	-84%
Sulfuric acid	1988	2,750	0	0	0	0	268,557	271,307	
	1989	2,750	0	0	0	0	199,759	202,509	
	1990	3,805	0	0	0	5	160,128	163,938	
	1991	9,445	0	0	0	27	118,391	127,863	

Appendix A
Unisys Company
Releases and Transfers of TRI Chemicals, 1988-1993

Chemical	Year	Total Air Emissions (pounds)	Surface Water Discharges (pounds)	Underground Injection (pounds)	Releases to Land (pounds)	Transfers to POTW (pounds)	Transfers Off-site for Treatment/ Disposal/Other (pounds)	Total Releases and Transfers (pounds)(1)	Percent Change 1988-1993 Total Releases and Transfers
	1992	5,443	0	0	0	70	71,876	77,389	
	1993	1,815	0	0	0	78	42,868	44,761	-84%
Non 33/50 Program Chemicals	1988	675,656	0	0	0	182,267	329,533	1,187,456	
	1989	556,805	0	0	0	63,662	309,380	929,847	
	1990	437,628	5	5	20	127,913	205,392	770,963	
	1991	282,808	6,575	0	0	20,544	124,969	434,896	
	1992	196,327	0	0	0	1,729	74,807	272,863	
	1993	101,486	0	0	0	23,040	48,771	173,297	-85%
All TRI Chemicals	1988	1,452,694	0	0	0	187,219	399,986	2,039,899	
	1989	1,194,035	0	0	0	66,116	350,164	1,610,315	
	1990	663,565	5	5	20	130,020	241,136	1,034,751	
	1991	382,092	6,575	0	0	20,978	131,208	540,853	
	1992	253,079	0	0	0	1,810	74,878	329,767	
	1993	122,295	0	0	0	23,149	48,983	194,427	-84%
Percent Change, 1988-1993									
33/50 Program Chemicals		-97%	--	--	--	-98%	-100%	-98%	
Non 33/50 Program Chemicals		-85%	--	--	--	-87%	-85%	-85%	
All TRI Chemicals		8%	--	--	--		12%	10%	

(1) 1991, 1992, and 1993 Total Releases and Transfers do not include transfers off-site for recycling or energy recovery.

Appendix B
Unisys Company (Selected Facilities)
Releases and Transfers of TRI Chemicals, 1988-1993

Facility	Chemical	Year	Total Air Emissions (pounds)	Surface Water Discharges (pounds)	Underground Injection (pounds)	Releases to Land (pounds)	Transfers to POTW (pounds)	Transfers Off-site for Treatment/ Disposal/Other (pounds)	Total Releases and Transfers (pounds)
PARAMAX SYSTEMS CORP. - SAINT PAUL, MN									
	Chromium compounds	1988	0	0	0	0	1,072	24,498	25,570
		1990	0	0	0	0	1,857	28,649	30,506
		1991	0	0	0	0	338	6,070	6,408
		1992	0	0	0	0	81	27	108
		1993	0	0	0	0	109	2	111
	Dichloromethane	1988	274,460	0	0	0	0	0	274,460
		1989	80,933	0	0	0	0	0	80,933
	Lead	1991	0	0	0	0	96	169	265
	Methyl ethyl ketone	1988	23,154	0	0	0	0	0	23,154
		1990	9,613	0	0	0	0	0	9,613
		1991	22,142	0	0	0	0	0	22,142
		1992	14,066	0	0	0	0	0	14,066
	1,1,1-Trichloroethane	1988	138,576	0	0	0	0	0	138,576
		1989	103,306	0	0	0	0	0	103,306
		1990	88,841	0	0	0	0	0	88,841
		1991	62,200	0	0	0	0	0	62,200
		1992	27,267	0	0	0	0	0	27,267
		1993	12,954	0	0	0	0	0	12,954
	Trichloroethylene	1988	113,512	0	0	0	0	0	113,512
		1989	73,929	0	0	0	0	0	73,929
	33/50 Program Chemicals	**1988**	**549,702**	**0**	**0**	**0**	**1,072**	**24,498**	**575,272**
		1989	**258,168**	**0**	**0**	**0**	**0**	**0**	**258,168**
		1990	**98,454**	**0**	**0**	**0**	**1,857**	**28,649**	**128,960**
		1991	**84,342**	**0**	**0**	**0**	**434**	**6,239**	**91,015**

Appendix B
Unisys Company (Selected Facilities)
Releases and Transfers of TRI Chemicals, 1988-1993

Facility	Chemical	Year	Total Air Emissions (pounds)	Surface Water Discharges (pounds)	Underground Injection (pounds)	Releases to Land (pounds)	Transfers to POTW (pounds)	Transfers Off-site for Treatment/ Disposal/Other (pounds)	Total Releases and Transfers (pounds)
		1992	**41,333**	**0**	**0**	**0**	**81**	**27**	**41,441**
		1993	**12,954**	**0**	**0**	**0**	**109**	**2**	**13,065**
	Copper	1988	0	0	0	0	1,146	23,768	24,914
		1989	0	0	0	0	1,070	13,571	14,641
		1990	0	0	0	0	2,083	18,583	20,666
		1991	0	0	0	0	676	3,900	4,576
		1992	0	0	0	0	288	541	829
		1993	0	0	0	0	674	0	674
	Freon 113	1988	173,666	0	0	0	0	0	173,666
		1989	116,752	0	0	0	0	0	116,752
		1990	78,666	0	0	0	0	0	78,666
		1991	72,582	0	0	0	0	0	72,582
		1992	70,215	0	0	0	0	0	70,215
		1993	20,594	0	0	0	0	0	20,594
	Sulfuric acid	1988	0	0	0	0	0	265,704	265,704
		1989	0	0	0	0	0	199,759	199,759
		1990	0	0	0	0	0	150,336	150,336
		1991	3,500	0	0	0	22	114,091	117,613
		1992	2,638	0	0	0	65	66,776	69,479
		1993	0	0	0	0	73	38,968	39,041
	Non 33/Program Chemicals	1988	204,971	0	0	0	1,146	289,472	495,589
		1989	130,635	0	0	0	1,070	213,330	345,035
		1990	79,916	0	0	0	2,083	168,919	250,918
		1991	76,369	0	0	0	699	117,991	195,059
		1992	73,293	0	0	0	364	67,317	140,974
		1993	20,757	0	0	0	10,850	38,968	70,575

Appendix B
Unisys Company (Selected Facilities)
Releases and Transfers of TRI Chemicals, 1988-1993

Facility	Chemical	Year	Total Air Emissions (pounds)	Surface Water Discharges (pounds)	Underground Injection (pounds)	Releases to Land (pounds)	Transfers to POTW (pounds)	Transfers Off-site for Treatment/ Disposal/Other (pounds)	Total Releases and Transfers (pounds)
	All TRI Chemicals	1988	754,673	0	0	0	2,218	313,970	1,070,861
		1989	388,803	0	0	0	1,070	213,330	603,203
		1990	178,370	0	0	0	3,940	197,568	379,878
		1991	160,711	0	0	0	1,133	124,230	286,074
		1992	114,626	0	0	0	445	67,344	182,415
		1993	33,711	0	0	0	10,959	38,970	83,640

(1) 1991, 1992 and 1993 Total Releases and Transfers do not include transfers off-site recycling or energy recovery.

Appendix C
Unisys Company
Pollution Prevention Act Reporting, 1991-1994 Data and 1995 Projections

Chemical	Year	Recycled On-Site (pounds)	Recycled Off-Site (pounds)	Energy Recovery On-Site (pounds)	Energy Recovery Off-Site (pounds)	Treated On-Site (pounds)	Treated Off-Site (pounds)	Quantity Released (pounds)	Percent Change 1991-1995 Quantity Released	Total Production Related Wastes (pounds)	Percent Change 1991-1995 Production Related Wastes
Chromium compounds	1991	440	19,891	0	0	0	6,408	0		26,739	
	1992	5,500	20,072	0	0	0	108	0		25,680	
	1993	0	13,874	0	0	0	111	0		13,985	
	1994	0	3,800	0	0	0	30	0		3,830	
	1995	0	2,800	0	0	0	23	0		2,823	-89%
Lead	1991	0	3,474	0	0	840	265	0		4,579	
	1992	0	6,282	0	0	891	110	0		7,283	
	1993	0	6,282	0	0	891	110	0		7,283	
	1994	0	0	0	0	0	0	0		0	
	1995	0	0	0	0	0	0	0		0	-100%
Methyl ethyl ketone	1991	0	12,898	0	0	0	0	22,142		35,040	
	1992	0	15,125	0	1,106	0	0	14,066		30,297	
	1993	0	5,000	0	0	0	0	4,000		9,000	
	1994	0	8,000	0	0	0	0	6,400		14,400	
	1995	0	0	0	0	0	0	0	-100%	0	-100%
1,1,1-Trichloroethane	1991	0	15,954	0	0	0	0	76,892		92,846	
	1992	0	21,110	0	0	0	0	42,267		63,377	
	1993	0	19,261	0	0	0	210	20,809		40,280	
	1994	0	0	0	0	0	0	0		0	
	1995	0	0	0	0	0	0	0	-100%	0	-100%
33/50 Program Chemicals	**1991**	**440**	**52,217**	**0**	**0**	**840**	**6,673**	**99,034**		**159,204**	
	1992	**5,500**	**62,589**	**0**	**1,106**	**891**	**218**	**56,333**		**126,637**	
	1993	**0**	**44,417**	**0**	**0**	**891**	**431**	**24,809**		**70,548**	
	1994	**0**	**11,800**	**0**	**0**	**0**	**30**	**6,400**		**18,230**	
	1995	**0**	**2,800**	**0**	**0**	**0**	**23**	**0**	**-100%**	**2,823**	**-98%**

Appendix C
Unisys Company
Pollution Prevention Act Reporting, 1991-1994 Data and 1995 Projections

Chemical	Year	Recycled On-Site (pounds)	Recycled Off-Site (pounds)	Energy Recovery On-Site (pounds)	Energy Recovery Off-Site (pounds)	Treated On-Site (pounds)	Treated Off-Site (pounds)	Quantity Released (pounds)	Percent Change 1991-1995 Quantity Released	Total Production Related Wastes (pounds)	Percent Change 1991-1995 Production Related Wastes
Copper	1991	30,000	77,759	0	0	0	4,576	0		112,335	
	1992	21,296	81,431	0	0	0	829	0		103,556	
	1993	0	74,997	0	0	0	674	0		75,671	
	1994	0	60,000	0	0	0	300	0		60,300	
	1995	0	45,000	0	0	0	225	0		45,225	-60%
Freon 113	1991	48,857	34,043	0	0	0	1,410	316,066		400,376	
	1992	41,572	13,621	0	0	0	2,713	231,029		288,935	
	1993	8,500	7,151	0	0	0	2,723	145,197		163,571	
	1994	5,080	6,700	0	0	0	0	8,621		20,401	
	1995	0	0	0	0	0	0	0	-100%	0	-100%
Sulfuric acid	1991	10,200	0	0	0	653,925	118,413	5,705		788,243	
	1992	33,293	0	0	0	646,402	71,941	4,453		756,089	
	1993	0	0	0	0	578,414	42,941	1,800		623,155	
	1994	0	0	0	0	452,000	34,500	1,800		488,300	
	1995	0	0	0	0	419,000	26,000	1,800	-68%	446,800	-43%
Non 33/50 Program Chemicals	1991	90,357	388,232	0	1,500	1,269,189	143,295	324,429		2,217,002	
	1992	100,861	225,577	0	0	1,297,124	110,611	238,666		1,972,839	
	1993	17,300	124,148	0	0	1,034,106	87,616	150,058		1,413,228	
	1994	45,080	111,700	0	0	875,900	56,923	11,778		1,101,381	
	1995	81,000	90,000	0	0	774,550	46,192	3,080	-99%	994,822	-55%
All TRI Chemicals	1991	90,797	440,449	0	1,500	1,270,029	149,968	423,463		2,376,206	
	1992	106,361	288,166	0	1,106	1,298,015	110,829	294,999		2,099,476	
	1993	17,300	168,565	0	0	1,034,997	88,047	174,867		1,483,776	
	1994	45,080	123,500	0	0	875,900	56,953	18,178		1,119,611	
	1995	81,000	92,800	0	0	774,550	46,215	3,080	-99%	997,645	-58%

Appendix C
Unisys Company
Pollution Prevention Act Reporting, 1991-1994 Data and 1995 Projections

Chemical	Year	Recycled On-Site (pounds)	Recycled Off-Site (pounds)	Energy Recovery On-Site (pounds)	Energy Recovery Off-Site (pounds)	Treated On-Site (pounds)	Treated Off-Site (pounds)	Quantity Released (pounds)	Percent Change 1991-1995 Quantity Released	Total Production Related Wastes (pounds)	Percent Change 1991-1995 Production Related Wastes
Percent Changes, 1991-1995											
33/50 Program chemicals		-100%	-95%	--	--	-100%	-100%	-100%		-98%	
Non 33/50 Program chemicals		-10%	-77%	--	-100%	-39%	-68%	-99%		-55%	
All TRI Chemicals		-11%	-79%	--	-100%	-39%	-69%	-99%		-58%	

Appendix D
Unisys Company (Selected Facilities)
Pollution Prevention Act Reporting, 1991-1994 Data and 1995 Projections

Chemical	Year	Recycled On-Site (pounds)	Recycled Off-Site (pounds)	Energy Recovery On-Site (pounds)	Energy Recovery Off-Site (pounds)	Treated On-Site (pounds)	Treated Off-Site (pounds)	Quantity Released (pounds)	Percent Change 1991-1995 Quantity Released	Total Production Related Wastes (pounds)	Percent Change 1991-1995 Production Related Wastes
PARAMAX SYSTEMS CORP. - SAINT PAUL, MN											
Chromium compounds	1991	440	19,891	0	0	0	6,408	0		26,739	
	1992	5,500	20,072	0	0	0	108	0		25,680	
	1993	0	13,874	0	0	0	111	0		13,985	
	1994	0	3,800	0	0	0	30	0		3,830	
	1995	0	2,800	0	0	0	23	0		2,823	-89%
Lead	1991	0	3,474	0	0	840	265	0		4,579	
	1992	0	6,282	0	0	891	110	0		7,283	
	1993	0	6,282	0	0	891	110	0	-100%	7,283	-100%
Methyl ethyl ketone	1991	0	12,898	0	0	0	0	22,142		35,040	
	1992	0	15,125	0	1,106	0	0	14,066		30,297	
	1993	0	5,000	0	0	0	0	4,000		9,000	
	1994	0	8,000	0	0	0	0	6,400	-100%	14,400	-100%
1,1,1-Trichloroethane	1991	0	8,470	0	0	0	0	62,200		70,670	
	1992	0	19,360	0	0	0	0	27,267		46,627	
	1993	0	14,520	0	0	0	0	12,954		27,474	
	1994	0	0	0	0	0	0	0		0	
	1995	0	0	0	0	0	0	0	-100%	0	-100%
33/50 Program Chemicals	**1991**	**440**	**44,733**	**0**	**0**	**840**	**6,673**	**84,342**		**137,028**	
	1992	**5,500**	**60,839**	**0**	**1,106**	**891**	**218**	**41,333**		**109,887**	
	1993	**0**	**39,676**	**0**	**0**	**891**	**221**	**16,954**		**57,742**	
	1994	**0**	**11,800**	**0**	**0**	**0**	**30**	**6,400**		**18,230**	
	1995	**0**	**2,800**	**0**	**0**	**0**	**23**	**0**	**-100%**	**2,823**	**-98%**
Copper	1991	30,000	77,759	0	0	0	4,576	0		112,335	
	1992	21,296	81,431	0	0	0	829	0		103,556	

Appendix D

Unisys Company (Selected Facilities)

Pollution Prevention Act Reporting, 1991-1994 Data and 1995 Projections

Chemical	Year	Recycled On-Site (pounds)	Recycled Off-Site (pounds)	Energy Recovery On-Site (pounds)	Energy Recovery Off-Site (pounds)	Treated On-Site (pounds)	Treated Off-Site (pounds)	Quantity Released (pounds)	Percent Change 1991-1995 Quantity Released	Total Production Related Wastes (pounds)	Percent Change 1991-1995 Production Related Wastes
	1993	0	74,997	0	0	0	674	0		75,671	
	1994	0	60,000	0	0	0	300	0		60,300	
	1995	0	45,000	0	0	0	225	0		45,225	-60%
Freon 113	1991	0	14,800	0	0	0	0	72,582		87,382	
	1992	0	7,150	0	0	0	0	70,215		77,365	
	1993	0	3,908	0	0	0	0	20,594		24,502	
	1994	0	1,700	0	0	0	0	2,700		4,400	
	1995	0	0	0	0	0	0	0	-100%	0	-100%
Sulfuric acid	1991	10,200	0	0	0	230,363	114,113	3,500		358,176	
	1992	33,293	0	0	0	161,007	66,841	2,638		263,779	
	1993	0	0	0	0	165,045	39,041	0		204,086	
	1994	0	0	0	0	132,000	31,000	0		163,000	
	1995	0	0	0	0	99,000	23,000	0	-100%	122,000	-66%
Non 33/50 Program Chemicals	1991	40,200	92,559	0	0	329,332	118,690	76,369		657,150	
	1992	54,589	88,581	0	0	204,586	76,396	73,293		497,445	
	1993	0	78,905	0	0	217,960	49,813	20,700		367,378	
	1994	0	61,700	0	0	185,400	40,223	2,807		290,130	
	1995	0	45,000	0	0	139,000	29,942	80	-100%	214,022	-67%
All TRI Chemicals	1991	40,640	137,292	0	0	330,172	125,363	160,711		794,178	
	1992	60,089	149,420	0	1,106	205,477	76,614	114,626		607,332	
	1993	0	118,581	0	0	218,851	50,034	37,654		425,120	
	1994	0	73,500	0	0	185,400	40,253	9,207		308,360	
	1995	0	47,800	0	0	139,000	29,965	80	-100%	216,845	-73%