United States Environmental Protection Agency
Office of Pollution Prevention and Toxics 7408
EPA745-K-95-005
*August 1995*

EPA

# EPA's 33/50 Program Company Profile

**LOCKHEED MARTIN**

Partnership in Prevention
Government-Industry-Community

Printed on Recycled Paper

# *EPA's 33/50 Program*
## *Company Profiles*

*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 November, 1995, nearly 1,300 companies had elected to participate in the Program, pledging to reduce emissions of the 17 target chemicals by more than 380 million pounds by 1995. Companies set their own reduction targets, which may vary from the Program's national 33% and 50% reduction goals.*

**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

*Industry exceeded the 33/50 Program's interim 33% reduction goal by more than 100 million pounds in 1992. National emissions of Program chemicals were reduced by an additional 100 million pounds in 1993, bringing total reductions since 1988 to more than 685 million pounds (46%). Facilities' TRI projections suggest that the Program's ultimate 50% reduction goal will be observed to have been achieved or exceeded in the 1994 TRI data, a full year ahead of schedule. The 1,300 companies enrolled in the 33/50 Program have accounted for most of the Program's pollution reductions. Representing just 15% of eligible companies and owning only a third of the facilities reporting Program chemicals to TRI, participants are responsible for 78% of the reductions since 1988 and 98% of the 100 million pounds reduced in 1993.*

*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 how companies have achieved their emissions reductions. 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. Mention of trade names, products, or services in this document does not convey, and should not be interpreted to convey, official EPA approval, endorsement, or recommendation.*

*Copies of other 33/50 Program Company Profiles, as well as Reductions Highlights documents summarizing all of these Profiles, may be obtained by contacting the Program as specified in the box below. In addition, all written company communications to EPA regarding the 33/50 Program are available to the public upon request.*

*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.*

[illegible]

[illegible]

# Lockheed Martin

## Summary

*Between 1988 and 1993, Lockheed Corporation reduced releases and off-site transfers of targeted 33/50 Program chemicals from 5,515,000 pounds to 1,298,000 pounds, approximately a 77 percent decrease. These figures represent reductions primarily in solvents, paints, coatings, and metal finishing materials used in aerospace manufacturing processes, including cleaning, degreasing, painting, bonding, anodizing, and plating.*

*This Profile provides highlights of three particular 33/50 Program chemical reduction projects:*

- *eliminating hazardous chemical usage and solvent emissions from cleaning/degreasing operations by substituting aqueous cleaning;*
- *process changes in the cleaning and coating of printed circuit boards; and*
- *eliminating hazardous chemicals and paint solvent emissions by using plastic media blasting.*

## Company Background

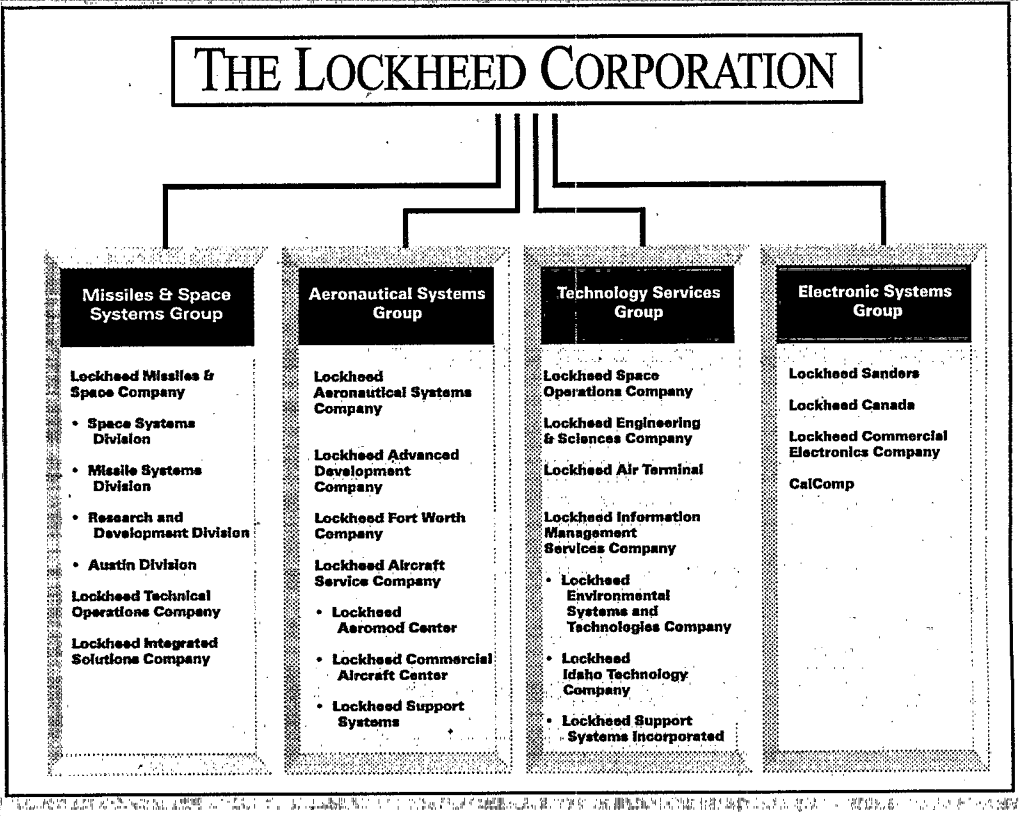
Lockheed Corporation and Martin Marietta Corporation merged on March 15, 1995 to form Lockheed Martin Corporation. This Profile focuses on the former Lockheed business units of Lockheed Martin. It is noteworthy that the former Martin Marietta companies have made similar progress in eliminating the use of 33/50 Program chemicals to that made by Lockheed. Martin Marietta achievements were well recognized in 1994. The EPA awarded Martin Marietta the 1994 EPA Stratospheric Protection Award. Martin Marietta was also the 1994 winner of the national Renew America Award for Pollution Prevention.

LOCKHEED MARTIN

Lockheed Martin is a Fortune 25 company headquartered in Bethesda, Maryland. It is the largest defense contractor in the world and the largest aerospace company in the United States. Lockheed Martin manufactures aircraft, missiles, space launch systems, and satellite and electronic systems; refurbishes air-

**Exhibit 1**

*The Lockheed Corporate Groups and Divisions*




***Lockheed Martin manufactures aircraft, missiles, space launch systems, and satellite and electronic systems; refurbishes aircraft; and performs a variety of aircraft maintenance services.***

craft; and performs a variety of aircraft maintenance services. Lockheed Martin is also a major contractor to the Department of Energy and provides clients with environmental remediation and consulting services. Included within these manufacturing operations and services are metal and composite cleaning/degreasing, finishing/plating, and painting/coating procedures.

At former Lockheed sites, approximately 78,000 employees work at 450 facilities located across the United States and around the world. At the end of 1993, Lockheed's business mix consisted of 64 percent U.S. government defense, 13 percent nondefense (primarily for the U.S. space program), 10 percent commercial, and 13 percent foreign military markets. In 1994, total sales for Lockheed totalled over $13 billion. Lockheed corporate groups and their divisions are shown in Exhibit 1.

"Lockheed Corporation is committed to conscientious stewardship of the environment, employee health and safety, and compliance with all relevant laws and regulations. We will operate facilities in a manner that is environmentally responsible and that ensures the health and safety of employees and the public. This is consistent with our commitment to active, responsible citizenship in all the communities in which we reside."

*-Dan Tellep*
*Lockheed Martin Chairman and CEO*

## Lockheed's Pollution Prevention Strategy

- Establish partnerships with customers and other key stakeholders
- Emphasize environmental technology innovation
- Leverage environmental technology across the corporation
- Integrate a hazardous material management process into all programs
- Institutionalize pollution prevention without creating a new institution
- Use extensive metrics to monitor progress and focus resources

# Environmental Strategy

Lockheed's commitment to environmental protection is delineated in its Corporate Management Policy Statement (MPS) 173 and its Operations Directive (OD) 17. These two documents establish the goals of the corporation and the lines of responsibility, from top management through the individual operating companies, to ensure that all Lockheed operations are conducted in a manner that protects the environment and worker safety and health.

***Lockheed's environmental programs are designed to allow the integration of ideas between hands-on labor, engineers, scientists, and top management.***

MPS 173, published in 1972, directs operating company management to "ensure that a hazardous material, environmental, safety, and health (ESH) review is conducted prior to introduction and/or new use of hazardous materials and that programs are established to prevent or reduce waste and emissions whenever feasible." The MPS also initiated extensive technology and data sharing requirements between departments and Lockheed companies, a formal self-evaluation process, and corporate-wide performance standards. OD 17, published in 1986, establishes key program elements and basic structures such as a hazardous material review process, a pollution prevention program, and a "lessons learned" program at each company. Exhibit 2 shows the high-level organization of Lockheed's environmental program.

An ESH procedures manual is used throughout the corporation. This manual assists in institutionalizing OD 17 requirements and provides detailed guidelines for self-inspections, methods of measuring performance, developing and implementing new technology, and disseminating "lessons learned" across the corporation. In addition, mechanisms are in place to ensure technology transfer across the corporation, including an Environmental Technologies (ET)

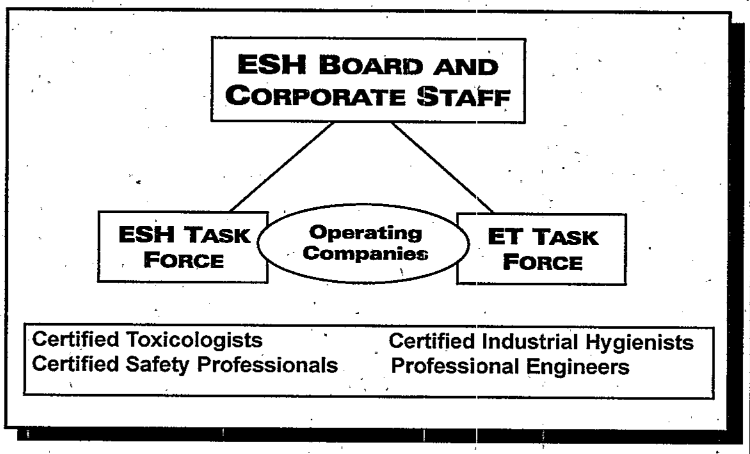



**Exhibit 2**

*Organization of Lockheed's Environmental Initiatives*

*In addition to reductions in 33/50 Program chemicals, by 1993 Lockheed had reduced corporate-wide use of ozone-depleting chemicals by 88 percent.*

Task Force, an Advanced Materials Task Force, and regularly scheduled ESH corporate conferences. In addition, the corporate ESH staff coordinates business unit activities and publishes a bimonthly analysis of key issues and a pollution prevention bulletin.

Lockheed's corporate-wide management structure assists in implementing these goals and directives. Elements include an integrated Corporate ESH Board comprised of top Lockheed officials whose decisions ultimately influence corporate direction, an ESH Task Force comprised of ESH coordinators from the major operating companies, and an ET task force of scientists and engineers who focus on eliminating hazardous materials through innovations in product design and manufacturing processes.

Lockheed's environmental programs are designed to allow the integration of ideas between hands-on labor, engineers, scientists, and top management. Each Lockheed employee is encouraged to be aware of and involved in the issues and challenges that face individual Lockheed companies, as well as the corporation as a whole.

**Exhibit 3**

*Partial List of Awards Received by Lockheed Companies*

## SELECTED ENVIRONMENTAL AWARDS PRESENTED TO LOCKHEED COMPANIES

Lockheed Corporation:

*1994 EPA Stratospheric Protection Award*

Lockheed Missiles and Space Company (LMSC), Sunnyvale, CA:

*1994 Honor Roll Award from the nonprofit National Environmental Development Association*
*1993 National Storm Water Program Excellence Award from the U.S. EPA*
*1992-1993 Susanne Wilson Environmental Achievement Award from the County of Santa Clara*
*1993 Golden Vision Award from the San Francisco Chapter of International Television Associates*
*1992 Commendation Letter from the City of Palo Alto for waste minimization*

Lockheed Aeronautical Systems Company (LASC), Marietta, GA:

*1993 Merit Award for Paper Recycling from the Cobb Clean Commission*
*1993 Certificate of Recognition from the National Safety Council*
*1993 Industrial Lab of the Year Award from the Georgia Water and Pollution Control Association*
*1992 EPA Certificate of Recognition for reducing painting operation air emissions*

Lockheed Fort Worth Company (LFWC), Fort Worth, TX:

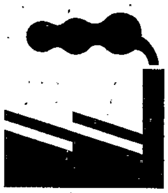
*1993 EPA Certificate of Recognition for significant reductions of hazardous air pollutants through innovative measures*
*1992 EPA Stratospheric Protection Award*

Lockheed Aircraft Services Company (LAS), Ontario, Canada:

*1993 EPA Certificate of Recognition for eliminating VOC/HAP emissions*

In addition to reduced use of 33/50 Program chemicals, Lockheed, by the end of 1993, reduced corporate-wide use of ozone-depleting chemicals (ODCs) by 88 percent. In March, 1995, Lockheed Fort Worth Company completely eliminated all use of ODCs in the manufacture of the F-16 aircraft. Also by the end of 1993, reductions in releases and transfers of all TRI compounds reached 65 percent from 1988 levels. In addition, many of the individual operating companies administer recycling programs, manage energy and water conservation efforts, and conduct community-directed activities addressing toxics-use reduction. As a result of these efforts, Lockheed companies have received numerous awards and commendations from the U.S. EPA, local regulatory agencies, and non-profit groups, as shown in Exhibit 3.

## Overview of 33/50 Program and TRI Chemical Releases and Transfers



Since 1988, Lockheed operating companies have reported releases and transfers of 11 of the 17 chemicals targeted by the 33/50 Program. A summary of Lockheed's releases and transfers is presented in Exhibit 4. Exhibits 5 and 6 provide a breakdown of 1988 releases and transfers by chemical and by media. Additional detail is provided in Appendices A through D at the end of this profile. The following is a list of these chemicals and their source of emissions at Lockheed:

***From 1985 through 1990, various Lockheed companies and departments investigated the feasibility of substituting aqueous/ semi-aqueous, nonaqueous, and other alternative cleaners for ozone-depleting and other chlorinated solvents used in vapor degreasing.***

***Chromium and compounds*** were used in metal finishing processes such as aluminum deoxidizing, anodizing, and sealing. Chromium compounds continue to be used for several of these processes. The majority of chromium was transferred off-site for processing; the remaining chromium was emitted into the air. Virtually all chromium compounds currently used are transferred off-site. The remaining chromium is discharged into surface water or emitted into air.

***Dichloromethane*** is used to strip paint. Emissions are primarily to air, and a small percentage of dichloromethane is transferred off-site.

**LOCKHEED'S RELEASES AND TRANSFERS OF TRI CHEMICALS**

| 33/50 Chemicals (1,000s lbs) | 1988 | 1993 |
|---|---|---|
| Cadmium compounds | NR | NR |
| Chromium & compounds | 34,050 | 147,849 |
| Dichloromethane | 181,350 | 88,085 |
| Lead | NR | NR |
| Methyl ethyl ketone | 564,150 | 115,371 |
| Methyl isobutyl ketone | 116,750 | 23,128 |
| Tetrachloroethylene | 498,850 | NR |
| Toluene | 530,870 | 74,884 |
| 1,1,1-Trichloroethane | 1,103,150 | 293,493 |
| Trichloroethylene | 2,007,900 | 482,103 |
| Xylene | 478,365 | 73,198 |
| 33/50 Subtotal* | 5,515,435 | 1,298,111 |
| Other TRI Chemicals: | 1,327,050 | 340,378 |
| TOTAL:* | 6,842,485 | 1,638,489 |

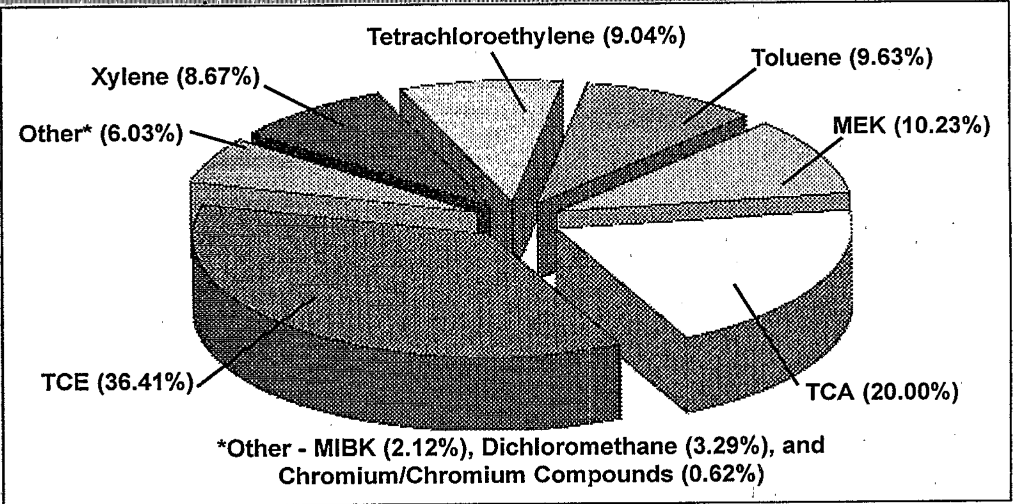
*NR: Not reported to TRI; use below reporting threshold.*
** Columns do not sum to total due to rounding.*

**Exhibit 4**

*Releases and Transfers of TRI Chemicals by Lockheed Corporation*

**Exhibit 5**

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




***Toluene and xylene*** are used in chemical milling maskants and in painting and coating applications. Toluene is a component of a conformal coating sprayed onto circuit boards, and xylene is a component of a solvent used to clean spray guns and support equipment in the conformal coating process. Toluene and xylene emissions are primarily to air, with their remainders transferred off-site.

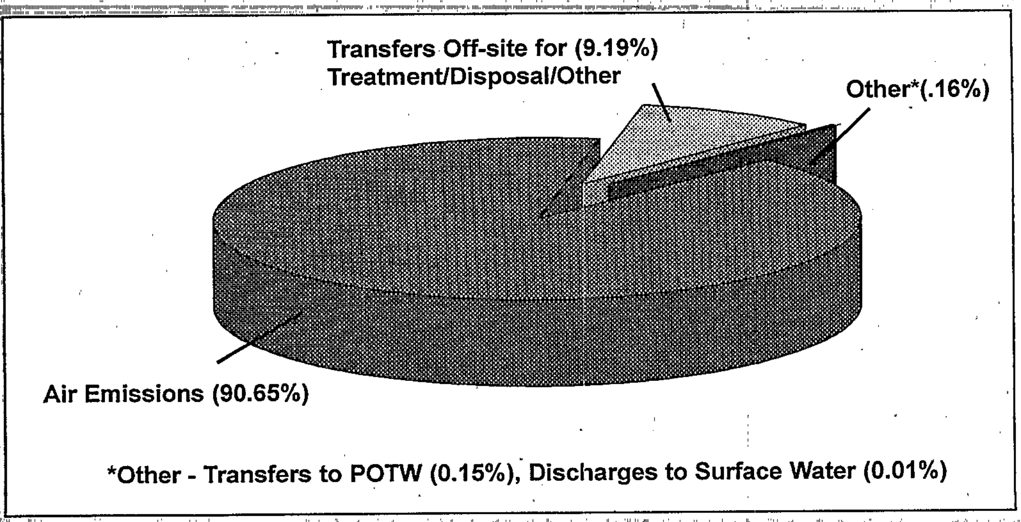
***Methyl ethyl ketone*** **(MEK)** is used in painting applications, in the application of specialty coatings, and at some sites for cleaning paint application equipment. Virtually all emissions are to air, with a small percentage of the chemical transferred off-site.

***Methyl isobutyl ketone*** **(MIBK)** is used in wipe-cleaning applications. Emissions are to air, with a fraction of the chemical transferred off-site.

***1,1,1-Trichloroethane*** **(TCA)** is used to clean and degrease metal, to clean electronics, and to apply specialty coatings. The majority of releases are to air, with a small amount of the chemical transferred off-site.

**Exhibit 6**

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



***Trichloroethylene*** (TCE) was used extensively as a metal cleaner prior to 1992. ***Tetrachloroethylene*** had been used for the same purpose in the late 1980s and virtually all emissions had been to air. Trichloroethylene emissions are predominantly to air, with a small quantity of the chemical transferred off-site.

In the 1988 baseline year, Lockheed companies reported releases and transfers of 6,842,485 pounds of all TRI chemicals. 33/50 Program chemicals accounted for approximately 81 percent of this total, with releases and transfers of 5,515,435 pounds.

## 33/50 Program Goals and Reduction Projects

In July of 1991, Lockheed joined the 33/50 Program, agreeing to voluntarily reduce releases and transfers of targeted chemicals by 33 percent in 1992, and by 50 percent in 1995, using 1988 as a baseline year. Based upon 1988 figures, these reductions would total 1,820,094 and 2,757,718 pounds, respectively. In order to reach these goals, the company focussed on seven operations that could potentially reduce releases and transfers by using improved, cost-effective technologies and more efficient production methods. Exhibit 7 outlines the operations targeted for modification, the chemicals historically used within that process, and the process changes enacted to reduce transfers and emissions of 33/50 Program chemicals. Three of Lockheed's emissions-reduction projects (labeled 1, 2 and 3 in Exhibit 7) are the focus of this Profile.

**Exhibit 7**

*The Operations and Chemicals Targeted for Modification at Lockheed and the Alternative Technology Substituted*

**33/50 PROGRAM CHEMICAL ELIMINATION PROJECTS**

| OPERATION(S) | CHEMICAL(S) | ALTERNATIVE TECHNOLOGIES |
|---|---|---|
| 1. Metal cleaning and degreasing | 1,1,1-Trichloroethane<br>Trichloroethylene<br>Tetrachloroethylene | • Aqueous/semi-aqueous cleaners (Project #1)<br>• Low vapor pressure wipe solvents<br>• "No clean" methods<br>• Water emulsifiable forming fluids and lubricants |
| 2. Electronics circuit board coating | Toluene<br>Xylene | • UV-cure conformal coating (Project #2) |
| 3. De-painting | Dichloromethane | • Plastic media blasting (Project #3) |
| 4. Electronics circuit board cleaning | 1,1,1-Trichloroethane | • Aqueous, alkaline cleaners<br>• Water-soluble fluxes |
| 5. Metal finishing | Cadmium<br>Chromium | • Non-chromium deoxidizers, etchants and anodizing solutions<br>• Solution regeneration and recycling<br>• Ion vapor deposition aluminum |
| 6. Painting | Methyl ethyl ketone<br>Methyl isobutyl ketone<br>Toluene<br>Xylene | • High solids paints<br>• High transfer efficiency paint guns<br>• Automated paint gun cleaning systems<br>• Low vapor pressure paint gun cleaning solvents<br>• Robotic painting systems<br>• Improved parts handling and sequencing |
| 7. Application of specialty coatings | 1,1,1-Trichloroethane<br>Methyl ethyl ketone | • Aqueous/semi-aqueous solvents and carriers<br>• Low vapor pressure, non-hazardous air pollutant solvents and carriers |

## *Project #1: Eliminating chlorinated solvent usage in metal cleaning*

Historically, Lockheed companies used chlorinated solvents, such as 1,1,1-trichloroethane (TCA) and trichloroethylene (TCE), in vapor degreasing equipment to clean aircraft components. Vapor degreasing efficiently cleans, rinses, and dries the various components prior to their painting, assembly, or storage. Lockheed's corporate goal to develop cleaning methods with minimal hazardous material use and emissions, coupled with the production phaseout deadlines for Class I ozone-depleting substances under the Montreal Protocol and the Clean Air Act Amendments of 1990, served to focus company efforts on finding alternatives to chlorinated solvents, such as TCE and TCA, used in this application.

***The aqueous degreasing process currently in operation at LMSC requires multiple processing steps.***

From 1985 through 1990, Lockheed investigated the viability of substituting aqueous/semi-aqueous, nonaqueous, and other alternative cleaners for ozone-depleting and other chlorinated solvents used in vapor degreasing. During that time, Lockheed successfully phased out the use of chlorinated solvents to "precision" clean small space and military hardware components. However, many Lockheed operations continued to use chlorinated solvents for large-scale industrial cleaning. Such was the case at Lockheed Missile and Space Company (LMSC) in Sunnyvale, California, where TCA-based vapor degreasing was used to clean rocket motor components, such as casings and nozzle parts, prior to painting and liner installation.

In 1987, experts from various LMSC departments, including engineering, process control, production, facilities, industrial hygiene, and environmental protection, collaborated on an effort to find an alternative to TCA in this application. Within two years, analysis suggested that aqueous cleaning could be substituted for solvent-based metal parts cleaning at LMSC. The National Aeronautics and Space Administration (NASA) agreed with LMSC's assessment and approved the modification of the contract and design requirements for the implementation of an alternate degreasing operation. Approval of this alternative cleaner allowed LMSC to halt the construction of a 60-foot deep, 15-foot wide, TCA vapor degreaser, which was designed to degrease rocket motor components fabricated for NASA's Advanced Solid Rocket Motor (ASRM) project.

LMSC reviewed over 100 cleaners in their search to find a feasible alternative to TCA degreasing. Fifty of the initially reviewed cleaners warranted further screening. This initial review addressed the efficiency, product quality, reliability, employee safety, and environmental benefits of the alternative cleaning systems compared with chlorinated solvent degreasing operations. Ultimately, the research identified four commercially available alkaline cleaners as possible replacements for TCA: Daraclean 282, Blue Gold, Turco 4338, and Brulin 815GD.

The next phase in the two-part screening and testing procedure involved running a series of optimization studies in which the company cleaned test panels with each of the candidate solutions and examined them for paint adhesion, adhesive bond strength, and part corrosion. The optimization studies also evaluated bath and rinse water chemistry for any negative trends that could be associated with heavy usage of the cleaner, such as etching and drag-out (a measure of cleaner loss).

As part of the optimization studies, testing was also done to compare measured amounts of non-volatile residue (NVR), a technique used to determine the cleanliness of a degreased surface. All tests conducted by Lockheed on aqueous cleaners through June, 1992, demonstrated NVR levels equal to or less than those associated with TCA use. For example, during comparison testing at LMSC, panels degreased with TCA exhibited an NVR level of 19 mg/sq.ft. while panels cleaned with an alkaline solution had an NVR level of 9 mg/sq.ft., less than half the NVR level obtained from TCA. Similar process changes at Lockheed Fort Worth for aircraft tube cleaning have also demonstrated higher levels of cleanliness with aqueous cleaning.

***Among the advantages of aqueous cleaning over TCA degreasing is the elimination of the need for expensive emissions control equipment.***

The optimization studies showed that aqueous cleaners worked as well as or better than TCA to clean metal parts in large-scale manufacturing operations. The Blue Gold and Daraclean 282 aqueous solutions were subsequently adopted.

Implementing the aqueous cleaning system at LMSC required purchasing a new small-spray washing machine for the plumbing shop. This washing machine primarily cleans fluid transfer tubing used in launch and missile systems. Conversion of an existing solvent immersion tank to use as an aqueous cleaner provided LMSC with the capability to degrease larger objects. Materials and processes and facilities engineers teamed in a traditional design and construction approach to select and convert the aqueous degreasing equipment.

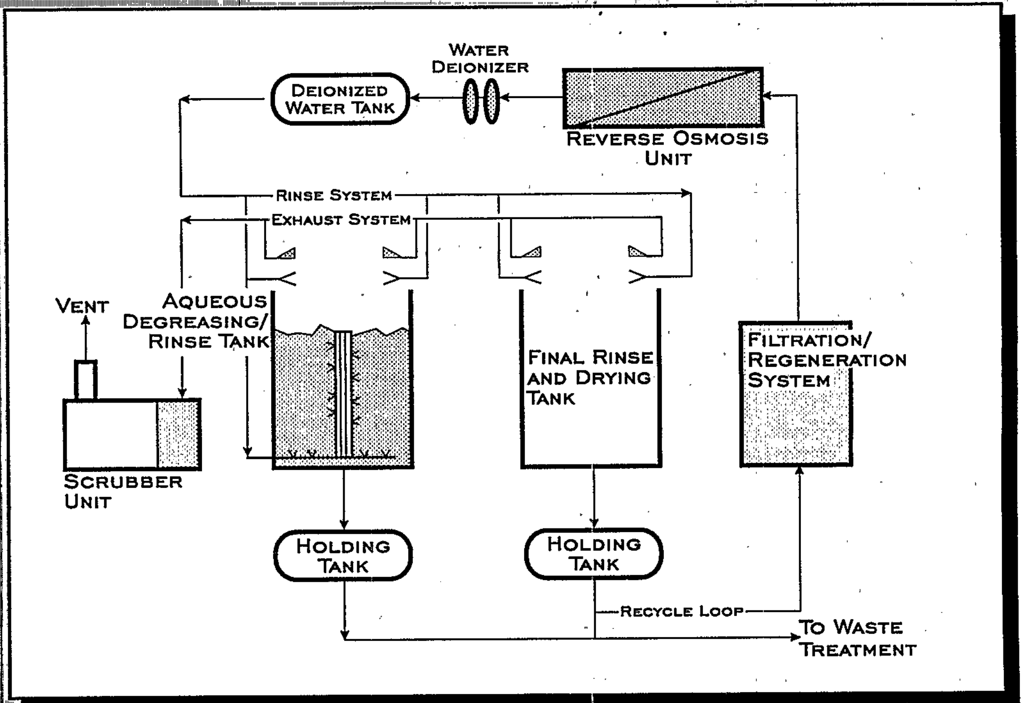
The aqueous degreasing process currently in operation at LMSC requires multiple processing steps (see Exhibit 8). First, the metal part to be cleaned is lowered into the aqueous degreasing tank. The aqueous solution in the tank is mechanically agitated, creating a scrubbing motion both inside and outside of the immersed part. As the metal part is removed from the tank an external and internal rinse spray is activated. The mist created by the spray is blown down, and fumes are exhausted into a scrubbing unit. The nominal amount of chemical residue captured in the scrubber is moved to a wastewater treatment facility for processing and possible reuse. The metal part is then placed into a chamber for final rinsing and drying. The spent solution in the final rinse and drying tank is constantly monitored for consistency to allow for its reuse.

***Another advantage of aqueous cleaning over TCA degreasing is lower operating costs.***

Wastewater from the cleaning operation is directed to a holding tank where its composition is monitored. If the water is determined to be recyclable, it is sent through a series of filtration and regeneration steps, followed by a reverse osmosis unit and a deionizer. Finally, it is stored in a deionized water tank. If the water is not recyclable, it is transported to an on-site wastewater treatment system, which was operational before the implementation of aqueous cleaning.

## Exhibit 8

*Aqueous Degreasing Flow Diagram*




The advantages of aqueous cleaning over TCA degreasing include:

- *Elimination of chlorinated chemical emissions and reduced environmental impacts;*
- *Elimination of the need for expensive emission control equipment;*
- *Reduction in the cost and risk of hazardous material storage and handling;*
- *Double containment and leak detection monitoring are no longer mandatory;*
- *Monitoring devices for volatile organic compound emissions are no longer required; and*
- *Reduced energy consumption.*

Disadvantages of implementing aqueous degreasing include:

- *Additional processing steps compared to cleaning with TCA;*
- *Additional operator time and expertise;*
- *Additional floor space and equipment to properly clean, rinse, and dry the components; and*
- *Support equipment necessary to prepare and recycle rinse water.*

***LMSC is pleased with its conversion from solvent degreasing to aqueous degreasing.***

LMSC is pleased with its conversion from solvent degreasing to aqueous degreasing. This process change provided the company with a solution for addressing its concerns regarding solvent use and occupational safety and health. Lockheed representatives also state that aqueous cleaning has led to a high degree of customer satisfaction due to improved product quality, reduced operating costs, reduced potential for environmental, health, and safety regulatory non-compliance, and improved overall work-area cleanliness.

## *Project #2: Eliminating solvent usage from printed circuit board coating operations*

As part of Lockheed's continuous effort to eliminate environmental emissions, Lockheed Aircraft Services Company (LAS), headquartered in Ontario, California, implemented a "zero emissions" technique for coating printed circuit boards used in flight data recorders.

Printed circuit boards installed in applications where they may be exposed to contamination or moisture are often coated with a protective layer to prevent damage. These coatings are referred to as conformal coatings. Historically, LAS sprayed circuit boards with a methyl methacrylate adhesive coating containing toluene and dimethylbenzene. This coating formulation produced volatile organic compound (VOC) emissions of 660 grams/liter of coating. After applying the coating to the circuit boards, the spray gun and support equipment required cleaning with a solvent containing xylene.

***Working together, Lockheed and Southern California Edison developed a coating that eliminated solvent emissions, reduced costs, and improved productivity.***

The solvent-based coating process previously used by LAS required a labor-intensive 24-hour processing cycle per board. During the process, an average of 10 percent of the boards had to be reworked because of drip marks or insufficient coating thicknesses.

To aid in their search for an alternative to toluene and xylene, LAS teamed with Southern California Edison's Clean Air Technologies Program. Working together, Lockheed and Southern California Edison sought a coating that would reduce solvent emissions, reduce costs, and improve productivity. The research team identified an innovative technology using solvent-free conformal coating cured with ultraviolet light, and in 1993 LAS adopted this process.

In the UV-cure conformal coating process, the coating is sprayed on one side of the printed circuit board inside a spray booth. The coated board is then placed on the conveyor belt of the curing system (pictured in Exhibit 9) for exposure to UV light. After passing through the instrument, the board is turned over, and the process is repeated. The whole

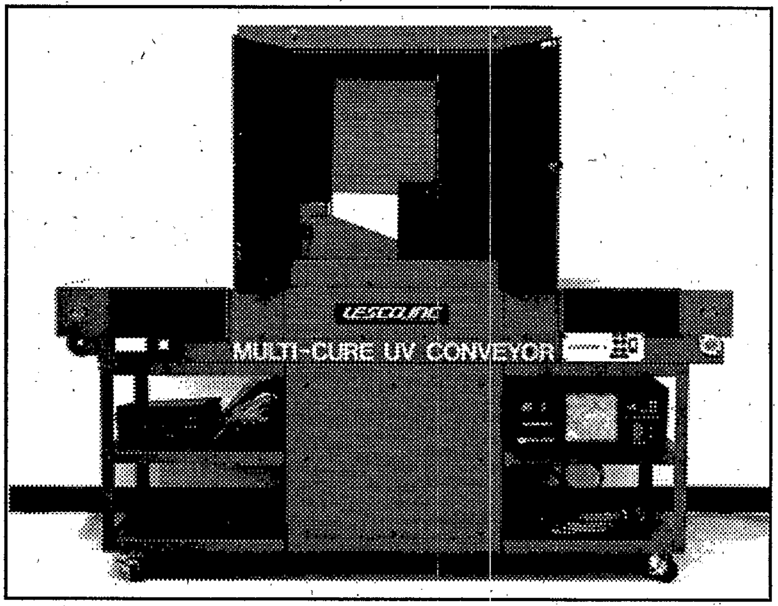



**Exhibit 9**

*The Ultraviolet Curing System*

procedure takes less than 10 minutes, which saves almost 24-hours compared with the previously used solvent-based coating process.

Advantages offered by the UV-cure coating process include:

- *Improved product quality;*
- *Lowered material costs;*
- *Reduced per-board cycle process time;*
- *No reworking of boards necessary;*
- *Zero emissions of pollutants into the atmosphere; and*
- *Rapid return on investment.*

Limitations of the UV-cure coating process include:

- *The size of the UV equipment limits the height and size of circuit boards; and*
- *Workers must wear protective gloves.*

The UV-cure conformal coating is a 100 percent solids material consisting of a single component UV-sensitive polymeric coating, Dymax Multi-Cure 984-LVF. This polymer is specifically formulated for rapid curing at room temperature when exposed to long-wave (320-380 nanometer) UV light.

***LAS considers the UV-cure coating process to be superior to the solvent-based process.***

LAS considers the new technique to be superior to the solvent-based process. The UV system produces a more uniform coating with no drip marks, and the coating requires no rework. After spraying, the applicator requires no cleaning, minimizing time and costs associated with cleanup activities. Also, the UV system uses one-fourth of the raw materials required by solvent-based coating operations, and any residual spray material can be recovered and reused. The UV conformal coating meets Federal Aviation Administration (FAA) specifications for protective coatings and is approved for use by the U.S. Air Force.

By adopting the new process, LAS has increased the plant's circuit board production potential while entirely eliminating toxic air emissions. In addition, the transition to the new process requires minimal training and reduces the time employees spend on each part.

Initial capital expenditure costs for the UV-cure coating equipment were $16,260. LAS environmental personnel estimated that substituting the UV-cure process for the previously used solvent- based coating process would provide an annual cost savings of more than $560,000. The company initially estimated a payback period of two to three months based on historical production levels. However, the day after the UV-curing system was installed LAS received an unusually large purchase order requiring 100 circuit boards to be coated and cured in one day. Because of this high volume of work, the process change paid for itself in a single day, and LAS realized a $30,000 savings in the first month of the UV-coating system's operation. At current decreased production levels, cost savings are approximately $60,000 annually. Exhibit 10 compares the solvent-based coating method with the UV-cure coating method.

**Exhibit 10**

*A Comparison Between the Solvent-based Coating Technique and the UV-Cure Coating Technique*

### COMPARISON OF COATING TECHNIQUES

| | SOLVENT-BASED | UV-CURE COATING |
|---|---|---|
| Capital cost of new equipment | --- | $16,260 |
| Regulatory compliance | | |
| - SCAQMD permit | Yes | Exempt |
| - Air scrubbing and monitoring | Yes | No |
| Processing/curing time | >24 hours | 5-10 minutes |
| Percentage parts reworked | 10-15 | 0 |
| VOC (g/l) | 660 | <1 |
| Estimated Annual Costs | $845,400 | $281,160 |

## *Project #3: Eliminating hazardous chemical use during paint stripping by using plastic media blasting*

One step in refurbishing aircraft is to remove old paint from components and the airframe prior to the application of new paints and coatings. Historically, this process required the use of dichloromethane, a potential human carcinogen and one of the chemicals targeted by the 33/50 Program. In 1988, LAS, LADC, and LFWC began testing a new paint stripping method, Plastic Media Blasting (PMB), which strips paint effectively without using hazardous liquid chemicals. This case history covers the LAS project.

Lockheed specialists selected this method for two reasons. First, PMB is considered to be the Best Available Control Technology (BACT) by the California South Coast Air Quality Management District (SCAQMD). Using BACT is required under the Clean Air Act in serious nonattainment areas for particulates, a criteria air pollutant. Second, PMB provides an economical solution to aircraft paint stripping.

Plastic Media Blasting involves impingement of aircraft surfaces with plastic beads. PMB equipment uses high-velocity air to project small, irregularly shaped plastic particles onto surfaces to mechanically remove paint and other coatings. The beads, leased to LAS from US Technology (UST) in Canton, Ohio, are usually 16 to 40 mesh in size (mesh is a sizing term relating to the number of openings per linear inch of a network, such as a screen; the smaller the mesh size, the larger the pellet). The lease price is $2.50/lb., which includes all packaging, shipping, handling, and return of spent media. The process is similar to sand blasting, but is more controlled due to the use of plastic media instead of sand. The beads are hard enough to remove paint, but soft enough to prevent damage to substrate materials.

***Plastic Media Blasting involves impingement of aircraft surfaces with plastic beads.***

Advantages of PMB include:

- *Elimination of liquid cleanup and disposal;*
- *No personnel exposure to toxic chemicals;*
- *Elimination of environmental hazards and liability associated with liquid chemical stripping;*
- *Plastic beads can be used for almost all types of paint stripping and coat ing removal operations. Beads are available in different sizes and hard ness values for use in a variety of applications; and*
- *Time required to strip an aircraft reduced by 50%, with a 70% savings of personnel time compared with chemical stripping.*

Disadvantages of PMB include:

- *Requirement of employee certification and training in the use of PMB and equipment operating experience in order to efficiently remove paints and coatings;*
- *Paint stripping facilities must be modified to accommodate the PMB equipment and handle the dust generated during operation; and*
- *Employees required to wear personal protective clothing and ear protection.*

***Lockheed estimates that conversion to PMB, based solely upon work hour decrease and product scheduling, results in approximately a $1 million annual savings.***

Initially, LAS used PMB solely on small components, but extended its application to different sizes and types of parts such as radomes, flight control surfaces, nacelles, and cargo ramps. In 1990, LAS operators stripped a complete C-130 airframe in a demonstration for the U.S. Air Force, exhibiting a personnel time savings of nearly 70 percent, and an elapsed time span savings of 50 percent compared with chemical stripping. The successful results prompted the Air Force to approve the process for future PMB stripping of all C-130 aircraft at LAS.

The environmental, health, and safety impacts of PMB are significantly less than those of chemical paint stripping. PMB eliminated the annual use of hundreds of gallons of stripper and the production of thousands of gallons of contaminated water associated with chemical stripping, all of which had to be disposed of as hazardous waste. With PMB, the media is recaptured through the equipment, separated from the contaminants, and then returned to UST. UST transports the spent media to its facility in Canton, Ohio, where it is used as a substitute for calcium carbonate in the manufacture of products such as bathroom sinks, countertop sinks, and shower floors. The paint waste is reduced to one 55-gallon drum of dry spent media per C-130 aircraft and disposed of as hazardous waste. The waste generated by PMB is significantly less than that of chemical stripping, which can yield 60,000 gallons of waste liquid and five drums of waste sludge per C-130 aircraft.

Lockheed estimates that conversion to PMB, based solely upon work-hour decreases and product scheduling, accounts for approximately a $1 million annual savings. Associated hazardous waste and chemical cost savings have not been quantified by the company, but would add to this amount. As a result of such significant cost reductions, the payback period for the project was less than six months.

# 33/50 Program Progress and TRI Data Summary

The projects profiled here provide notable examples of efforts made across Lockheed Corporation to reduce toxic chemical usage. Through undertakings such as these, Lockheed surpassed its 33/50 Program commitment far in advance of set deadlines, reporting 1,298,111 pounds of releases and transfers of 33/50 Program chemicals in 1993, compared to 5,515,435 pounds in 1988. This represents an overall reduction of approximately 77 percent. This reduction included a complete elimination of releases and transfers of cadmium compounds, lead compounds, and tetrachloroethylene. The other major contributors to Lockheed's success include the following reductions:

| | | |
|---|---|---|
| Dichloromethane | - | 88,085 pounds (51 percent) |
| Methyl Ethyl Ketone | - | 115,371 pounds (80 percent) |
| Methyl Isobutyl Ketone | - | 23,128 pounds (80 percent) |
| Toluene | - | 74,884 pounds (86 percent) |
| 1,1,1-Trichloroethane | - | 293,493 pounds (73 percent) |
| Trichloroethylene | - | 482,103 pounds (76 percent) |
| Xylene | - | 73,198 pounds (85 percent) |

Although it was not part of its stated 33/50 Program goal, Lockheed also achieved significant reductions in releases and transfers of non-33/50 TRI chemicals during the period 1988 to 1993. Total non-33/50 TRI releases and transfers were 340,378 pounds in 1993, down 986,672 pounds (66 percent) from the 1988 baseline. Exhibit 11 illustrates the reductions in 33/50 Program and other TRI chemical releases and transfers at Lockheed. Exhibits 12 and 13 provide a breakdown of Lockheed's 1993 releases and transfers by chemical and by media.

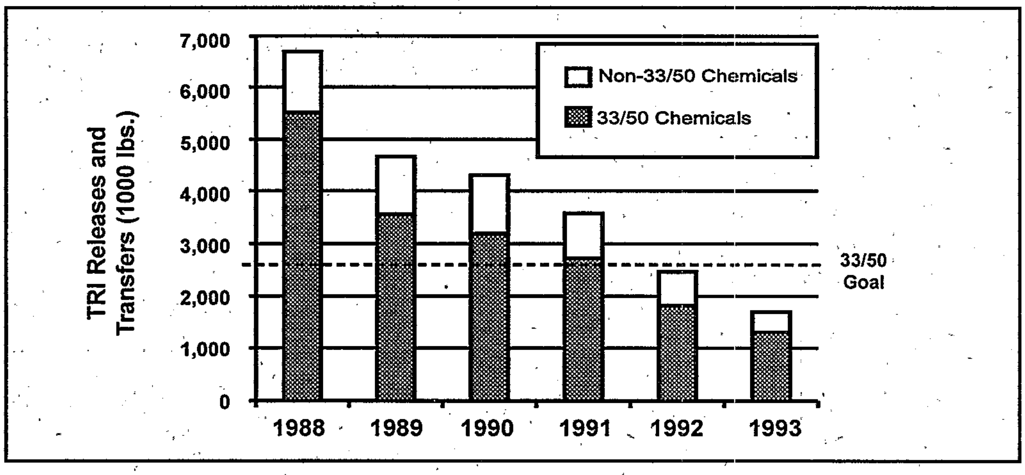



**Exhibit 11**

*Lockheed's Progress Toward Meeting Its 33/50 Program Goals*

**Exhibit 12**

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

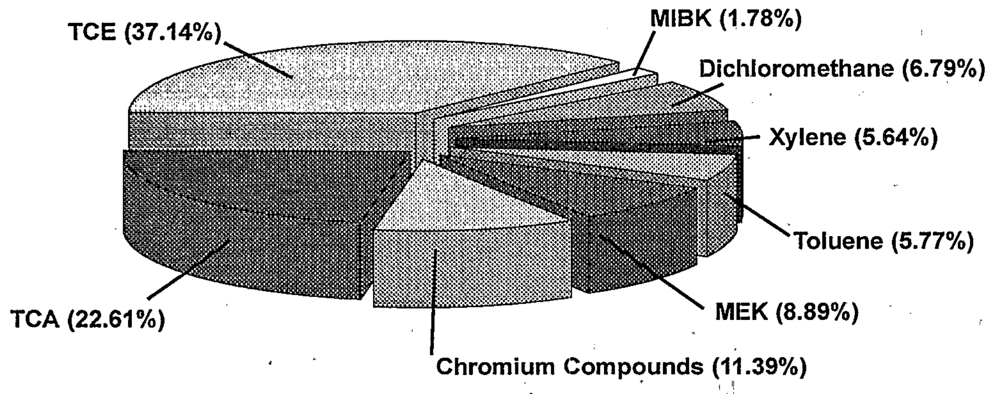
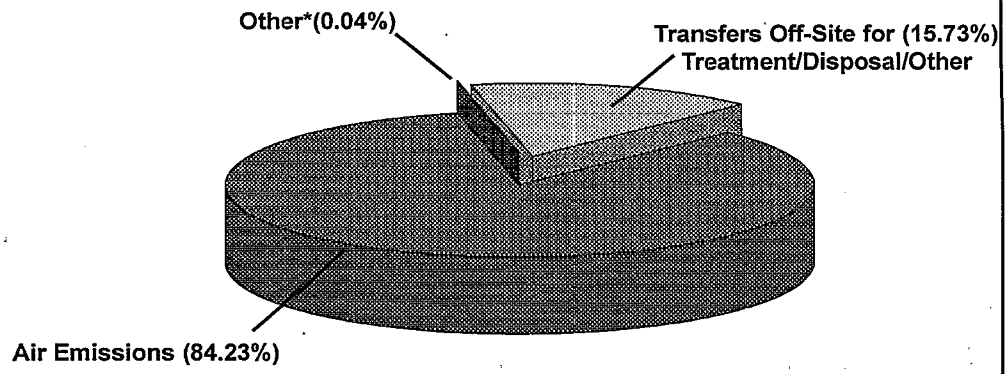



**Exhibit 13**

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




Lockheed's experience with the 33/50 Program has been a marked success due to the coordinated efforts between engineering, process control, production, environmental, health and safety, and facilities personnel across the corporation. Although pollution reduction and hazardous material elimination efforts had been underway for a number of years, making a commitment to the 33/50 Program increased visibility with all stakeholders and provided a focus for their efforts.

## Future Challenges

Several mechanisms established by Lockheed will be implemented within Lockheed Martin to ensure continued progress toward reducing toxic chemical usage throughout the corporation. One such example is the Environmental Technologies Task Force, where pollution prevention coordinators and material and process engineers from the major operating companies share information and experiences to promote the efficient implementation of pollution prevention efforts with maximum cost savings. Another example is the "ESH

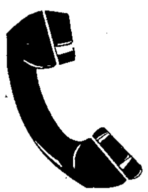
Report", a Lockheed Martin publication containing information on technical developments. The distribution of this publication encourages implementation of such technological progressions.

Current efforts are focused on helping all Lockheed Martin companies take full advantage of process advancements in the following areas:

- *Eliminating all Class I ODCs used in manufacture and maintenance of products;*
- *Eliminating solvents from degreasing and cleaning operations;*
- *Reducing VOC/HAP use and emissions in painting operations;*
- *Eliminating chromium and cadmium from plating, anodizing, deoxidizing, primer painting, and sealant materials; and*
- *Recycling of process solutions and rinse waters through electrodialysis, ultrafiltration, and reverse osmosis.*

## CONTACT FOR FURTHER INFORMATION

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



**Stephen Evanoff, P.E., DEE, R.E.M.**
**Corporate Environment, Safety, and Health**
**Lockheed Martin Corporation**
**7921 Southpark Plaza**
**Suite 204**
**Littleton, CO 80120**
**TEL: (303) 971-1880**
**FAX: (303) 971-5065**

Appendix A
Lockheed Corporation
Releases and Transfers of TRI Chemicals, 1988-1993

| Chemical | Year | Total Air Emissions (pounds) | Surface Water Discharges (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 |
|---|---|---|---|---|---|---|---|
| Cadmium compounds | 1989 | 0 | 0 | 0 | 3,396 | 3,396 | --- |
| Chromium | 1988 | 1,300 | 0 | 0 | 2,000 | 3,300 | --- |
| Chromium compounds | 1988 | 750 | 0 | 6,300 | 23,700 | 30,750 | |
| | 1989 | 860 | 0 | 7,100 | 21,950 | 29,910 | |
| | 1990 | 750 | 24 | 11,230 | 145,183 | 157,187 | |
| | 1991 | 750 | 250 | 7,200 | 100,400 | 108,600 | |
| | 1992 | 3,750 | 250 | 1,258 | 139,310 | 144,568 | |
| | 1993 | 250 | 250 | 250 | 147,099 | 147,849 | 381% |
| Dichloromethane | 1988 | 134,900 | 250 | 750 | 45,450 | 181,350 | |
| | 1989 | 74,625 | 250 | 250 | 28,250 | 103,375 | |
| | 1990 | 51,448 | 0 | 5 | 5,260 | 56,713 | |
| | 1991 | 65,061 | 0 | 0 | 750 | 65,811 | |
| | 1992 | 62,574 | 0 | 5 | 1,627 | 64,206 | |
| | 1993 | 85,155 | 0 | 5 | 2,925 | 88,085 | -51% |
| Lead compounds | 1990 | 0 | 5 | 0 | 4,347 | 4,352 | |
| | 1991 | 0 | 250 | 0 | 2,700 | 2,950 | --- |
| Methyl ethyl ketone | 1988 | 418,850 | 250 | 500 | 144,550 | 564,150 | |
| | 1989 | 336,006 | 0 | 250 | 136,750 | 473,006 | |
| | 1990 | 240,726 | 0 | 5 | 26,957 | 267,688 | |
| | 1991 | 395,275 | 0 | 0 | 11,300 | 406,575 | |
| | 1992 | 233,625 | 0 | 5 | 32,107 | 265,737 | |
| | 1993 | 110,303 | 0 | 0 | 5,068 | 115,371 | -80% |

## Appendix A
## Lockheed Corporation
## Releases and Transfers of TRI Chemicals, 1988-1993

| Chemical | Year | Total Air Emissions (pounds) | Surface Water Discharges (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 |
|---|---|---|---|---|---|---|---|
| Methyl isobutyl ketone | 1988 | 91,000 | 0 | 250 | 25,500 | 116,750 | |
| | 1989 | 107,100 | 0 | 0 | 8,600 | 115,700 | |
| | 1990 | 50,967 | 0 | 0 | 1,450 | 52,417 | |
| | 1991 | 14,400 | 0 | 0 | 750 | 15,150 | |
| | 1992 | 24,200 | 0 | 0 | 250 | 24,450 | |
| | 1993 | 22,623 | 0 | 0 | 505 | 23,128 | -80% |
| Tetrachloroethylene | 1988 | 498,850 | 0 | 0 | 0 | 498,850 | |
| | 1989 | 173,470 | 0 | 0 | 5,400 | 178,870 | |
| | 1990 | 137,000 | 0 | 0 | 250 | 137,250 | |
| | 1991 | 22,000 | 0 | 0 | 0 | 22,000 | --- |
| Toluene | 1988 | 518,150 | 0 | 250 | 12,470 | 530,870 | |
| | 1989 | 271,700 | 0 | 0 | 14,180 | 285,880 | |
| | 1990 | 194,159 | 0 | 0 | 6,718 | 200,877 | |
| | 1991 | 169,110 | 0 | 0 | 4,672 | 173,782 | |
| | 1992 | 97,588 | 0 | 0 | 5,840 | 103,428 | |
| | 1993 | 67,403 | 0 | 0 | 7,481 | 74,884 | -86% |
| 1,1,1-Trichloroethane | 1988 | 928,050 | 0 | 250 | 174,850 | 1,103,150 | |
| | 1989 | 612,779 | 0 | 265 | 94,135 | 707,179 | |
| | 1990 | 621,148 | 0 | 250 | 28,790 | 650,188 | |
| | 1991 | 1,319,096 | 0 | 250 | 18,088 | 1,337,434 | |
| | 1992 | 434,140 | 0 | 250 | 25,979 | 460,369 | |
| | 1993 | 279,131 | 0 | 5 | 14,357 | 293,493 | -73% |

Appendix A
Lockheed Corporation
Releases and Transfers of TRI Chemicals, 1988-1993

| Chemical | Year | Total Air Emissions (pounds) | Surface Water Discharges (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 | 1,938,000 | 0 | 0 | 69,900 | 2,007,900 | |
| | 1989 | 1,471,000 | 0 | 0 | 21,500 | 1,492,500 | |
| | 1990 | 1,549,666 | 0 | 0 | 505 | 1,550,171 | |
| | 1991 | 412,000 | 0 | 0 | 750 | 412,750 | |
| | 1992 | 669,700 | 0 | 0 | 500 | 670,200 | |
| | 1993 | 456,653 | 0 | 0 | 25,450 | 482,103 | -76% |
| Xylene (mixed isomers) | 1988 | 470,000 | 0 | 0 | 8,365 | 478,365 | |
| | 1989 | 168,437 | 0 | 0 | 12,900 | 181,337 | |
| | 1990 | 111,000 | 0 | 0 | 1,550 | 112,550 | |
| | 1991 | 158,000 | 0 | 0 | 1,700 | 159,700 | |
| | 1992 | 83,200 | 0 | 0 | 250 | 83,450 | |
| | 1993 | 71,938 | 0 | 0 | 1,260 | 73,198 | -85% |
| 33/50 Program Chemicals | 1988 | 4,999,850 | 500 | 8,300 | 506,785 | 5,515,435 | |
| | 1989 | 3,215,977 | 250 | 7,865 | 347,061 | 3,571,153 | |
| | 1990 | 2,956,864 | 29 | 11,490 | 221,010 | 3,189,393 | |
| | 1991 | 2,555,692 | 500 | 7,450 | 141,110 | 2,704,752 | |
| | 1992 | 1,608,777 | 250 | 1,518 | 205,863 | 1,816,408 | |
| | 1993 | 1,093,456 | 250 | 260 | 204,145 | 1,298,111 | -76% |
| All Non-33/50 TRI Chemicals | 1988 | 998,150 | 20,000 | 56,250 | 252,650 | 1,327,050 | |
| | 1989 | 735,385 | 20,000 | 82,040 | 92,575 | 930,000 | |
| | 1990 | 669,060 | 20,250 | 255 | 351,018 | 1,040,583 | |
| | 1991 | 575,517 | 21,497 | 255 | 210,400 | 807,669 | |
| | 1992 | 426,265 | 21,500 | 10 | 112,875 | 560,650 | |
| | 1993 | 125,622 | 20,250 | 0 | 194,506 | 340,378 | -74% |

## Appendix A
## Lockheed Corporation
## Releases and Transfers of TRI Chemicals, 1988-1993

| Chemical | Year | Total Air Emissions (pounds) | Surface Water Discharges (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 |
|---|---|---|---|---|---|---|---|
| All TRI Chemicals | 1988 | 5,998,000 | 20,500 | 64,550 | 759,435 | 6,842,485 | |
| | 1989 | 3,951,362 | 20,250 | 89,905 | 439,636 | 4,501,153 | |
| | 1990 | 3,625,924 | 20,279 | 11,745 | 572,028 | 4,229,976 | |
| | 1991 | 3,131,209 | 21,997 | 7,705 | 351,510 | 3,512,421 | |
| | 1992 | 2,035,042 | 21,750 | 1,528 | 318,738 | 2,377,058 | |
| | 1993 | 1,219,078 | 20,500 | 260 | 398,651 | 1,638,489 | -65% |
| Percent Change, 1988-1993 | | | | | | | |
| 33/50 Program Chemicals | | -78% | -50% | -97% | -60% | -76% | |
| Non-33/50 Program Chemicals | | -87% | 1% | -100% | -23% | -74% | |
| All TRI Chemicals | | -80% | 0% | -100% | -48% | -76% | |

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

Appendix B

Lockheed Company Facilities

Releases and Transfers of TRI Chemicals, 1988-1993

| Facility | Chemical | Year | Total Air Emissions (pounds) | Surface Water Discharges (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 & Transfers |
|---|---|---|---|---|---|---|---|---|
| LOCKHEED AERONAUTICAL SYSTEMS - ONTARIO, CA | | | | | | | | |
| | Dichloromethane | 1988 | 500 | 250 | 250 | 250 | 1,250 | |
| | | 1989 | 500 | 250 | 250 | 250 | 1,250 | --- |
| | Methyl ethyl ketone | 1988 | 500 | 250 | 0 | 5,450 | 6,200 | --- |
| | 33/50 Program Chemicals | 1988 | 1,000 | 500 | 250 | 5,700 | 7,450 | |
| | | 1989 | 500 | 250 | 250 | 250 | 1,250 | --- |
| | All TRI Chemicals | 1988 | 1,000 | 500 | 250 | 5,700 | 7,450 | |
| | | 1989 | 500 | 250 | 250 | 250 | 1,250 | --- |
| LOCKHEED MISSILES & SPACE CO. - SUNNYVALE, CA | | | | | | | | |
| | Dichloromethane | 1988 | 22,700 | 0 | 250 | 250 | 23,200 | --- |
| | Methyl ethyl ketone | 1988 | 17,900 | 0 | 250 | 4,150 | 22,300 | |
| | | 1989 | 18,600 | 0 | 250 | 4,600 | 23,450 | |
| | | 1990 | 13,700 | 0 | 5 | 1,000 | 14,705 | |
| | | 1992 | 5,100 | 0 | 5 | 250 | 5,355 | |
| | | 1993 | 4,165 | 0 | 0 | 250 | 4,415 | -80% |

Appendix B

Lockheed Company Facilities

Releases and Transfers of TRI Chemicals, 1988-1993

| Facility | Chemical | Year | Total Air Emissions (pounds) | Surface Water Discharges (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 & Transfers |
|---|---|---|---|---|---|---|---|---|
| | 1,1,1-Trichloroethane | 1988 | 157,000 | 0 | 250 | 1,000 | 158,250 | |
| | | 1989 | 153,000 | 0 | 250 | 500 | 153,750 | |
| | | 1990 | 116,000 | 0 | 250 | 1,500 | 117,750 | |
| | | 1991 | 40,000 | 0 | 250 | 250 | 40,500 | |
| | | 1992 | 54,000 | 0 | 250 | 3,750 | 58,000 | |
| | | 1993 | 32,800 | 0 | 0 | 500 | 33,300 | -79% |
| | <u>33/50 Program Chemicals</u> | 1988 | 197,600 | 0 | 750 | 5,400 | 203,750 | |
| | | 1989 | 171,600 | 0 | 500 | 5,100 | 177,200 | |
| | | 1990 | 129,700 | 0 | 255 | 2,500 | 132,455 | |
| | | 1991 | 40,000 | 0 | 250 | 250 | 40,500 | |
| | | 1992 | 59,100 | 0 | 255 | 4,000 | 63,355 | |
| | | 1993 | 36,965 | 0 | 0 | 750 | 37,715 | -81% |
| | Non-33/50 Program Chemical | 1988 | 196,000 | 0 | 250 | 16,350 | 212,600 | |
| | | 1989 | 125,500 | 0 | 250 | 7,250 | 133,000 | |
| | | 1990 | 112,455 | 0 | 255 | 6,400 | 119,110 | |
| | | 1991 | 67,255 | 0 | 255 | 42,250 | 109,760 | |
| | | 1992 | 76,255 | 0 | 10 | 1,505 | 77,770 | |
| | | 1993 | 51,255 | 0 | 0 | 8,020 | 59,275 | -72% |

Appendix B

Lockheed Company Facilities

Releases and Transfers of TRI Chemicals, 1988-1993

| Facility | Chemical | Year | Total Air Emissions (pounds) | Surface Water Discharges (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 & Transfers |
|---|---|---|---|---|---|---|---|---|
| | All TRI Chemicals | 1988 | 393,600 | 0 | 1,000 | 21,750 | 416,350 | |
| | | 1989 | 297,100 | 0 | 750 | 12,350 | 310,200 | |
| | | 1990 | 242,155 | 0 | 510 | 8,900 | 251,565 | |
| | | 1991 | 107,255 | 0 | 505 | 42,500 | 150,260 | |
| | | 1992 | 135,355 | 0 | 265 | 5,505 | 141,125 | |
| | | 1993 | 88,220 | 0 | 0 | 8,770 | 96,990 | -77% |

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

## Appendix C
## Lockheed Corporation
## Pollution Prevention Act Reporting, 1991-1993 Data and 1994-1995 Projections

| Chemical | Year | Recycled On-Site (pounds) | Recycled Off-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 | 0 | 0 | 0 | 0 | 7,200 | 93,200 | | 100,400 | |
| | 1992 | 0 | 0 | 0 | 0 | 1,200 | 142,700 | | 143,900 | |
| | 1993 | 0 | 0 | 0 | 0 | 4,350 | 177,434 | | 181,784 | |
| | 1994 | 0 | 0 | 0 | 0 | 1,600 | 151,000 | | 152,600 | |
| | 1995 | 0 | 0 | 0 | 0 | 1,300 | 110,400 | 18% | 111,700 | 11% |
| Dichloromethane | 1991 | 0 | 7,186 | 0 | 0 | 170 | 64,759 | | 72,115 | |
| | 1992 | 0 | 0 | 1,100 | 0 | 808 | 61,831 | | 63,739 | |
| | 1993 | 0 | 0 | 2,300 | 0 | 2,457 | 83,405 | | 88,162 | |
| | 1994 | 0 | 0 | 1,700 | 0 | 1,200 | 62,000 | | 64,900 | |
| | 1995 | 0 | 0 | 850 | 0 | 700 | 43,000 | -34% | 44,550 | -38% |
| Lead compounds | 1991 | 0 | 0 | 0 | 0 | 0 | 3,300 | | 3,300 | |
| | 1992 | 0 | 0 | 0 | 0 | 0 | 3,600 | | 3,600 | |
| | 1993 | 0 | 0 | 0 | 0 | 0 | 3,950 | | 3,950 | |
| | 1994 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | |
| | 1995 | 0 | 0 | 0 | 0 | 0 | 0 | -100% | 0 | -100% |
| Methyl ethyl ketone | 1991 | 200 | 103,400 | 72,700 | 5,000 | 6,177 | 393,745 | | 581,222 | |
| | 1992 | 250 | 9,900 | 69,500 | 4,200 | 1,330 | 234,456 | | 319,636 | |
| | 1993 | 1,376 | 11,600 | 130,226 | 4,000 | 5,455 | 215,246 | | 367,903 | |
| | 1994 | 1,000 | 6,000 | 11,800 | 0 | 1,280 | 179,100 | | 199,180 | |
| | 1995 | 500 | 5,000 | 8,700 | 0 | 1,280 | 170,850 | -57% | 186,330 | -68% |

Appendix C

Lockheed Corporation

Pollution Prevention Act Reporting, 1991-1993 Data and 1994-1995 Projections

| Chemical | Year | Recycled On-Site (pounds) | Recycled Off-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 |
|---|---|---|---|---|---|---|---|---|---|---|
| Methyl isobutyl ketone | 1991 | 0 | 5,800 | 7,400 | 0 | 0 | 14,000 | | 27,200 | |
| | 1992 | 0 | 5,800 | 6,200 | 0 | 0 | 24,200 | | 36,200 | |
| | 1993 | 0 | 0 | 7,423 | 0 | 200 | 22,623 | | 30,246 | |
| | 1994 | 0 | 0 | 1,800 | 0 | 0 | 12,911 | | 14,711 | |
| | 1995 | 0 | 0 | 1,800 | 0 | 0 | 12,911 | -8% | 14,711 | -46% |
| Tetrachloroethylene | 1991 | 0 | 17,000 | 92 | 0 | 0 | 22,000 | | 39,092 | |
| | 1992 | 0 | 0 | 0 | 0 | 0 | 150 | | 150 | |
| | 1993 | 0 | 0 | 0 | 0 | 0 | 150 | | 150 | |
| | 1994 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | |
| | 1995 | 0 | 0 | 0 | 0 | 0 | 0 | -100% | 0 | -100% |
| Toluene | 1991 | 100 | 40,200 | 15,000 | 0 | 4,142 | 162,639 | | 222,081 | |
| | 1992 | 150 | 0 | 13,600 | 0 | 12 | 97,588 | | 111,350 | |
| | 1993 | 2,064 | 0 | 66,997 | 0 | 7,905 | 97,700 | | 174,666 | |
| | 1994 | 2,000 | 0 | 1,500 | 4,600 | 7,000 | 57,200 | | 72,300 | |
| | 1995 | 2,000 | 0 | 1,500 | 4,600 | 7,000 | 52,200 | -68% | 67,300 | -70% |
| 1,1,1-Trichloroethane | 1991 | 19,400 | 184,004 | 3,700 | 280 | 13,747 | 1,296,996 | | 1,518,127 | |
| | 1992 | 21,000 | 49,000 | 0 | 610 | 28,000 | 485,810 | | 584,420 | |
| | 1993 | 20,000 | 113,981 | 10,242 | 460 | 12,897 | 396,194 | | 553,774 | |
| | 1994 | 5,000 | 26,000 | 0 | 460 | 5,650 | 241,800 | | 278,910 | |
| | 1995 | 0 | 2,000 | 0 | 0 | 200 | 125,000 | -90% | 127,200 | -92% |

## Appendix C

### Lockheed Corporation

### Pollution Prevention Act Reporting, 1991-1993 Data and 1994-1995 Projections

| Chemical | Year | Recycled On-Site (pounds) | Recycled Off-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 |
|---|---|---|---|---|---|---|---|---|---|---|
| Trichloroethylene | 1991 | 0 | 188,900 | 0 | 0 | 490 | 412,000 | | 601,390 | |
| | 1992 | 0 | 51,700 | 0 | 0 | 200 | 669,700 | | 721,600 | |
| | 1993 | 0 | 43,468 | 26,872 | 0 | 4,600 | 513,392 | | 588,332 | |
| | 1994 | 0 | 3,600 | 3,200 | 0 | 4,600 | 466,900 | | 478,300 | |
| | 1995 | 0 | 0 | 0 | 0 | 4,600 | 450,000 | 9% | 454,600 | -24% |
| Xylene (mixed isomers) | 1991 | 0 | 6,400 | 9,700 | 0 | 1,700 | 160,000 | | 177,800 | |
| | 1992 | 0 | 7,600 | 6,500 | 0 | 400 | 83,200 | | 97,700 | |
| | 1993 | 0 | 0 | 31,723 | 0 | 1,000 | 71,938 | | 104,661 | |
| | 1994 | 0 | 0 | 600 | 0 | 35 | 12,000 | | 12,635 | |
| | 1995 | 0 | 0 | 600 | 0 | 35 | 12,000 | -93% | 12,635 | -93% |
| 33/50 Program Chemicals | 1991 | 19,700 | 552,890 | 108,592 | 5,280 | 33,626 | 2,622,639 | | 3,342,727 | |
| | 1992 | 21,400 | 124,000 | 96,900 | 4,810 | 31,950 | 1,803,235 | | 2,082,295 | |
| | 1993 | 23,440 | 169,049 | 275,783 | 4,460 | 38,864 | 1,582,032 | | 2,093,628 | |
| | 1994 | 8,000 | 35,600 | 20,600 | 5,060 | 21,365 | 1,182,911 | | 1,273,536 | |
| | 1995 | 2,500 | 7,000 | 13,450 | 4,600 | 15,115 | 976,361 | -63% | 1,019,026 | -70% |
| All Non-33/50 Program Chemicals | 1991 | 71,000 | 55,000 | 16,800 | 489,604 | 49,246 | 738,182 | | 1,419,832 | |
| | 1992 | 18,500 | 28,200 | 12,380 | 774,510 | 9,100 | 580,496 | | 1,423,186 | |
| | 1993 | 1,000 | 42,800 | 12,450 | 445,155 | 22,400 | 401,754 | | 925,559 | |
| | 1994 | 5,000 | 5,300 | 9,100 | 384,700 | 15,600 | 291,245 | | 710,945 | |
| | 1995 | 1,200 | 0 | 1,200 | 351,200 | 15,600 | 257,845 | -65% | 627,045 | -56% |

Appendix C

Lockheed Corporation

Pollution Prevention Act Reporting, 1991-1993 Data and 1994-1995 Projections

| Chemical | Year | Recycled On-Site (pounds) | Recycled Off-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 |
|---|---|---|---|---|---|---|---|---|---|---|
| All TRI Chemicals | 1991 | 90,700 | 607,890 | 125,392 | 494,884 | 82,872 | 3,360,821 | | 4,762,559 | |
| | 1992 | 39,900 | 152,200 | 109,280 | 779,320 | 41,050 | 2,383,731 | | 3,505,481 | |
| | 1993 | 24,440 | 211,849 | 288,233 | 449,615 | 61,264 | 1,983,786 | | 3,019,187 | |
| | 1994 | 13,000 | 40,900 | 29,700 | 389,760 | 36,965 | 1,474,156 | | 1,984,481 | |
| | 1995 | 3,700 | 7,000 | 14,650 | 355,800 | 30,715 | 1,234,206 | -63% | 1,646,071 | -65% |
| <u>Percent Changes, 1991-1995</u> | | | | | | | | | | |
| 33/50 Program chemicals | | -87% | -99% | -88% | -13% | -55% | -63% | | -70% | |
| Non-33/50 Program chemicals | | -98% | -100% | -93% | -28% | -68% | -65% | | -56% | |
| All TRI Chemicals | | -96% | -99% | -88% | -28% | -63% | -63% | | -65% | |

Appendix D

Lockheed Company Facilities

Pollution Prevention Act Reporting, 1991-1993 Data and 1994-1995 Projections

| Facility | Chemical | Year | Recycled On-Site (pounds) | Recycled 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 |
|---|---|---|---|---|---|---|---|---|---|---|
| LOCKHEED MISSILE & SPACE COMPANY - SUNNYVALE, CA | | | | | | | | | | |
| | Methyl ethyl ketone | 1991 | 0 | 0 | 0 | 0 | 0 | | 0 | |
| | | 1992 | 0 | 8,000 | 0 | 400 | 5,100 | | 13,500 | |
| | | 1993 | 0 | 10,100 | 0 | 200 | 4,165 | | 14,465 | |
| | | 1994 | 0 | 6,000 | 0 | 200 | 4,000 | | 10,200 | |
| | | 1995 | 0 | 5,000 | 0 | 200 | 3,000 | --- | 8,200 | --- |
| | 1,1,1-Trichloroethane | 1991 | 0 | 18,400 | 0 | 32 | 40,000 | | 58,432 | |
| | | 1992 | 0 | 3,800 | 0 | 3,600 | 54,000 | | 61,400 | |
| | | 1993 | 0 | 18,000 | 0 | 100 | 32,800 | | 50,900 | |
| | | 1994 | 0 | 5,000 | 0 | 100 | 15,000 | | 20,100 | |
| | | 1995 | 0 | 2,000 | 0 | 100 | 5,000 | -88% | 7,100 | -88% |
| | 33/50 Program Chemicals | 1991 | 0 | 18,400 | 0 | 32 | 40,000 | | 58,432 | |
| | | 1992 | 0 | 11,800 | 0 | 4,000 | 59,100 | | 74,900 | |
| | | 1993 | 0 | 28,100 | 0 | 300 | 36,965 | | 65,365 | |
| | | 1994 | 0 | 11,000 | 0 | 300 | 19,000 | | 30,300 | |
| | | 1995 | 0 | 7,000 | 0 | 300 | 8,000 | -80% | 15,300 | -74% |

Appendix D

Lockheed Company Facilities

Pollution Prevention Act Reporting, 1991-1993 Data and 1994-1995 Projections

| Facility | Chemical | Year | Recycled On-Site (pounds) | Recycled 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 |
|---|---|---|---|---|---|---|---|---|---|---|
| | Non 33/50 Program Chemicals | 1991 | 71,000 | 19,000 | 21,000 | 40,000 | 67,040 | | 218,040 | |
| | | 1992 | 18,500 | 10,500 | 6,000 | 7,800 | 76,030 | | 118,830 | |
| | | 1993 | 1,000 | 39,000 | 36,000 | 8,100 | 51,030 | | 135,130 | |
| | | 1994 | 5,000 | 5,000 | 30,000 | 10,000 | 15,030 | | 65,030 | |
| | | 1995 | 0 | 0 | 30,000 | 10,000 | 30 | -100% | 40,030 | -82% |
| | All TRI Chemicals | 1991 | 71,000 | 37,400 | 21,000 | 40,032 | 107,040 | | 276,472 | |
| | | 1992 | 18,500 | 22,300 | 6,000 | 11,800 | 135,130 | | 193,730 | |
| | | 1993 | 1,000 | 67,100 | 36,000 | 8,400 | 87,995 | | 200,495 | |
| | | 1994 | 5,000 | 16,000 | 30,000 | 10,300 | 34,030 | | 95,330 | |
| | | 1995 | 0 | 7,000 | 30,000 | 10,300 | 8,030 | -92% | 55,330 | -80% |