American Defense Preparedness Association

Proceedings

3rd Annual

Air Force Worldwide Pollution Prevention

AF CENTER FOR ENVIRONMENTAL EXCELLENCE

Conference and Exhibition

San Antonio, Texas
August 29–September 1, 1994

3,896 PDF

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
BROOKS AIR FORCE BASE TEXAS

29 AUG 1994

HQ AFCEE/CC
8106 Chennault Road
Brooks AFB TX 78235-5318

Dear Conference Attendee

Welcome to San Antonio! I am excited you are here to participate in our 3rd Annual Air Force Worldwide Pollution Prevention Conference and Exhibition. Because of the enormous amount of positive feedback we received from last year's conference, we have expanded the scope of the conference to include a broader audience, a more diversified array of vendor displays and a larger number of technical sessions.

You are joined by many Air Force representatives, other service members, industry, academia, and other federal agencies, along with the news media. The objective of this conference is to provide an open forum for exchanging ideas, success stories, case histories and technologies related to pollution prevention program implementation.

This welcome package is provided for your information and orientation. If you require additional assistance, please contact Lt Col Patrick Fink or one of his staff. Our goal is for you to have an enjoyable, productive and informative stay.

Sincerely

Thomas W Gorges

THOMAS W. GORGES, Colonel, USAF
Commander

Attachment:
Welcome Package

TABLE OF CONTENTS

TABLE OF CONTENTS (Continuation)

PRESENTATIONS | *PAGE*

TABLE OF CONTENTS (Continuation)

TABLE OF CONTENTS (Continuation)

TABLE OF CONTENTS (Continuation)

TABLE OF CONTENTS (Continuation)

TABLE OF CONTENTS (Continuation)

TABLE OF CONTENTS (Continuation)

TABLE OF CONTENTS (Continuation)

TABLE OF CONTENTS (Continuation)

SESSION I

POLLUTION PREVENTION IN ACQUISITION

Session Chairpersons:
Eric Stephens, HSC/EM
Lt Col Ron Godfrey, HQ AFM/CEVV

Institutionalizing Pollution Prevention - A Step in the Right Direction

Presented by:
Capt Tony Papatyi
ASC/EME Bldg. 8
1801 Tenth Street
Wright-Patterson Air Force Base, OH 45433-7626
Ph. (513) 255-3059 DSN 785-3059

Because of National Security concerns, Federal facilities have been exempt from the majority of the environmental rules and regulations imposed on commercial enterprises. With the passing of the Federal Facilities Compliance Act (1992) and the Emergency Planning and Community Right to Know Act (1986), these facilities - specifically Air Force bases - are now required to disclose hazardous waste discharges and follow the existing environmental rules and regulations. The old days of dumping the excess, soiled or unused in the back forty are gone forever. Today's Air Force is becoming increasingly active in its pursuit of hazardous waste management and pollution prevention. In an effort to aid the changing culture, the Acquisition Environmental Management Program Office of Aeronautical Systems Center (ASC/EM) has undertaken several initiatives. One of those initiatives is the institutionalization of pollution prevention through the creation of a set of tools aimed at the acquisition community. It is the acquisition community within the Air Force that controls not only the future generations of fighters and bombers, but also the modifications to existing military aircraft and support systems. This community is the arm of the Air Force that can specify and mandate the production of a greener weapon system - during production and throughout its life-cycle.

The need for tools as instruments of institutionalization was not self evident. It took over eight months of wrestling with a number of ideas and trying to understand the ever increasing senior leadership guidance that seemed to be flooding our office. At the time, NAS-411 was undergoing its growing pains, Executive Orders were spilling onto the masses, the EPA 33/50 program was in full swing, and the Federal Facilities Compliance Act was breathing down our throat. There was RCRA, NEPA, EPCRA, SAF/AQ and CSAF/SAF Policy letters and many more alphabet soup requirements and regulations to take into account. There seemed to be sets of requirements and guidance that were in conflict with one another. System Program Offices did not fully understand the impacts that would be realized as a result of this flood of regulations. Most Program Offices hunkered down in two camps. Either they were ready to meet the challenge head on, or they were going to wait until the water calmed down to see what floated to the surface. Unfortunately, the camp that was ready to meet the challenge head on did so in a mostly uncoordinated and reactive manner. There were Program Offices letting contracts for baseline studies, others were setting up a pollution prevention program plan, while still others were trying to stay afloat and report the required "metrics" to senior management within the Air Force.

After watching and participating in this chaotic approach to the new environmental requirements, we came to the realization that a set of tools was needed to assist Program Managers understand the new program requirements. The tools would have to be specific to the business of acquisition. They would also have to be broad enough to capture the wide range of different acquisition activities within the whole of the Air Force.

Through a number of brain-storming sessions and a great deal of soul searching, we realized that the only way to tackle this challenge was to begin the process of pollution prevention institutionalization through the creation of a set of tools. Since the majority of the acquisition activities at Aeronautical Systems Center (ASC) are in the Engineering and Manufacturing Development *or* the Production stages of their acquisition life, we made the decision to focus our efforts in those two areas. Throughout the brain-storming sessions, a recurring question arose. How does one go about institutionalizing anything? In a bureaucratic environment such as the Air Force acquisition community, coupled with tremendous over-sight from our Congressional representatives, how does one go about changing the system to accommodate pollution prevention initiatives? Luckily, the Air Force has an existing tool -- the Air Force Acquisition Model (AFAM). This is a computer driven Windows based software program that contains information about weapon system acquisitions. It provides examples of documents, legal instructions, a section named Wisdom and a best practices/lessons learned data group. It looked like the perfect place to insert pollution prevention information. Additionally, we decided that a series of handbooks would be beneficial and could be used as a ready reference on the desk of each acquisition professional.

Now that we had developed a semi-clear vision of the needs and a reasonable means to fulfill them, we identified specific project rationale. We knew that the project/product must respond to higher headquarters objectives - i.e., incorporate policies, guidance and direction. Additionally, the project/product must be able to assist System Program Offices to avoid other ODC like problems.

With these two rationales in mind, a road-map was established to guide us through the maze of activities necessary to provide a useful product. The road-map was described in terms of understanding three critical issues. 1. We felt that we needed to fully understand the issues and problems that our Program Offices are encountering. We used surveys and face-to-face interviews to glean information from a number of organizations within the acquisition community (both Government and industry). 2. We also felt that a thorough knowledge of the laws, regulations, policy statements and guidance was essential. A comprehensive review of these documents was conducted during the early stages of the project. 3. Additionally, we felt that it was necessary to completely understand the acquisition business and how it is run throughout Air Force Materiel Command. This was accomplished through employing gray beard acquisition professionals as well as conducting extensive interviews with a number of Functional organizations at ASC. The project employed professionals that had over 200 years of cumulative experience in weapon system acquisition.

Through our interview and survey process, two categories of data surfaced. One data category was labeled "Acquisition Program Needs". The other was "Recurring Themes". It seemed that the acquisition programs were crying for specific guidance on the overwhelming volume of rules and regulations that were driving programmatic changes. They wanted to know (very specifically) what they *needed* to do to satisfy the requirements of these rules and regulations. We also discovered that there was a complete void and a great need for tools to assist project engineers and program managers sort through this mound of guidance. There were six recurring themes that also surfaced during our research. Those themes are listed below:

- P^2 makes good business sense
- Mil-Prime philosophy must be employed
- P^2 must fit into the existing systems engineering framework

- Additional trade study variable must be pollution potential
- Must focus on materials and processes that will be passed onto the Air Force
- National Aerospace Standard - 411 (NAS-411) can help

Once our research was nearing completion, and the themes and needs began to solidify, we developed an approach philosophy. The philosophy dictated that we create a toolset that contains guidance, templates, references, examples, instructions, checklists and rationale that can be used by project engineers as well as program managers to infuse pollution prevention into their weapon system program. This must be done through a complete understanding of all applicable laws, rules, regulations, the military standard on systems engineering, and NAS-411. These critical pieces coupled with the Mil-Prime philosophy served as the foundation of the creation of the toolset. The vision of the toolset was to provide concrete guidance for acquisition processes and tasks that meet the requirements of the policies and laws. We believed that if we created a tool-set providing specific examples, templates, and checklists for the project engineer, we would be able to begin satisfying the objective of institutionalizing pollution prevention.

Another ground rule used when building the toolset was that it must fit into the existing framework of the systems engineering process already in place. Pollution prevention initiatives must fold into the existing work break-down structures, Integrated Master Plans, Integrated Master Schedules, Award Fees and Technical Performance Measures. We are convinced that preventing pollution will not work unless this approach is taken.

One of the key focuses of the toolset/handbook is the establishment of a pollution prevention program. We strongly suggest that to realize a decrease in pollution, organizations -- mainly contractors -- must establish a comprehensive plan for initiating pollution prevention objectives. The program must include plans to make in-roads into the existing systems engineering processes. This includes heavy involvement in the material and process selection decision making processes. It is imperative that the green perspective be represented during the design phases of material and process selections. The ***focus*** of the green perspective must be centered on the ***materials and processes that will be passed onto the Air Force*** after the contractor delivers the weapon system. The program must also include plans to inventory hazardous materials that are in use or are planned for use. For without that, one cannot go forward with a meaningful pollution prevention scheme. Also, without a baseline inventory of hazardous materials, one will not be able to measure successes and failures.

The handbook also describes a ***process*** that may be used to infuse pollution prevention into an acquisition program through its existing systems engineering framework, Integrated Product Team Structure, and present team composition. The process is a common sense approach to establishing pollution prevention as a variable within the systems engineering discipline. It is based on developing a pollution prevention program and providing feedback on its accomplishments.

Throughout the development of the handbook/toolset, it was necessary to keep a clear definition of pollution and pollution prevention. Pollution, or the uncontrolled release of materials, can occur at any stage in the development of a weapon system. We have found that there is an expanding trickle down effect for pollution. The processes and material selections made during system design or modification are passed onto the manufacturer who in-turn passes them to the operational Air Force (Air Combat Command and Air Mobility

Command) as well as the Air Force Depots. Finally, these materials and processes must be disposed of by the Air Force. We chose to focus our initial efforts on the center of this flow (the Engineering and Manufacturing Development *and* Production phases of acquisition) while maintaining a perspective on the other phases.

The structure of the handbook that has emerged shows a logical process to infuse and institutionalize pollution prevention into the acquisition process. It begins by introducing pollution prevention and providing a brief historical and legal background. The second chapter provides a "how to" discussion on injecting pollution prevention and environmental concerns into the existing acquisition and systems engineering processes. The third chapter is the heart of the document. It contains specific "how to" guidance for thirty-one different acquisition processes and documents. This is where the templates, checklists, examples and specific guidance is contained. Additionally, there is an appendix that provides summaries of existing directives and guidance, a glossary, acronym list and a reference list.

The next phase of the program is to formally coordinate both the handbook and the AFAM inputs. Additionally we plan to produce the other handbooks and AFAM input sets -- for Concept Exploration and Demonstration/Validation *and* for Operations, Support and Disposal. We also plan to add a more comprehensive discussion about costing pollution prevention initiatives.

POLLUTION PREVENTION IN SYSTEM ACQUISITION

A Historical Perspective and Future Vision

Eric Stephens
Director of Environmental Management
HSC/EM
2909 North Road
Brooks AFB TX 78235-5128

DSN: 240-2346
COMM: 210-536-2346
FAX: 210-536-2033

BACKGROUND:

AF Weapon Systems have evolved dramatically from the Wright Flyer to the F-22, but a process to consider environmental issues during the design of the systems is only now beginning to evolve.

Pollution Prevention in Air Force Acquisition had a genesis from a 1986 Air Force Scientific Advisory Board Report titled "Selection and Use of Hazardous and Toxic Materials in the Weapons System Development and Acquisition Process". It found that there was no process in place to consider environmental issues, specifically hazardous materials, during the acquisition process. It recommended that System Program Offices, SPOs, take the lead as that is where the engineering decisions and authority rest.

The Air Force Civil Engineer is responsible for the Air Force environmental program and has a $2 billion annual requirement to clean-up over 4400 sites plus stay in compliance with current legislation. An analysis of how that money is being spent shows that weapon systems are the largest driver.

Ms Goodman, Deputy Under Secretary of Defense for Environmental Systems (DUSD/ES) has publicly stated that 80 percent of the Department of Defense's hazardous material generation can be tied to weapon systems production, maintenance, and disposal.

AF Materiel Command in 1992 purchased 2838 tons of EPA-17 hazardous materials to support their industrial operations.

The 23 December 1993, Secretary of the Air Force for Acquisition Policy Letter on Pollution Prevention in Acquisition is a landmark environmental policy. For the first time, the acquisition community is officially charged to consider environmental issues during the life cycle of the system. It specifically charges the Single Managers to:

- Develop a Pollution Prevention Plan
- Track reduction of ODCs and EPA-17 (lbs/uses)
- Track Technical Order revisions
- Consider life cycle cost of material selections
- Fund Pollution Prevention from within their program

In effect, they are directed to consider environmental issues during their trade-off studies just as they look at reliability, maintainability, and supportability in addition to cost, schedule, and performance.

CURRENT EFFORTS:

To help the acquisition community meet theses new challenges, the Human Systems Center at Brooks Air Force Base has three initiatives.

"Tools" common to all Single Managers:

These eleven Tools comprise an analytical Took Kit. There are Tools to help set up a Pollution Prevention program, to write contract language, to perform life cycle cost trade-offs for processes and materials, to estimate Pollution Prevention costs, as well as a training program to address the awareness issue. Contact HSC/YAQ (Environmental Systems Division), Capt Nick Muszynski, at 210-536-5120 (DSN240-5120), for more information.

Ozone Depleting Chemical (ODC) Information Exchange:

This new capability opened its doors on 15 June 1994. Its role is to be the focal point people can go to to obtain ODC information. The Exchange has access to numerous data bases, as well as the Air Force ODC waiver data base. It is a joint effort with AFCEE, the Air Force Center for Environmental Excellence. To contact the ODC Information Exchange in HSC/YAQ, call Mr. David Zapata, at the AFCEE PROACT number 1-800-233-4356.

"Material/Process Substitutions" common to Single Managers:

The key to the success of the Acquisition Pollution Prevention program is actually making material and process changes. Single Managers have the ultimate responsibility to make these changes on their individual system. However, there are many plating, painting, and cleaning processes that are common to several programs. In these cases, it makes sense to find a single acceptable solution versus ten Single Managers each chasing their own solution. This is where the Materiel/Process Substitution Integrated Product Team (IPT) can help. Located in HSC/YAQ, they can work with the engineers from several SPOs to find a common solution to a common problem. For more information, contact HSC/YAQ, Maj Randy Stager or Capt Laurie DeGarmo, 210-536-4904.

FUTURE VISION:

In the Weapon System acquisition business, the future is now. The engineering decisions the F-22 and B-2 make today will be with us for three decades. Our goal is to provide the Air Force and its Single Managers the tools, information, and engineering solutions, it needs to develop "green" systems in the future.

ENVIRONMENTAL GUIDE FOR WEAPON SYSTEMS ACQUISITION: SECOND EDITION

Andy Perich, U.S. Army PBMA, Picatinny Arsenal, NJ 07806-5000
Steve Sobol, SAIC, Hackensack, NJ 07601

The U.S. Army Production Base Modernization Activity (PBMA) published the "Life Cycle Environmental Guide for Weapon Systems Project Managers" in October 1992. This document serves as a primer on environmental issues for weapon systems project managers including the DOD 5000 series requirements; and was well received by the Army and DOD communities, including its use as formal policy by the Army's Program Executive Officer for Armaments. Based on user comments and additional experience on weapon systems programs, the guide is being updated to include new information.

The major change to the guide involves development of a companion volume which will describe the specific steps necessary for the project manager's environmental staff to develop and execute a comprehensive life cycle environmental program. The revised document will describe Army and DOD requirements as well as recommended actions for a strong and cost-effective program. Topics covered will include: establishing a management structure, team and budget; how to prepare documents including Life Cycle Environmental Assessments and the level of detail necessary; and how to manage environmental concerns effectively throughout the life cycle, including the role and implementation of environmental technologies for compliance and pollution prevention purposes.

The guide will contain input from multiple sources, including the Environmental Protection Agency with regard to life cycle analyses, and the Army's Industrial Operations Command with respect to environmental concerns associated with the industrial base. The completed second edition will be a "how-to" document, providing specific guidance to satisfy the broad requirements contained in DOD and Army regulations. Completion of the expanded second edition is scheduled for December 1994. Written requests for the completed document should be addressed to:

Andy Perich
Life Cycle Readiness Division
U.S. Army PBMA
Attn: AMSMC-PBR
Building 172
Picatinny Arsenal, NJ 07806-5000

POLLUTION PREVENTION IN THE ACQUISITION PROCESS

Mathias L. Kolleck
Booz•Allen & Hamilton Inc.
4141 Col. Glenn Highway, Suite 131
Dayton, Ohio 45431
513-429-9509

Abstract

The Congress of the United States enacted Public Law 101-508 on November 5, 1990. This law is also known as the Pollution Prevention Act of 1990. The intent of this law is to force industry to reduce or prevent pollution at the source, i.e., as part of the weapon system acquisition process. The acquisition process includes the development, production, operation, and final disposition of all weapon systems procured by the Department of Defense (DoD). Also included in this concept are the raw materials used in the production and maintenance of weapon systems. By addressing the issue of pollution prevention early in the acquisition cycle, cost-effective changes can be made to a system to allow it to comply with all environmental laws. This will have the effect of reducing the potential for costly liability settlements by the federal government as well as protecting the environment.

In order to be most effective, an environmental philosophy must be implanted in the acquisition process beginning with Phase 0, Concept Exploration. During this phase, the types of considerations should include the potential environmental impacts of the various options being considered. It is during this phase that the most cost-effective pollution prevention design decisions can be made. In Phase 1, Demonstration & Validation, system performance and environmental impact trade-offs must be made. This is the final phase in which the window of opportunity for cost-effective pollution prevention solutions remains completely open. Beginning with Phase 2, Engineering & Manufacturing Development, opportunities for pollution prevention begin decreasing because the weapon system design is frozen and the issues shift to those of control of harmful substances and compliance with applicable laws.

Discussion

Pollution prevention is quickly becoming more than a desirable goal. It is approaching the status of a necessity. Clean-up costs are skyrocketing. Hazardous waste disposal and liability costs have increased tenfold over the past five years. Landfill space has dwindled 80% over the past decade (1). Even with total compliance with all regulatory laws and policies, the lack of physical space for disposition of wastes cannot be ignored. Siting for new landfills or hazardous waste facilities has become extremely contentious. Not-in-my-backyard (NIMBY) has become the rallying cry of those individuals and groups opposing new landfills or other types of waste facility. Examples of this situation abound. A recent article in The Wall Street Journal describes the situation in San Diego, California, where a group of homeowners is suing San Diego County for $20 million because the county plans to expand an existing landfill, a landfill that existed before most of the homeowners moved into the area. What makes this case somewhat unique is that the landfill is not in a poor or minority neighborhood. It is located in one of the county's most affluent areas (2). Similar situations will almost certainly occur in many other parts of the country. To minimize these, systems must be designed that avoid or reduce disposal requirements.

Most current environmental programs deal with the end of the acquisition pipe. Clean-up and compliance policies and programs fall into this situation. To a certain extent, conservation programs do also. This is the least desirable and most costly option to addressing environmental pollution. Pollution prevention, on the other hand, deals with environmental protection at the other end of the acquisition pipeline - during Phase 0 (Concept Exploration) and Phase I (Demonstration/ Validation). Once a program has progressed into Phase II (Engineering and Manufacturing Development), emphasis necessarily shifts to pollution control, compliance with appropriate laws, and ultimately, clean-up and disposal. Environmental considerations during each stage of the acquisition cycle are shown in Figure 1.

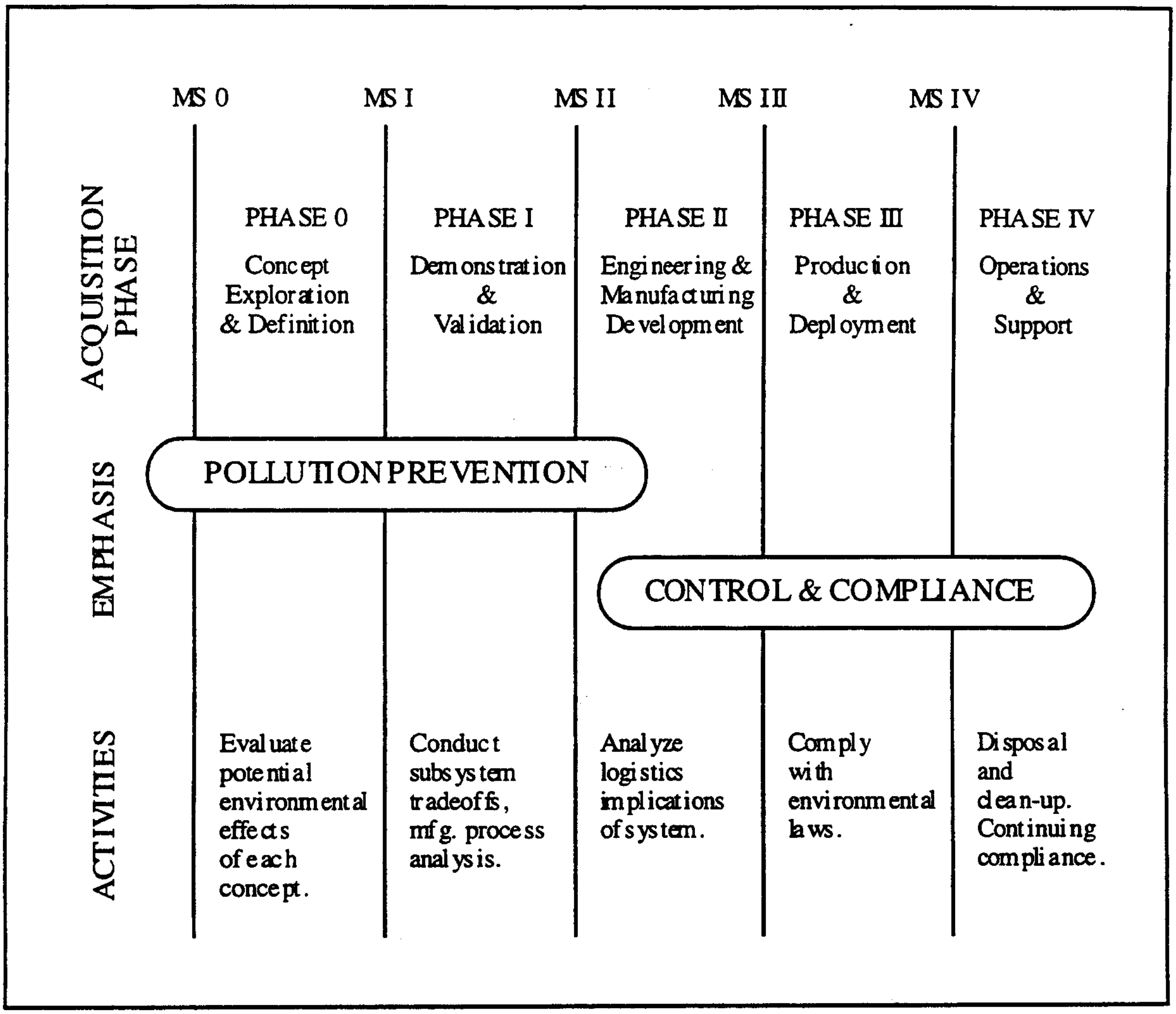


Figure 1. Environmental Activities During Acquisition Cycle

An ounce of prevention is worth a pound of cure. Everybody has heard this old Ben Franklin adage many times. If an ounce of prevention is in fact worth a pound of cure, that's a 16 to 1 benefit/cost ratio. Is this platitude applicable in today's world when addressing problems such as pollution prevention? Examples from a number of companies have shown that this is possible. Forty documented case studies have shown that pollution prevention is not only good in terms of protecting the environment, but also in terms of dollars and cents (3). The firms involved in the case studies were grouped by Standard Industrial Classification (SIC) codes and encompassed agriculture, mining, food products, textiles, furniture, paper and printing, chemicals, electronic and electrical equipment, and service industries. The results are impressive. By adopting pollution prevention strategies, the firms achieved the following:

- 13 firms improved productivity,
- 26 firms reduced raw material usage,
- 13 firms improved energy costs,
- 17 firms reduced pollution control costs, and
- 7 firms improved product quality.

While not all of the SIC codes covered in the case studies are applicable to the defense industry, certainly those in the SICs for chemicals, electronic and electrical equipment, and service industries are appropriate.

Can these cost savings, already recognized by private sector firms, be realized in the systems acquired by DoD? The federal government and the Department of Defense apparently feel that the answer to this question is "Yes". DoD is getting very serious about pollution prevention. How serious are they? Serious enough to create a program and position at the deputy under secretary of defense level. The secretary of defense has created the DoD Environmental Security Program and placed the responsibility for this program under the Office of the Deputy Under Secretary of Defense (Environmental Security) (ODUSD(ES)). The mission of this office is to integrate DoD environmental concerns and policies. To this end, DoD has developed a number of directives and instructions dealing with pollution prevention, including DODD 4210.15, Hazardous Material Pollution Prevention, and a revised DoD 5000 series dealing with systems acquisition. DoD Instruction 5000.2, Defense Acquisition Management Policies and Procedures, dated February 23, 1991 typifies this increased environmental emphasis. In this revised Instruction, none of the acquisition milestones can be successful completed without analysis of the potential environmental consequences of the program and development/identification of appropriate mitigation measures. DoD Instruction 5000.2 further requires that the Integrated Program Summary necessary for Milestones I, II, III, and IV, contain in Appendix E the environmental analysis. Procedures for conducting this analysis are contained in Part 6, Section I (4).

The problem then becomes one of developing a systems acquisition methodology that can incorporate pollution prevention concepts into it. Fortunately, the basis for such a methodology already exists and is well established in the acquisition process - life cycle costing. Life cycle costing has been used for a long time in the acquisition process to calculate "cradle-to-grave" costs associated with a weapon system. This concept is still valid, except that "cradle-to-grave" needs to be expanded to include what happens when the hardware associated with a weapons system reaches the "grave". Will it be around for hundreds or thousands of years after it is disposed of? Will its residues seep in to local ground water supplies? Will the cost of ownership continue far beyond its demise?

Life Cycle Assessment (LCA) is the name given to the current approach in evaluating products from an environmental approach - the environmental burden of a weapon system. An LCA evaluates the environmental releases and impacts of a product/process/activity by tracking its development from raw materials through production, and ultimately to disposal. LCAs are not a new phenomenon. They have been used for approximately the past twenty years. Most of the studies have been funded and conducted by private firms and are not generally made available to the public. Some of the more well known and publicly available LCAs include a 1990s study sponsored by Proctor & Gamble on disposable versus cloth diapers and a study on the polystyrene "foam" containers used by McDonald's Corp. These studies will be described in detail later. The conduct of an LCA is a time consuming and, therefore, expensive process. This helps explain why, out of the millions of products and processes in the U.S. economy, only a very small handful (approximately 100) of studies has been performed.

An LCA is composed of three phases. Phase I is a basic input-output inventory analysis. Figure 2 presents a conceptual framework for conducting this analysis, a process which can be applied to weapon system acquisition. A very important consideration during this phase is the amount of energy used during the production, operation, support, and disposal of the weapon system. During Phase I, data are gathered on all the processes and intermediate products that go into the production of a weapons system. These data are gathered for all phases of the acquisition process. This includes data on the raw materials used in the system, manufacturing processes, operational procedures, maintenance requirements, and ultimate disposal.

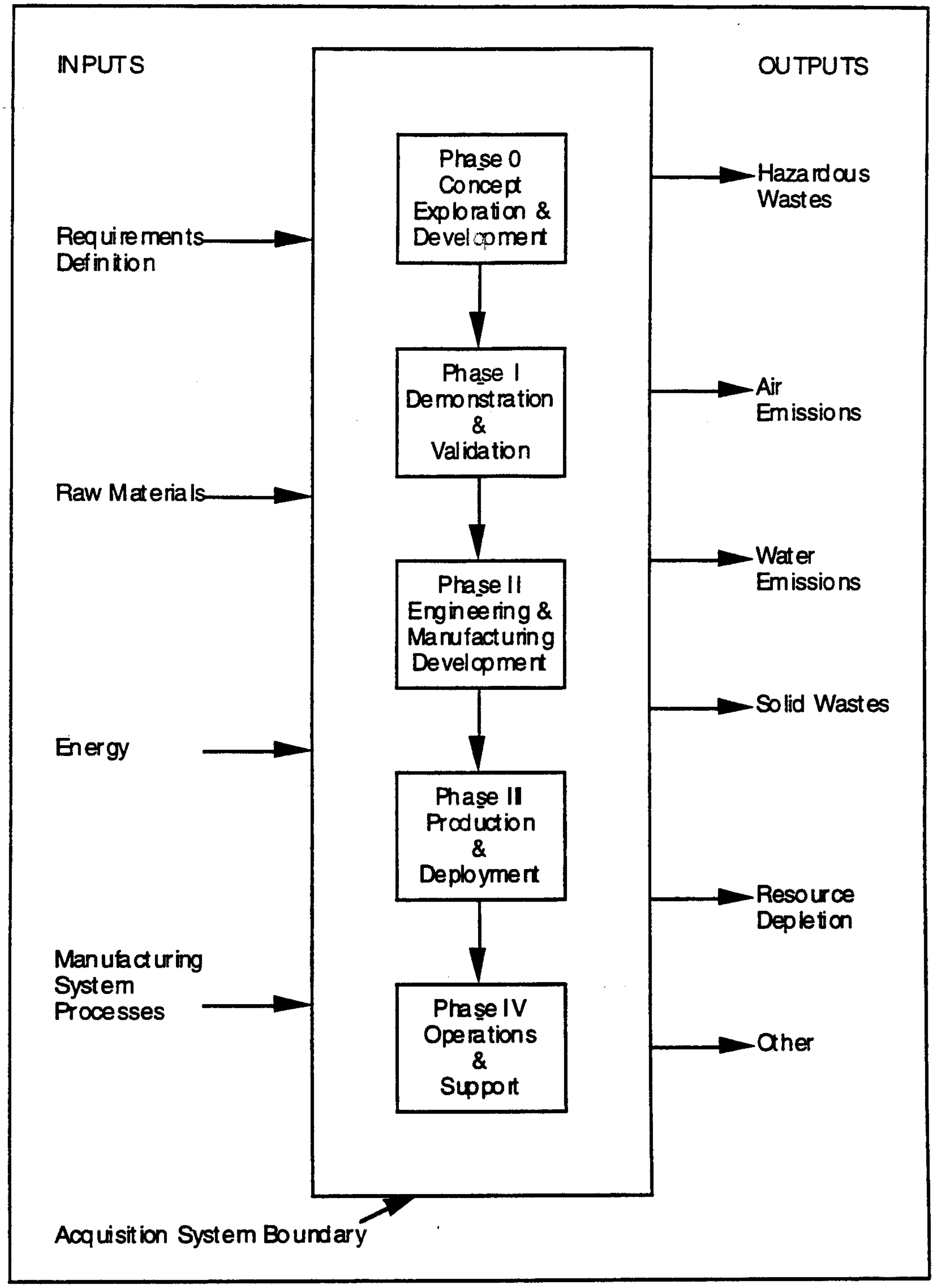


Figure 2. Input-Output Analysis Framework

The most efficient approach to performing an LCA is to utilize existing life-cycle cost models where possible. These models contain data on the "nuts and bolts" of the components and subsystems that go into a weapon system and can form the basic level of an LCA. The next higher level in the assessment will be the parametric level which will quantify system performance and introduce risk factors. The third and highest level of the assessment is used to evaluate the life-cycle impact on the total environment - the environmental burden. A conceptual model for this process in presented in Figure 3.

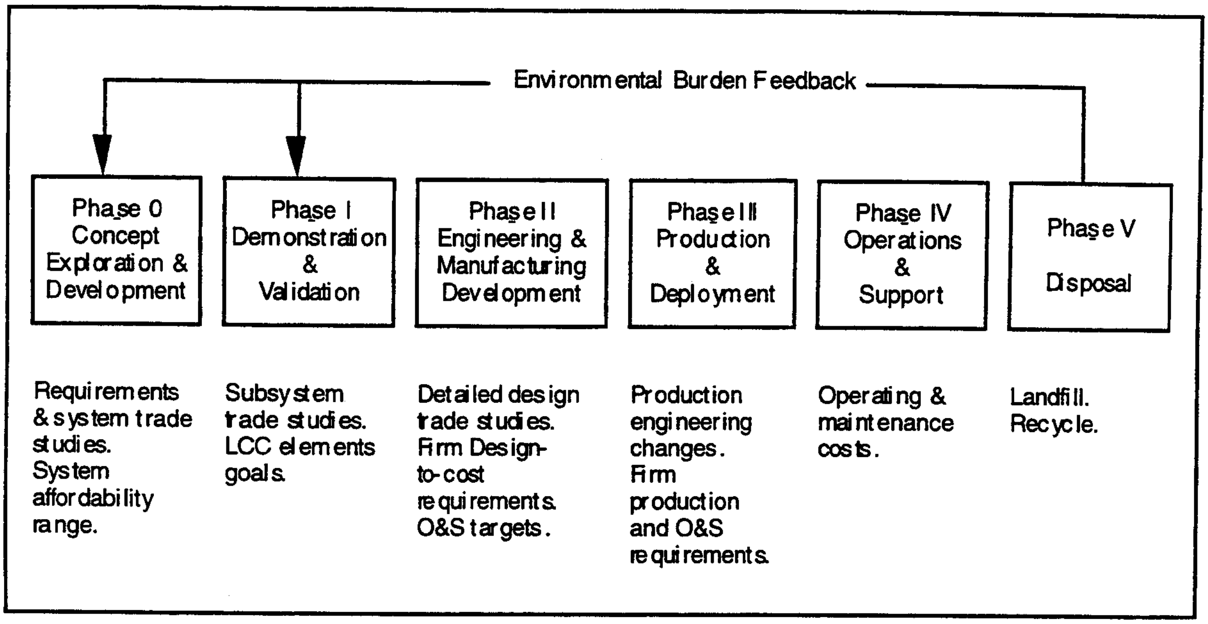


Figure 3. LCA Analysis Framework

Phase I of an LCA as presented above is fairly well defined. Depending on the scope of the LCA, additional phases might be required. Phase II deals with impact analyses during which emission quantities and their relative environmental consequences are evaluated. Whether or not Phase II is performed depends on the objectives of the study. If an impact analysis is desired, it is imperative that what constitutes an impact in the context of the LCA be defined initially. Typical impact definitions range from human health risks to habitat alterations. Phase II is not well defined at this point in time because the relationship between an environmental emission identified in Phase I and a harmful effect is not well understood. Furthermore, no recognized method exists for comparing various environmental impacts. For example, if the input-output analysis performed in Phase I reveals that a specific production process will generate a pound of sludge as a waste product, is it worth the consumption of additional BTUs of energy to eliminate it?

Phase III deals with improvement analyses. Certain aspects of improvement analyses are also not well defined. These typically revolve around making value judgments when considering whether to change a process or activity to create less solid waste but perhaps more air pollution. This type of shortcoming has been identified and discussed previously when describing Phase II activities. However, some types of improvements can be identified which don't involve a decision of this nature. These improvements are implemented and result in significant cost and/or pollution reduction as shown in the case studies described previously.

While providing a useful tool to establish the environmental burden of a specific weapon system which is produced and maintained using specific procedures and standards, LCAs are not the complete answer. The biggest drawback is that there are no agreed upon approaches or standards to use when evaluating a system being acquired. Value judgments must be made. For example, is it better to use more BTUs from a nonrenewable energy source, such as coal, possibly increasing air pollution during the energy generation process, to produce a product which will be more biodegradable upon its final disposal (less solid waste)? Normative questions such as this cannot be answered using LCA.

Lack of standards can also produce inconsistent results. The Proctor & Gamble and McDonald studies mentioned earlier are two cases in point. In the Proctor & Gamble study, it was found that cloth diapers consumed more than three times as much energy, from cradle to grave, as disposables. However, a study sponsored by the National Association of Diaper Services reported that disposables consumed 70% more energy than cloth diapers. This discrepancy was traced largely to accounting methods used in measuring energy consumption during the processes (1).

In the McDonald study performed by environmental consultant Franklin Associates Ltd., polystyrene "foam" containers were shown to use less energy in the production process, pollute less, and create less trash by weight than paper containers. However, a study by environmentalists concluded that foam is not biodegradable and makes more trash by volume than paper. McDonald's eventually phased out the foam. A few months later, a Canadian chemistry professor published a study suggesting that foam cups were better environmentally than the paper ones (5).

LCAs are data intensive and this creates a potential problem. It is difficult, if not impossible, to obtain detailed basic data for the entire life cycle of the product/activity being studied. Also, some data may not be available because they are proprietary. In these types of circumstances, the use of industrial averages obtained either from government data bases or trade associations can be used to fill data voids. Where possible, sensitivity analyses should be performed to determine if some data have a disproportionate impact on the assessment. The existence of such data would necessitate greater care and accuracy when obtaining them.

Given the problems mentioned above, of what use can an LCA be in the acquisition process? There are three primary benefits which can accrue from the completion of an LCA:

- LCAs are useful in identifying pollution prevention opportunities in various production processes used in acquiring weapon systems.
- One of the major reasons for conducting an LCA is to compare different approaches to the development, production, operation, and disposal of weapons systems. Given the level of inaccuracy in determining the absolute level of environmental burden produced by various processes, the difference between them is useful information in deciding which is the best.
- The DoD is a major consumer in the economy. By requiring that its suppliers provide some type of LCA for the products they sell, DoD can have a significant impact on the total burden placed on our environment.

Summary

Until recently, one of the basic underlying assumptions of mankind was that processing mankind's waste products was a primary function of this planet. That view is slowly changing as the difficulties of disposing of waste material continue to mount. Achieving the level of environmental awareness and sensitivity necessary to ingrain pollution prevention into the acquisition process will not be an easy task. Despite its shortcomings and limitations, LCA provides an analytical tool by which this process can begin.

Pollution prevention by DoD weapon systems will require more than developing new tools and changing the technology involved in the production process. It will require changes in the mindset of the people who develop, produce, and purchase weapon systems for the DoD. Perhaps the only way to achieve such a mindset change is to establish a national commitment similar to that which helped land a man on the moon 25 years ago.

References

(1) Curran, Mary Ann *Environmental Science and Technology* 1993, 27(3), 430-36.

(2) "A Wealthy Suburb Airs Its Complaint: Flies in the 'Hood," *The Wall Street Journal,* July 11, 1994.

(3) "Proven Profits from Pollution Prevention: Case Studies in Resource Conservation and Waste Reduction," Donald Huisingh, Larry Martin, Helene Hinger, and Neil Seldman: 1986.

(4) DoD Instruction 5000.2, "Defense Acquisition Management Policies and Procedures," February 23, 1991.

(5) "Life-Cycle Analysis Measures Greenness, But Results May Not Be Black and White," *The Wall Street Journal,* February 28, 1991.

SESSION II

RECYCLING/COMPOSTING

<u>Session Chairpersons</u>:

E. Alexander Stokes, III, HQ AFCEE/EP
Colonel Markus Madrid, HQ ACC/CEV

Doing Your Part to
Meet the National Waste
Minimization Goal

Ronald E. Lamb
Dynamac Corporation
2275 Research Boulevard
Rockville, Maryland 20850-3268
(301) 417-9800

Most people would agree that the most important trend in waste management over the last few year has been recycling. But just as recycling has caught the public's imagination, it has smothered other viable methods to deal with solid wastes. Most Americans would also be very surprised to learn that most policy makers and waste management professionals rank waste minimization, not recycling, at the top of their list of ways to deal with municipal solid waste.

Largely as a result of the public's overwhelming response to recycling, waste minimization hasn't received the attention it deserves. This paper will discuss what constitutes waste minimization, historical trends in municipal solid waste (MSW) generation, our nation's waste minimization goal, progress since 1988 in meeting the goal, and what you can do to support waste minimization.

What is Waste Minimization?
The term waste minimization, also known as source reduction, is rarely well defined or well understood. For example, people often mistakenly refer to recycling as waste minimization. However, waste minimization is any action that leads to a net reduction in the quantity and/or toxicity of material *before* it becomes municipal solid waste. Recycling is an alternative disposal method once the material become municipal solid waste.

Waste minimization incorporates a number of concepts:

1. First, it is <u>not</u> a waste management process, such as recycling, waste-to-energy incineration or landfilling.

2. Waste minimization occurs before a product or package becomes solid waste or enters the waste stream.

3. Waste minimization entails resource conservation.

4. Waste minimization cannot be applied by local solid waste officials. There are two basic routes to waste minimization: manufacturers can change the design of their products and packaging, and consumers can alter their purchasing decisions.

Waste minimization efforts can originate within all segments of industry, government, or consumer society. A simple example of waste minimization is industry efforts to offer "lightweight" bottles or containers. A one-gallon plastic milk jug requires one-third less material than one in the early 1970s, but is just as functional. Another example of waste minimization is McDonald's switch from disposable soft drink mix containers to pumping syrup from delivery trucks directly into the restaurant's own reusable tanks, reducing solid waste discards to virtually zero. Reuse can also be waste minimization.

An example of this is donating usable clothing, construction materials, or paint to an organization that will use it instead of throwing it away.

Historical Trends in MSW Generation

Even before garbage barges hit the media by traveling between communities hunting for someone to accept their loads, policy-makers believed we were heading for a garbage crisis. In 1988, the Environmental Protection Agency (EPA) data indicated that the U.S. was recycling only five to ten percent of its waste and landfilling most of the rest. Between 1980 and 1988, the amount of solid waste generated by households, commercial establishments, and institutions increased by 26.3 percent, and people began to believe that we were quickly running out of landfill space.

There are a number of factors behind this increase. Between 1972 and 1987 solid waste generated in the U.S. grew by 34 percent, but accelerating recycling and other recovery programs reduced the growth of materials actually discarded to 28 percent. During this 15-year period, the population grew by 16 percent. On a per capita basis, then, waste discards grew by 16 percent. Several important changes conspired to cause this increase in per capita discards, including those cited below:

Cultural and Demographic Changes. The number of households increased by 34 percent, with a leading factor being the 73 percent increase in single-person households. A related change is the 61 percent increase in females in the workforce. These factors have led to an 80 percent increase in the discards of furniture and furnishings, 48 percent increase in appliance discards, and more convenience packaging.

Changes in Work Patterns. Changes in working patterns also affected waste discards. The number of office workers increased by 72 percent. It was originally thought that the widespread use of computers would introduce the "paperless" society. However, it has become clear that the opposite may be true. The well equipped office--with high speed copiers, fax machines, computer printers, and desk top publishing systems--is now able to put out paper at record rates. The use of office papers was up 87 percent between 1972 and 1987. Accompanying this was a 24 percent increase in books and instruction manuals; a 38 percent increase in magazine paper; and a 133 percent increase in general printed matter, which includes catalogs, brochures, reports and third-class mail. All this paper also resulted in a 23 percent increase in the use and discard of corrugated boxes to ship the paper.

Changes in Eating Patterns. Increased consumption of fish, poultry, and fresh fruits and vegetables has resulted in a 52 percent increase in corrugated boxes. More convenience packaging has also taken place.

While difficult to measure, increased disposable income may also be a factor. Consumers have more money and purchase more goods. For example, many households today tend to have multiples of some consumer products such as TVs, stereo radios, calculators, cameras, telephones, and home and beauty care appliances.

Our Waste Minimization Goal

As a result of these trends and increases in generation rates of municipal solid waste, and the perceived shortage in disposal capacity, in January, 1988, the EPA set a national goal of reducing or recycling the amount of solid waste generated by 25 percent by 1992.

In February, 1989, EPA gave this issue a higher profile when it published "The Solid Waste Dilemma: An Agenda For Action." In it, then EPA assistant administrator for Solid Waste and Emergency Response, J. Winston Porter said, "Our nation must stop the increase in our per capita generation rate.

And in the long run, we must also strive to reduce it." EPA set for itself the objective of increasing waste minimization efforts by industry, government, and citizens.

Specifically, EPA said it would:

- Study options for reducing lead and cadmium in products in order to reduce the risks of emissions and ash from incinerators, landfill leachate, and recycling operations;

- Foster workshops for manufacturers and educators to promote the design of products and packaging for effective waste management;

- Identify economic, regulatory, and possibly legislative incentives for decreasing the volume and toxicity of waste;

- Take steps to facilitate Federal procurement of products with source reduction attributes;

- Direct industry to conduct waste audits and determine ways to decrease the volume and toxicity of materials used in manufacture.

Progress Since 1988 in Meeting the Goal

The U.S. has made great strides in recycling and reducing our nation's dependence on landfills, but it seemingly has made little progress in reducing the amount of waste generated in the first place.

For example, in 1990, Americans recycled 17 percent of their waste, incinerated 16 percent, and landfilled 67 percent, a dramatic change from just a few years earlier. Yet, in tonnage, the amount of garbage landfilled in 1990 was 25 million tons more than in 1980. Why? Per capita generation rate had increased by 16 percent, from 3.7 to 4.3 pounds per day from 1980 to 1990. On top of that, our population had increased by 10 percent. In terms of sheer per capita generation rates, it is clear that the U.S. has not met its goal of halting or reversing the amount of solid waste generated. Should we simply conclude that we have failed? Can we at least identify areas of success? In fact, progress has been made in some areas, even though we haven't met our overall goals.

Real areas of progress include the following:

- Reduced toxics in products
- Reduced toxics in packaging
- Reduced weight and volume of packaging
- Reduced food spoilage and waste

Toxics in products

This is a difficult area to measure, since there is no direct data on toxic substances entering the municipal solid waste stream. Little is known about the distribution of toxic substances in various products. Some information is available on heavy metals such as mercury, cadmium, and lead. These are generally recognized as toxic and they are used in many products. Mercury is a component of most household batteries, as well as fluorescent light bulbs, thermometers, mirrors, and mildew-proof paints. The largest source of lead (two-thirds) is automobile batteries. Other sources include electronic components, rust-proofing paints and paint pigments, ceramic glazes, inks, and wire and cable insulation. Cadmium is found in metal coatings and plantings, rechargeable household batteries, paints, and inks, electronics, stabilizers in some plastics and in metal coatings and platings. Data indicates a general trend toward less of these metals in products.

Toxics in Packaging

One of the most interesting and promising packaging initiatives was the cooperative agreements organized by the Coalition of Northeastern Governors (CONEG). In 1989, the CONEG Source Reduction Council, an advisory group of state, industry, and public interest group representatives, developed the Model Toxics in Packaging (MTP) Legislation. The purpose of the MTP is to reduce the amount of heavy metals (cadmium, lead, mercury, and hexavalent chromium) in packaging and packaging components sold or distributed throughout the states. As of 1993, legislation based on the MTP has been adopted in 16 states nationwide. This has led to significant reductions in these metals in packaging.

Other CONEG initiatives include an examination of toxics in products, composting, variable rate pricing of garbage collection, and reductions in the weight or volume of packaging.

Weight and Volume of Packaging

Packaging is something consumers love to hate. Most people would be surprised, however, to learn that packaging is a declining part of our waste. Important factors include lightweighting of bottles and substitution from heavy, thick glass and steel to lightweight aluminum and plastics and from rigid containers to flexible film and pouches. On a per capita basis, packaging waste has declined almost 2 percent between 1980 and 1990. Better and more efficient packaging has also led to less breakage, food spoilage, and waste.

Food Spoilage and Waste

Data indicates that food wastes are a declining percentage of the waste stream, down from almost 15 percent of discards after recycling in 1960 to 8.1 percent in 1990. In fact, on a per capita basis, food wastes are the only part of the waste stream that has seen a decline over the last 30 years, and also declined 9 percent between 1980 and 1990. This can be attributed to greater use of garbage disposals, which send food wastes to the sewer systems rather than MSW and to increasing use of prepared foods. For example, more than 60 percent of corn or green peas are inedible husks, cobs, pods, and stems. When we buy these vegetables fresh, the extra is added to the waste stream and is landfilled. When we buy frozen corn and peas, we buy only the edible portion and the remaining wastes stay in the food processing plant where they are converted into by-products such as animal feed.

If there is any lesson to be learned from these examples, it is that all these successes were driven by good economics. Harness the marketplace to save money and foster waste minimization. In 1992, the U.S. Congress, Office of Technology Assessment released a very comprehensive study of manufacturer's efforts to incorporate environmental considerations into their products and packaging. An important conclusion of this study was that market forces are driving manufacturers to change their products and packages.

What is Left To Be Done to meet our Goal?

As mentioned earlier, there are two paths to waste minimization: manufacturers changing what they make and consumers changing what they buy. Based on these paths, the following are seven specific suggestions for further waste minimization:

Educate and Give Waste Minimization A Higher Priority. Since many people do not understand waste minimization, educating them about alternatives is important. All too often, efforts to promote recycling have hindered or have been given preference over source reduction efforts. In some cases contradictions between source reduction and recycling are inevitable, but this is not always the case. Procurement officers and officials can and should give more consideration to waste minimization.

Specify Bulk or Reusable Packaging. There are many examples where retailers have worked with their suppliers to reduce packaging. The Wal-Mart Corporation has been a leader in promoting waste reduction. Retailers should ask their suppliers if the product is available in a concentrated form which will reduce volume and packaging waste. For example, products can be shipped in durable, reusable crates; baskets; or other bulk packs. Also, retailers should be prepared to consider different stocking options. Brick packs of coffee represent an 85 percent reduction (by weight) over steel cans.

Change Landscaping Practices or Use Natural Grasses. It is important to remember that yard wastes (grass clippings, brush and leaves) represent 20 percent of our nation's solid waste, by weight. Recognizing this, many states have gone as far as banning yard waste from landfills. However, states generally recommend sending yard waste to a composting plant. While this may help preserve landfill space, composting operations are relatively expensive and sometimes plagued by odor problems. An alternative would be changing lawn maintenance procedures by not collecting the cuttings or by minimizing cuttings by reducing the use of fertilizers. Another alternative is to plant natural grasses and wild flowers that require fewer maintenance and produce less cuttings. Also, the use of integrated pest management techniques can replace the use of toxic pesticides.

Reduce Office Paper. Considerable changes can be made in office operations. the examples are many: use electronic E-Mail to reduce paper memos; place information on announcement boards; circulate memos, newspapers, magazines, and newsletters; update distribution/mailing lists frequently and remove those who no longer need the information; make two-sided copies when ever possible; use plain-paper faxes instead of thermal paper faxes that require photocopying; and specify unbleached office papers, paperboard, and coffee filters.

Increase Use of Longer-life Durable, Reparable, or Reusable Goods. Replacement costs today appear to be less than repair costs, so consumers tend to discard items and replace them rather than having them repaired. This may not always be the best choice economically or environmentally. Consider the warranted life of the product or the true, expected life of the product. Consider incorporating a call for an extended warranty or guaranteed buy-back (if appropriate) in RFBs to determine the best choice. Examples are longer life tires; longer life or rechargeable batteries; more durable food service equipment, office equipment, carpet, or modular office furniture; and higher grade textiles or washing cloths that can be washed and reused. Consider repairing wooden pallets or purchasing more durable pallets made from recycled plastic. Other issues to consider include product sharing, borrowing, or rental and determination of whether the product can be reconditioned, remanufactured, or upgraded to extend its life.

Decrease Purchase of Toxic Materials. Probably the biggest potential savings here is in Household Hazardous Wastes. These are products, typically found in the garage, bathroom, or kitchen such as solvents, bug sprays, cleaners, etc. Many of these products are safe when properly used, but unused material or residues can be hazardous for disposal. People should be careful to buy only what they need and consider less toxic alternatives.

Institute Volume-based Residential Collection Programs. Individuals currently have little economic incentive to consider the implications of solid waste in their purchasing and consumption patterns. In most locations a family that discards one 30-gallon trash can of waste every two weeks pays the same as a family that generates many times more. Some communities have adopted alternative collection programs based on volume or on the number and size of bags. Data indicates that this has been an effective incentive for families to consider waste minimization.

References

"Analysis of Trends in Municipal Solid Waste Generation, 1972 to 1987," Franklin Associates, January 1992.

"The Solid Waste Dilemma: An Agenda for Action," U.S. Environmental Protection Agency, February 1989.

"Toward a Recycling Ethic," Dr. J. Winston Porter, *Waste Age*, March 1988.

"Characterization of Municipal Solid Waste in the United States-1990 Update, Franklin Associates, June 1992.

"INFO Backgrounder: Source Reduction," Council on Plastics and Packaging in the Environment, December 1990.

"Facing America's Trash: What Next for Municipal Solid Waste?" Congress of the United States, Office of Technology Assessment, October 1989.

"Green Products by Design," Congress of the United States, Office of Technology Assessment, September 1992.

"The CONEG Challenge, Voluntary Packaging Reductions by Industry," Coalition of Northeastern Governors, November, 1993.

"Model Toxics in Packaging Legislation," Coalition of Northeastern Governors, 1991.

"Packaging in America in the 1990s," Robert F. Testin, Ph.D., and Peter J. Vergano, Sc.D., Clemson, South Carolina, August 1990.

"In Defense of Garbage," Judd H. Alexander, 1993.

"Getting at the Source: Strategies for Reducing Municipal Solid Waste," The Conservation Foundation, 1991.

REUSE, RECLAMATION AND RECYCLING OF TURBINE ENGINE LUBRICANTS

PHILLIP W. CENTERS, Ph.D.

WL/POSL, Bldg 490, 1790 Loop Road North, Wright Laboratory, Wright-Patterson Air Force Base, OH 45433-7103, Tel (513) 255-6608, Fax (513) 476-7176

ABSTRACT

Military and commercial aircraft powered by gas turbine engines use synthetic ester based lubricants. Properly formulated with selected additives, the lubricants have long lives in many applications. The lubricants are not routinely changed in military aircraft engines on a time basis, however, changes do occur due to other oil wetted system maintenance actions generating a waste stream. Typical disposal of used lubricants is by mixing the lubricant into heating oil for burning on-base or paying a contractor to collect and use the lubricant for the same purpose. Based on the significant quantities of used turbine lubricants being generated by military and commercial aircraft yearly and recent additional costs for commercial used oil collection a multi-faceted approach to the development of methods for collecting, disposal, reuse and/or reclaiming turbine lubricants has been initiated. Critical goals of the effort include the development and demonstration of a fluid segregation system to maintain sample integrity for use in a prototype collection facility that would be suitable for economical gathering of used lubricants. The status of each phase of the effort is reported.

INTRODUCTION

The advent of aviation gas turbine engine propulsion systems in the 1940's and wide implementation into the military services in the 1950's benefitted from the development of synthetic ester lubricants. The lubricant technology was based on pre-World War II German research. The ester lubricants have superior wide temperature viscosity properties as well as high temperature thermal and oxidative capabilities when compared to mineral oil-based formulations. For the most part, advances in ester lubrication technology have been evolutionary rather than revolutionary. The life of MIL-L-7808(1), the Air Force turbine 3 centiStoke (cSt @ 100C) engine lubricant, has increased by a factor of fifteen since 1965. The Air Force uses a less viscous lubricant than the similar Navy oil (5cSt), MIL-L-23699(2), due to worldwide operational requirements, including the arctic. The Air Force lubricant has a low temperature operational limit of -60F compared to the Navy's -40F. Each service uses the other services' lubricant when there is a need. The military specifications are performance, not chemically, based. That is, any formulation that meets test criteria can be qualified for procurement. The specification approach is designed to provide high quality, high performance lubricants at minimal cost while maintaining a competitive vendor base. The lubricants are quite similar to those used in commercial airline fleets.

Recently, the Air Force issued a dual viscosity turbine engine lubricant MIL-L-7808 specification that permits procurement of a 4 cSt lubricant, in addition to the current 3 cSt fluid that meets the low temperature viscosity requirement while providing greater film thickness and improved thermal and oxidative capability. The Navy is planning for a corrosion inhibited version of the 5 cSt lubricant as well. A current draft specification provides for the planned procurement of those two grades of MIL-L-23699.

Research continues to develop lubricants and lubrication systems that will meet the requirements for propulsion systems planned for demonstration in the next decade. High bulk oil and auto ignition temperatures will be required for these advanced formulations. Good low temperature pumpability is also desired. A major challenge in the development of advanced lubricants is that the wide temperature requirements will be difficult to achieve in one formulation.

For most Air Force applications, lubricant losses overboard and through seals necessitating "topping up" have resulted in the non-recommendation of oil changes on a time basis. Of course, when an inspection or maintenance action is taken that involves the oil-wetted section, the lubricant is changed. These results are due to comprehensive studies during the past three decades that found that unless a diffuser splits, a seal opens up, etc., the lubricant remains in serviceable condition. The mechanical events described are rare enough that sampling and analysis of lubricants is not a common practice, even though several devices have been developed to permit such analyses to be performed with little cost or manpower impact. Some engines do degrade lubricant to a greater extent than others, but none degrade the lubricant routinely to the point of non-serviceability. In rare instances where a mechanical problem occurs that does affect the lubricant, those analyses have been performed very effectively. These procedures are usually followed until an engineering 'fix' is installed.

Even with current procedures, significant quantities of used lubricants are generated from both operational engines, "green" engine runs of overhauled equipment, and test programs. The lubricants generated in the distant past would have been collected by a vendor who would find an alternate use such as a low cost plastizer, etc., or, more typically, and now, almost exclusively, disposed of by mixing it into a fuel for heating purposes. The burning of the mixture occurs either on-base or at a commercial site, depending upon the arrangement.

In the late 1970's - mid 1980's, the interest in reclaiming lubricants for reuse was driven primarily by the prospect of possible reduction in basestock availability of turbine engine lubricants[3,4,5,6,7]. This scenario included loss of middle East crude and the resultant dislocations in the supply stream. Two contractors evaluated the potential using two different methods of lubricant reclamation. One method basically stripped all degradation products and additives from the used lubricant and then a standard additive package was added to the recycled basestock. The other team took the approach of sophisticated analyses followed by modest clean-up and replacement of additives required to upgrade the used lube. That approach is in limited use in the United Kingdom now. It is claimed that where only one formulation is used, the process is highly cost-effective if certain contaminants are not present. The reclaimed lubricant can be supplied at 25-50% of new lubricant costs. A major drawback of this approach is that its extensive use has the potential to decrease the vendor base which has provided excellent lubricants at very reasonable cost over the years. This tempers advocacy of such systems. Based on those studies, a draft reclaimed lubricant specification for MIL-L-7808 has been prepared and a turbine engine qualification of a reclaimed lubricant has been performed. However, until recently, reclamation has not been pursued since it could not be justified on economic basis due to collection and transportation costs and, especially the higher costs incurred if collected materials were contaminated, which occurred 15% of the time[7].

Now, the situation is again changing. First, some military bases are now paying for disposal of lubricants, dramatically affecting the cost-benefit ratio. Second, there have been recent questions concerning potential toxin formation during burning of certain synthetic turbine lubricants. Third, an Executive Order[8] strongly encourages procurement of products containing reclaimed product. And, finally, the disposal regulations are now the province of local as well as national regulatory organizations where the general trend appears to be for states and districts to be more stringent in setting limits. There is also tendency to move each contaminant limit down to that level reached by the most sensitive technique developed to date. Handling of lubricants has reached the "ultimate" conclusion in Germany where the vendor supplies the military with a large multiliter container of lubricant, the used oil is then gathered and returned to the vendor for disposal in the same container. Thus, the vendor is truly responsible from cradle to grave for use and disposal of the lubricant.

All these circumstances suggest that at the minimum, the typical way that gas turbine engine lubricants are used, collected and disposed of will change dramatically in the not-to-distant future. Actions that need to be undertaken near term include definition of the requirements for disposal systems, the necessity to develop a collection system, that can maintain used sample integrity evaluation of methods and procedures that have potential for reclamation of used turbine lubricants, decisions made regarding viability of such systems, and, also a decision made whether lubricants can be directly reused in some situations.

CURRENT DIRECTIONS

LUBRICANT BURN PROGRAM

Although gas turbine engine lubricants have been successfully commingled with fuels to be burned for heating over the years, new data[9,10] on the possible formation of a neurotoxin has generated renewed interest in determining stack emissions of burned gas turbine lubricant-fuel mixtures. Such experiments have recently been completed at Tyndall AFB with participation of Tyndall, Brooks and Wright-Patterson personnel. Tyndall personnel designed and fabricated a boiler with mixing fuel supply. Instruments capable of controlling and recording condition of the experiments were included. Brooks analyzed stack gases using standard EPA methods. WPAFB supplied two turbine lubricants formulated to span the range of possible feedstocks and performed specific analysis of the stack gases required to identify toxins. The Navy Toxicological Detachment at Wright-Patterson provided expertise and guidance on any potential toxins identified. The conclusions of the effort, to be reported upon shortly, should more accurately assess any potential problems associated with burning gas turbine lubricants in a commingled feedstock and provide a documented basis for the burning of such fuels.

LUBRICANT SEGREGATOR

One of the most influential factors for determining the suitability of candidate used lubricants for reclaiming is contamination. In one study[7], even though strict instructions and guidance for collection of used lubricants were given, 15% of those materials delivered for reclaiming were contaminated with unacceptable quantities of halogenated, primarily chlorinated, fluids. The use of such, halogenated materials is rapidly diminishing in military facilities and should not be a significant problem in the future. However, the paperwork and procedures required to dispose of halogenated fluids are also increasing which may contribute to the motivation of someone to add such contaminants to used lubricants to avoid those procedures. Of equal concern is the possibility that natural or synthetic hydraulic fluids, silicone coolants, etc, may be added to collected lubricants either by error or design. The development of an effective lubricant/fluid segregator[11] is now proceeding to overcome many of these potential problems. A prototype of this device was demonstrated in our laboratory in late 1993. That unit has the capability to determine conductivity, detect vapors from contaminants, and viscosity of the fluid. If any of the tests fail, the segregator rejects the sample and directs its flow to a separate container. An enhanced version of the segregator, in development, may include a notch filtering infrared system for fluid type identification. During the next year, these prototype devices are planned for demonstration at Air Force, Navy and commercial sites. Successful development of segregator technologies will permit maintenance of sample integrity and increase the potential for development of cost-effective reuse and/or reclamation of lubricants.

REUSE, RECLAIMING AND RECYCLING

REUSE

The reuse of synthetic turbine engine lubricant at overhaul sites for "green" engines has been suggested and is most likely occurring at some locations. The concept has merit when implemented with spectrometric analyses of the used material, filtering and, most critically, maintenance of sample integrity. Difficulty in maintaining sample integrity is the basis for not supporting the concept at this time. The possibility of doing serious damage to an engine that may have incurred $100K expense for an overhaul, with a savings of $100 - $200 in lubricant costs is not sufficient to justify the risk. If, however, a segregator and separate storage for lubricants are used, then the risk becomes much more manageable and acceptable.

RECLAIMING AND RECYCLING

No organization within the United States is currently offering to reclaim used turbine lubricants on a routine commercial basis. There are many problems to be addressed including adequacy of the quantity of collected lubricants, transportation, potential toxicity, and the need to dispose of depleted additives. To investigate the full range of options, there is a need for a US vendor to demonstrate reclaiming and recycling capability as a potentially viable economic enterprise and the desire to pursue commercial development of the process. This technology might be obtained from the UK vendor or developed here either by an independent organization or an original formulator of synthetic lubricants. Sponsorship of the initial phases of such development are planned after demonstration of the enhanced segregator capability. The need to maintain a viable vendor base through their involvement must also be considered. Such participation might come if economic incentives were offered, or, perhaps some regulatory version of the German system were put into effect.

SUMMARY

As can be seen, conditions are changing that impact the viability of decisions regarding reuse, reclaim or recycling of synthetic turbine engine lubricants as well as other functional Air Force fluids. The number of factors that need to be considered are many. However, the impact on the operational military services could be minimal, if the technology is available to service the need. A well-developed collection and reclamation system would aid the Air Force in addressing lubricant environmental challenges including pollution prevention and minimization of waste. However, many of the choices will have to be assessed on the basis of economy and utility, realizing that a viable lubricant reuse/reclamation system must meet all Air Force needs while maintaining an adequate supplier base.

REFERENCES

1. Military Specification MIL-L-7808J "Lubricating Oil, Aircraft Turbine Engine, Synthetic Base (NATO 0-148)," ASD/ENES, Wright-Patterson Air Force Base, OH 45433-7103, 1982.

2. Military Specification MIL-L-23699D, "Lubricating Oil, Aircraft Turbine Engine, Synthetic Base (NATO 0-156)", NASC/AIR-5362, 1421 Jefferson Davis Highway, Arlington VA 22243-5360, Oct 1990.

3. Glasgow, G.D., and R.J. Bruns, "Reclamation of Synthetic Turbine Engine Oil Mixtures", Technical Report AFAPL-TR-78-50, Wright-Patterson Air Force Base, OH 45433-7103, April 1979.

4. Beermsterboer, G.L., and R.J. Bruns, "Turbine Engine Lubricant Reclamation", Technical Report AFWAL-TR-81-2053, Wright-Patterson Air Force Base, OH 45433-7103, Dec 1981.

5. Micallef, R.A., and A.T.B.P. Squires, "Reclamation of Synthetic Turbine Engine Lubricants", Technical Report AFWAL-TR-81-2072, Wright-Patterson Air Force Base, OH 45433-7103, Aug 1981.

6. Micallef, R.A., and A.T.B.P. Squires, "Characterization of Used MIL-L-7808 Lubricant", Technical Report AFWAL-TR-85-2017, Wright-Patterson Air Force Base, OH 45433-7103, May 1985.

7. Micallef, R.A., and A.T.B.P. Squires, "Reclamation of Used MIL-L-23699 Lubricants for Reuse in Military Aircraft Turbine Engines", Technical Report AFWAL-TR-87-2067 Wright-Patterson Air Force Base, OH 45433-7103, Nov 1987.

8. "Federal Agency Recycling and the Council on Federal Recycling and Procurement Policy", Executive Order 12780, 31 Oct 91.

9. Centers, P.W., "Potential Neurotoxin Formation in Thermally Degraded Synthetis Ester Turbine Lubricants", Arch. Toxicology, 66. 679-680 (1992).

10. Wyman, J. et al., "Evaluation of Shipboard Formation of a Neurotoxicant (Trimethylolpropane Phosphate) from Thermal Decomposition of Synthetic Aircraft Engine Lubricant", J. Am. Ind. Hyg. Assoc., 54, 584-592 (1993).

11. Kaufmann, R.E., Sqrow, L., Swartzbaugh, J.T. and J.D. Wolf, "Advanced Lubricant Segregation Capability for Oil Collection Facility", Technical Report, Wright-Patterson Air Force Base, OH, Jul 1994.

COMPOSTING, THE NEXT STEP

Mr. Bob Kerlinger
GEO-MARINE INC. Contractor
Air Combat Command
610 Thimble Shoals Blvd.
Newport News, VA 23606
Voice (804) 873-3702; Fax (804) 873-3703

Mr. Tim Brecheen
4CES/CEV
1095 Mitchell Ave.
Seymour Johnson AFB, NC 27531-2355
DSN 488-6501/6690

INTRODUCTION: While recycling has become commonplace in America the past few years, composting, especially on a large scale is still in its infancy. Based on recent waste audits at six ACC bases, it appears that around 12% of our total municipal solid waste stream is food waste. Food waste is compostable, but because of health concerns, odor, and other problems, it normally is not considered for composting. Now, because of new technology, food waste and other organics can be turned into a resource instead of being disposed of as a waste.

These new in-vessel composting systems are designed to minimize the handling of putrefactive organic waste, ensure the control of odors, and minimize maintenance. These fully enclosed systems can transform any type of organic waste including meats, fish, dairy products, fruits, vegetables, grains, paper waste, and sludge into a soil-like material in a few weeks or less. Recent experiments have also shown that these systems can remediate petroleum contaminated soil which has the potential to save the Air Force millions of dollars yearly. In another experiment, one of these systems even remediated gun powder contaminated soil with no addition of special microbes.

WHAT IS IN-VESSEL COMPOSTING? As the name implies, it is composting done inside some type of enclosed container. The vessels are computer controlled or monitored so that optimum temperature, moisture, and oxygen is maintained. This makes possible their very short composting period of between three to twenty-eight days, depending on which system is used.

WHAT ARE THE ADVANTAGES OF IN-VESSEL COMPOSTING? The advantages of in-vessel composting over traditional composting are many. First, there is the shortened time period required to compost which means much less space is required. Also, because of much better control over the process, the end product is of superior quality and more uniform. Because it is an enclosed system, the normal compost problems of odors, rodents, insects, and birds are eliminated. Although it has not been proven yet, it appears that the operational cost per ton of finished product is less than in traditional compost systems. Organics such as food waste and sewer sludge, which most traditional systems shy away from, are handled with ease in the in-vessel environment. Another very important advantage to the in-vessel systems is that they can be used to remediate soil contaminated with oil products and gunpowder which has tremendous cost saving potential for military installations. Because of the enclosed nature of these systems, weather is not a factor as it is in traditional composting. They just keep producing a quality end product year round regardless of outside weather conditions. Another important advantage is that the pathogen kill in these systems are well within the guidelines of the EPA and the Canadian Government.

WHAT ARE THE ADVANTAGES OF THE END PRODUCT?

1) It improves soil structure and the attributes of porosity, drainage, and moisture retention. Porosity is needed for water to permeate the soil and to allow proper drainage if water is excessive, yet the particles in the soil must also have an ability to retain moisture for the use of plants.

2) It increases aeration in soil which helps plant roots to retain the required oxygen. In-vessel compost provides spaces for air even while retaining moisture.

3) It is an environmentally safe source of plant nutrients. When roots are not able to use all of the fertilizer which is offered to them, the fertilizing chemicals can be lost by leaching through the soil. This of course becomes a contaminant in ground water. Nutrients contained in compost are not immediately lost through leaching and remain available for several years. Also, since compost is not concentrated, it is difficult to accidentally create an excess of plant nutrients. Finally, compost provides a buffer for soil pH and decreases the tendency of chemical fertilizers to be leached from the root zone.

4) Compost also fights plant disease. The diversity of active micro-organisms in compost fight many of the specific pathogenic organisms that cause plant disease. Because of this natural mechanism there is less chance that the need will arise for expensive chemicals with unknown side effects.

5) Compost moderates soil temperatures. Both within the soil and as a mulch on the top of soil, compost provides air spaces which act as insulation which allows plants more time to naturally adjust to changes in seasons.

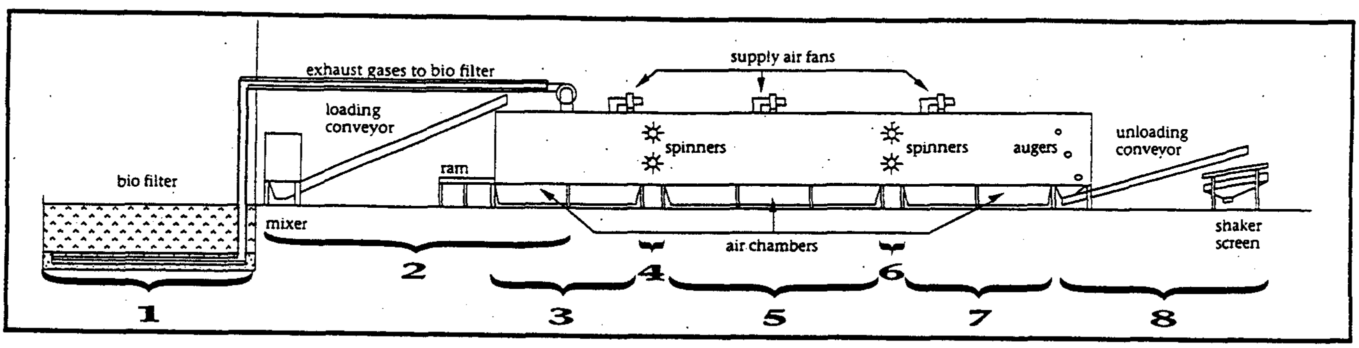
Air Combat Command is currently reviewing two different in-vessel systems through the Management Equipment and Evaluation Program (MEEP). Both systems are new, but are proven technology in several locations. It has not yet been determined if one system is more practical than the other for a military installation environment. Both systems are currently being tested on ACC bases. We hope to have the results within the next six months. The following is a brief overview of the two systems.

WRIGHT ENVIRONMENTAL MANAGEMENT INC.

The Composting System: The system is like a rectangular box with a moving floor. It was designed to minimize the handling of highly putrefactive organic waste, ensure the control of odors, and minimize maintenance. Depending on the quantity and the type of wastes to be managed , the composting unit can be designed to accept from 100 pounds to hundreds of tons of waste per day, requiring approximately 80 to 1,500 square feet of area for operation.

With a minimum of moving parts, use of non-corrosive stainless steel for all internal parts and surfaces, and a simple design, the unit provides continual and reliable service with little maintenance and minimal utility costs.

ANATOMY OF A COMPOSTER



The composting vessel is a double-walled tunnel, stainless steel on the inside, burnished steel on the outside and insulated to control the heat produced, when organic materials decompose. Temperature and moisture levels inside the vessel's seven air zones are monitored constantly, and airflow is computer adjusted to ensure optimum composting conditions. Although totally enclosed for use indoors, the vessel can be located outdoors, requiring only a small shed to contain the loading zone.

1) BIO-FILTER: An external bio-filter controls odors. Sitting on a drain-rock bed the bio-filter is a mixture of limestone, mushroom compost and wood chips piled four feet high. Exhaust air from the compost vessel is pumped through a series of pipes under the filter. The bio-filter mass eliminates odors as the exhaust works its way through to the open air.

2) LOADING ZONE: Containerized, source-separated food waste is delivered to the loading area. The food waste is mixed with a variety of amendments' -- Leaves and yard waste, wood chips, newsprint, or paper towels to increase its bulk, make it more porous, and to maintain proper carbon/nitrogen ratios. The resulting mix is emptied from the mixer onto a conveyor which carries it to a sliding hydraulic door atop the composter. A hydraulic ram located at floor level forces a steel tray, or "transporter," through the sealed entry port. The newly mixed waste falls through the charging door where it piles up on the transporter to a height of about six feet. An empty transporter is pushed into the vessel every day, moving the composting mass forward with no interruption in biological activity.

3) COMPOSTING ZONE 1: Bacterial action begins soon after the waste is piled on the transporter. Air, from self-contained air chambers under the transporter floor is continually circulated around and through the composting mass. The computer monitors temperature levels and adds fresh air as necessary. Careful control is critical to maintaining the high temperature levels needed to obtain pathogen kill in this first phase of the composting process. A fan located on top of the vessel continually exhausts air to maintain negative pressure in the composter. This ensures that all air leaving the composter is piped to the external bio-filter where contaminants and odors are removed naturally .

4) MIXING ZONE 1: On the sixth day, the transporter moves the composting mass through the first mixing zone. Specially designed spinners turn and throw the composting material forward. The material is very thoroughly mixed and exposed to the air. Congealed masses are broken up and redistributed to discourage layering. The mixing process ensures an even distribution of the active bacteria and prevents packing and settling which impedes aerobic decomposition.

5) COMPOSTING ZONE 2: It takes another 15 days for the partially decomposed waste to move through Composting Zone 2. Air continues to be circulated through and around the waste to support bacterial activity. Since Zone 2 has an independently controlled air intake fan, airflow-management is zone-specific.

6) MIXING ZONE 2: Using the same type of apparatus as in Mixing Zone 1, the composting waste is again spun forward, mixed, and aerated. It is re-deposited on the transporter as it moves into Composting Zone 3. Because of their unique design, the mixers are always clear of the decomposing waste.

7) COMPOSTING ZONE 3: Decomposition continues in Zone 3, but temperature and air requirements are lower. The composting mass will remain in Zone 3 for an additional seven days before being discharged. Air flow is independently controlled in Zone 3, as it was in Zones 1 and 2, to ensure optimal composting conditions.

8) UNLOADING ZONE: On the 28th day, the insertion of a new transporter at the loading stage forces the transporter carrying finished compost through the augers at the unloading station. The turning action of the augers draws the compost to the side of the vessel and discharges it on to a conveyor. The conveyor deposits the compost in the shaker screen which separates larger pieces from the compost. These pieces will be added as amendment and recirculated through the composter.

Note A: This equipment is licensed to be built by an American company in Albany, New York.

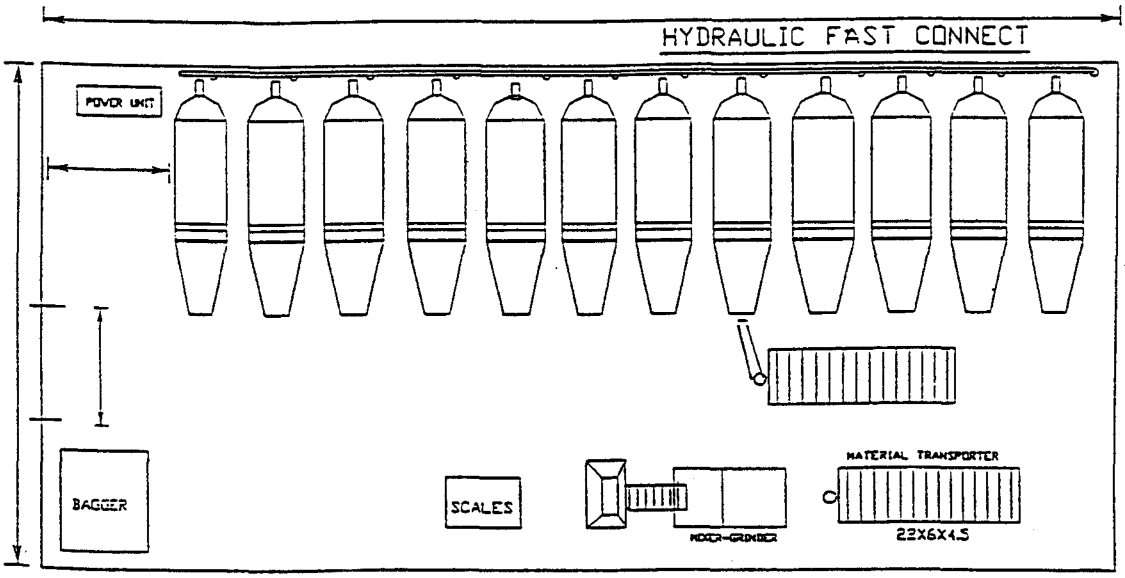
Note B: Wright Environmental is developing this basic concept for use on the American Space Station. It will be a self contained system to compost all organic waste aboard the station, help use up the nitrogen produced by the astronauts, produce oxygen, and grow some of their food.

AG-RENU INC.

The Composting System: In contrast to the previous system, the AG-RENU system is more like an oversized cement mixer where the entire vessel rotates as necessary. They are made in one size which will fit on a low-boy trailer for ease of transportation and will hold 20 cubic yards of material. Expansion is achieved by adding more vessels.

The microbes in the AG-RENU composter multiply rapidly and through their ferocious appetites are able to convert raw waste to compost in as little as 72 hours. In this system, the raw material is loaded at one time and then the vessel is closed and not opened until the process is finished. When finished, the entire drum of compost is unloaded and the drum is once again loaded with raw material.

The following is a schematic of a 12 drum site requiring a 7800 sq. ft. building, which can be expanded by adding more drums.



The main process support components include: Front-end loader, Reel-Auggie material handler, tub grinder and/or mixer-grinder unit, and composting vessel. The tub grinder is necessary to shred carbon sources such as paper, cardboard, or leaves. The mixer-grinder unit is required if wet material, such as a sewage sludge/paper feed need to be blended further. The Reel-Auggie material handler is operated with a tractor and is used to blend and weigh feed materials as well as load and unload them into and from the composting vessel.

Another interesting benefit of this system is that germinated plant seeds are also destroyed by antibiotics secreted by the microbes during the conversion process and most ungerminated seeds are also destroyed by the high temperatures generated during the process. In addition, by using special mineral additives, heavy metals such as cadmium, cesium, zinc, etc. are "shackled" in the composter. Harmless organic molecules surround the heavy metals to form a complex. The heavy metals are busy being part of this complex and are taken out of the biological soil cycles. The effectiveness of the detoxification has been verified by the University of Sarrbruecken, Germany.

CONCLUSION: By taking part in the beginning of this technology explosion we will demonstrate environmental leadership in a highly visual way. The benefits are many: reduce waste, create a resource, remediation of soil, and have the opportunity for a three to five year payback based on local conditions. It gives the Air Force an opportunity to show vision and be innovators in an important area of environmental responsibility.

REFERENCES:

1) Wright Environmental Management Inc., 511 Woodland Acres Cres., R.R. 2 Maple, Ontario, Canada, L6A 1G2, (905) 737-4717 or (416) 252-6069

2) Ag-Renu Inc., 1600 Made Industrial Drive, Middletown, Ohio 45044, (513) 423-1775

SESSION III

POLLUTION PREVENTION IN CLEANING PROCESSES

Session Chairpersons:
Kent Rohlof, SAIC
Shelah Roberts, NGB/CEV

UBEX ENVIRONMENTALLY SAFE BIODEGRADABLE NON CORROSIVE CLEANING COMPOUNDS

by
Lloyd O. Gilbert Consultant Chemist
824 East Central Park Avenue
Davenport, Iowa 52803-1714
Phone (319) 323-8243

Environmental restrictions and prohibitions continue to narrow the available options in cleaning and chemical conversion coatings used in preparing aircraft for painting or repainting. Near caotic conditions have resulted as both suppliers and users in industry and the military seek alternatives materials and processes which would substitute aqueous cleaners for the solvents and other cleaners used in the past. Acceptable cleaner substitutes today must not only provide the desired cleaning function but they must be environmentally friendly. Many of the alkaline cleaners succesfully used in the past as well as some of the solvent types currently being evaluated contribute to the toxic waste stream and add substantially to the cost of cleaning.
An environmentally safe, biodegradable, non-corrosive, water reduceable enzyme based cleaning compound marketed by THE ENZYNE PLUS DIV. of Anderson Affiliates Inc. as "UBIX- 0092 meets the requiremenmts of MIL- C-83873A.

The product in addition to being an outstandingly effective cleaner has highly desireable additional attributes resulting from the enzyme blend. Ubix-0092 consists of a blend of more than 15 families of enzymes, cofactors, enzyme activators and surfactants. The unique properties can be understood better by considering the contributions made by the enzyme content of the product.

Enzymes consist of a colloidal dispersion of complex high molecular weight amino acid proteins. (MW 14,000 to 483,000) These unique compounds function as organic catalysts which bring about chemical degradation of organic soils, fats and oils without being destroyed in the process. The reaction velocity is governed by both concentration and temperature of the solution. Optimum operation temperatures range is from 95F.to 130F. Prolonged exposure to temperatures in excess of 130F results in gradual degradation and destruction of the enzymes. Therefore the recommended cleaning temperature range is 120F.to 125F. though lower application temperatures may be employed. As indicated above, the slower cleaning rate at lower temperatures may be compensated for by increasing the concentration of the cleaner. As is the case with most chemical reactions, the rate of cleaning doubles for each 10 degrees Centigrade (approximately 20 degrees Fahrenheit) increase in temperature. In all enzymes the suspended enzyme micelles carry an electrical charge. Oxygen concentration cells develop in crevices and around fasteners when an electrolyte is present. The potential generated in these cells causes migration of the colloidal enzyme to the faying surfaces. There the charges on each micelle is discharged and a insoluble proteinaceous coating remains to reduce the corrosion potential. This action,in a like manner also prevents filiform corrosion around fastener heads and at the edges of unsealed crevices. Contrast this condition with alkaline cleaners where alkali intrudes into crevices with short transverse grain where intergranular exfoliation will be initiated. The unique additional characteristics of Ubex are as follows:

Without a doubt the most outstanding feature of the enzyme cleaner is its ability to eliminate intercoat adhesion failures. Understanding the function of enzymes in eliminating this widespread problem requires that we identify the source of the failure. Aliphatic amine catalysed epoxy primers are almost universaly employed in the aerospace industry. The most vexing problem in their use consists of inability to consistantly bond to the subsequently applied top coat. In the past, several methods have been employed to assure intercoat adhesion. Scuff-sanding provided a partial answer if it was followed with a methyl-ethyl-ketone solvent wipe-down. A second method involved applying a mist coat of the epoxy primer and immediately applying the finish coat. Neither of these methods address the cause of the problem, nor do they constitute a reliable cure. It has recently been found that if the epoxy primer is applied at 70 degrees Fahrenheit with ambient relative humidities above 80% or at a temperature of 55 degrees Fahrenheit and relative humidities above 40% the amine catalyst (cross-linker) reacts with the water and carbon dioxide in the atmosphere and is converted to an insoluble amine carbamate (urea) salt at or near the surface. There it causes intercoat adhesion failure. When this "contaminated" surface is brought into contact with an enzyme blend containing the enzyme urease, the urea conpound is converted to ammonia and carbon dioxide. The reaction leaves a clean surface which displays outstanding topcoat adhesion. In those situations where an epoxy primer is allowed to remain without top-coating for several days or weeks such as detail primed parts an amine "blush" caused by migration of unreacted amines to the surface is encountered. The surface often displays an alkaline condition which also contributes to intercoat adhesion failures. This condition has also been found to be corrected when the surface is cleaned with the Ubix-0092 cleaner.

The cleaner removes oils and soils together with oxidized paint (chalk) without damaging the underlying paint. The electrostatically charged dust from hand sanding and feathering of damaged areas is thoroughly removed. It passes the metal sandwich corrosion test as well as other corrosion tests required by MIL-C-83873A in which metals utilized in aircraft construction are subjected to immersion in both the cleaner concentrate and the more dilute 6% working concentration. The enzyme based cleaner eliminates the labor intensive scuff-sanding and methyl-ethyl-ketone wipe-down of aged epoxy prime coats and when recoating existant paint systems. Wet tape tests have varified inproved adherance.

Safety concerns have rightfully dictated that users of alkaline cleaners, terpine cleaners and hot emulsion cleaners be protected against chemical burns and allergies by the manditory use of rubber aprons, gloves, and face shields goggles and boots. When using the hypo-allergenic Ubix-0092 such equipment is not necessary except to protect against wetness.

One of the unexpected results of using enzyme based cleaners has been the ability of the cleaner to eliminate odors. Areas around latrines, relief tubes and bilge areas are completely deodorized after being cleaned with the Ubix-0092.

Finally it must be revealed that requiring biodegradibility in all cleaners results in increased cost where the cleaners are used in soak tank applications with air spargers for agitation. The same limitation on the life of the cleaner will be encountered in high pressure spray washers where any biodegradable cleaner is sujected to exposure to the oxygen in the air. It can be said in conclusion that environmental compliance is seldom without a monetary penalty.

Cleanliness Verification Process at Martin Marietta Astronautics

Elizabeth A. King and Thomas J. Giordano, Ph.D.
Martin Marietta Astronautics
PO Box 179 M/S H0355
Denver, Colorado 80201
(303)977-3745

INTRODUCTION

The Montreal Protocol and the 1990 Clean Air Act Amendments mandate 1,1,2-trichloro-1,2,2-trifluoroethane (CFC-113), other chlorinated fluorocarbons (CFCs) and 1,1,1-Trichloroethane (TCA) be banned from production after December 31, 1995. In response to increasing pressure, the Air Force has formulated policy that prohibits purchase of these solvents for Air Force use after April 1, 1994. The Air Force will also require contractors desist from using ozone depleting chemicals (ODCs) on Government Owned Contractor Operated (GOCO) properties. Martin Marietta Astronautics (MMA) operates the Engineering Propulsion Lab (EPL), a laboratory located on Air Force plant PJKS. All processes and operations at EPL that use CFCs were identified. In order to fulfill current and future contracts with the Air Force and others, Martin Marietta must institute processes compatible with the new environmental guidelines. These processes must be fully evaluated and qualified to ensure technical performance and quality are continued.

Precision cleaning of mechanical hardware is performed within the Valve Shop at EPL. The current method of cleanliness verification at EPL uses a final rinse of the cleaned part with CFC-113, isopropyl alcohol, or deionized water (specified by the manufacturing process). The rinse fluid is then analyzed to determine that the contaminants have been removed to the specified level.

TEST APPROACH

The overall approach for testing, demonstrating, and validating alternative solvents for cleanliness verification at PJKS is to perform initial and detailed tests at a laboratory scale followed by demonstration and validation tests of the most viable solvent candidates. The initial tests investigated contaminant removal. The detailed tests looked at contaminant removal from complex parts, material compatibility, and propellant compatibility. The demonstration and validation tests involved full scale cleaning of typical parts (including those with complex geometry and entrapment areas). The initial solvent nonvolatile residues were analyzed and results were less than 1 mg/100 ml for all solvent candidates.

INITIAL TESTS

Contaminant removal - This test investigated the ability of the solvents to remove known contaminants under controlled conditions. The contaminants used were Mobil EP2 grease (hydrocarbon), Drilube 822 (silicone grease), MIL-6083 Hydraulic oil, Dykem layout fluid, and Krytox 240 AC (fluorocarbon). Each contaminant was applied to three preweighed, 1" x 3" stainless steel coupons. A weight of the coupons was then recorded. The coupons were immersed in 100 ml of solvent in separate beakers, and agitated with a stir bar at slow speed for approximately five minutes. The coupons were then dried in a 45°C oven, cooled in a dessicator and reweighed. Contaminant removal was calculated as percent removed. CFC-113 was used with the alternate solvents to establish a reference point. An uncontaminated coupon was run with each sample set as a control blank. Three coupons were run for each contaminant in each solvent as a quality control check.

Residue - The solvent from each contaminant removal test was evaporated and the residue weighed to provide a check of contaminant removal. The weight of contaminant remaining in solution should be equivalent to the weight of contaminant removed.

DETAILED TESTS

Contaminant removal - This test investigated the removal of contaminants from complex parts. The parts were a variety of fittings whose geometry makes them difficult to clean. EP2 grease and Drilube grease were separately applied to precleaned, preweighed fittings. A weight of the parts was then recorded. The parts were immersed in 100 ml of solvent in separate beakers, and agitated with a stir bar at slow speed for approximately five minutes. The parts were then dried in a 45°C oven, cooled in a dessicator and reweighed. Contaminant removal was calculated as percent removed. CFC-113 was used with the alternate solvents to establish a reference point. An uncontaminated coupon was run with each sample set as a control blank. Five coupons were run for each contaminant in each solvent as a quality control check.

Material compatibility - This test determined if the final candidate solvent was compatible with the materials being cleaned. Coupons of each type of material were weighed and an initial visual condition was recorded. The coupons were then partially submerged in ~100 ml of the final solvent candidate in a glass jar. The jars were then closed. The coupons were visually inspected for degradation after one hour, 24 hours and 72 hours. Following 72 hours, the coupons were removed from the solvent and allowed to air dry. The final weight of each coupon was then recorded.

Propellant compatibility - This test determined the effect of the final candidate solvent on propellants. Initial screening of propellant compatibility was completed by placing 1 ml of the solvent in a clean beaker. The beaker was then transferred to a glove box and 1 ml of nitrogen tetroxide (NTO) was added. Visual observations of any reactions were recorded after the addition of NTO. The same procedure was used with Aerozine-50, a 1:1 blend of unsymmetrical dimethylhydrazine and hydrazine.

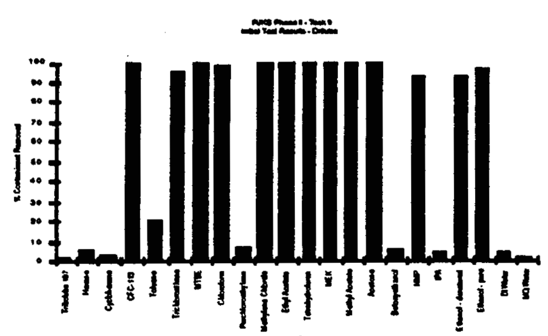
DEMONSTRATION AND VALIDATION TESTS

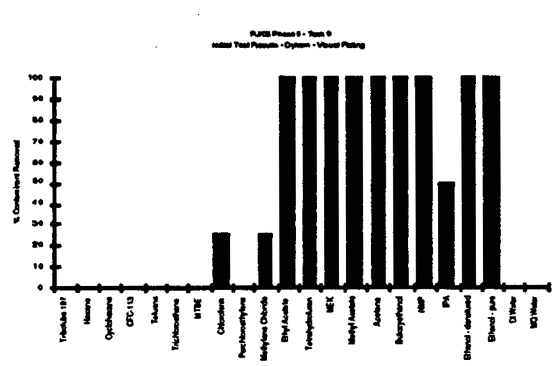
Demonstration and validation tests were completed to verify proper performance of the selected alternative for implementation. Four 1/4" O.D stainless steel tubes, with a 90° bend were selected as the demonstration parts. The parts were first cleaned with the existing process before being contaminated. EP2 and Drilube contaminants were applied to the clean parts. The parts were baked for 1 week at 120°F. The contaminated parts #1 & #3 were rinsed with 200 ml of CFC-113, then 200 ml of ethyl acetate. Parts #2 & #4 were rinsed with 200 ml of ethyl acetate then 200 ml of CFC-113. Each 200 ml rinse sample was then checked for NVR using the existing Quality Control Laboratory methods. A comparison of the percent contaminant removed from the first rinse was then used to determine if ethyl acetate is at least as effective as CFC-113 for NVR determination.

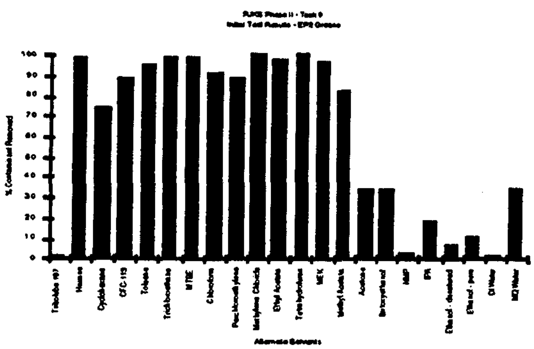
RESULTS

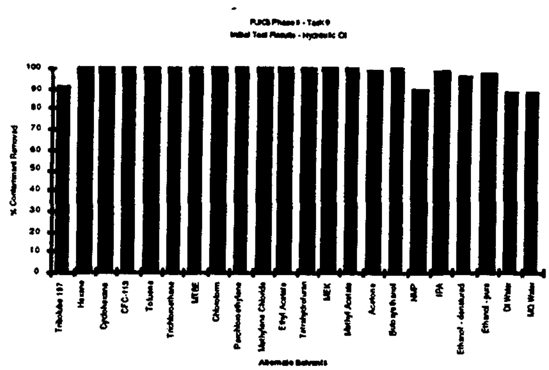
INITIAL TESTS

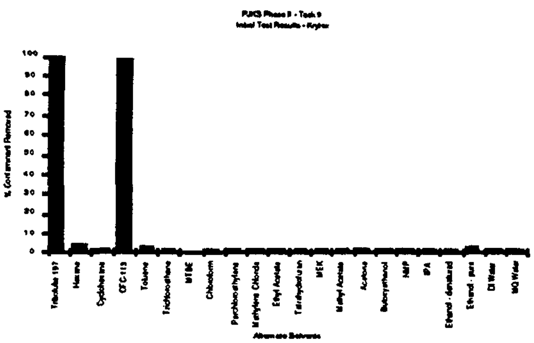
Figure 1 - Initial Test Results











- Polarity of the solvent is a significant factor. Less polar solvents, such as hexane, were more effective in removing EP2, a non-polar grease, then in removing the polar contaminants, Drilube and Dykem.

- Dykem fluid was extremely light, and the percent removal had a high standard deviation among the results. A visual screening of the removal of Dykem was used as a better indicator of contaminant removal. Screening was based on the removal of the blue color from the coupon and the presence of color in the solvent.

- All solvents removed hydraulic oil, even when the oil was not soluble in the solvent. This is primarily due to the mechanical agitation.

- Krytox was only removed by CFC-113 and Tribolube 197. This supports observations that fluorinated greases are only removed by fluorinated solvents. Tribolube 197 did not remove non-fluorinated contaminants.

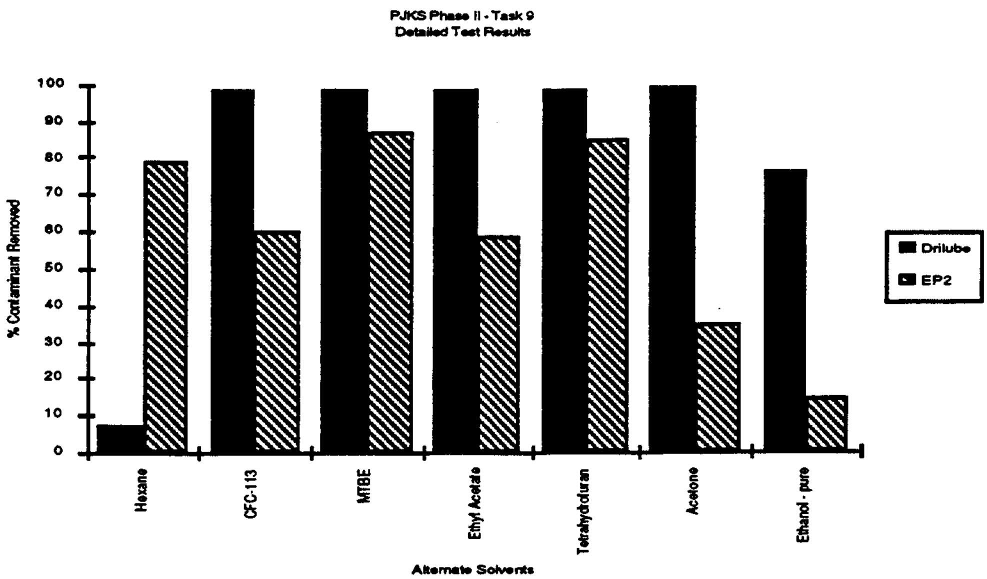
- There is evidence that increasing viscosity reduces contaminant removal. This is shown with ethyl alcohol and isopropyl alcohol test results. Ethyl alcohol, which has a lower viscosity, had a higher percent removal of all contaminants than isopropyl alcohol, even though it has a higher polarity.

- Denatured ethyl alcohol is less effective in removing contaminants than pure ethyl alcohol. This may be caused by the presence of methyl alcohol, which is more polar than ethyl alcohol.

The results showed that methyl t-butyl ether (MTBE), tetrahydrofuran, ethyl acetate and acetone were the top performers in contaminant removal. Pure ethyl alcohol was also carried into the detailed testing in order to include an alcohol in the final candidates. Hexane was included in detail testing because it has been recommended as a NVR solvent for payload fairings. These six solvents were used for detailed testing with CFC-113 as the baseline. Drilube and EP2 greases were determined to be the best discriminators among the contaminants for detailed testing.

DETAILED TEST

Figure 2 - Detailed Test Results



- The rankings of the six candidate solvents is as follows:
  1) Methyl t-butyl ether (MTBE)
  2) Tetrahydrofuran
  3) Ethyl Acetate
  4) Acetone
  5) Hexane
  6) Ethyl alcohol

- Ethyl Acetate performs at least as well as CFC-113 in removing both contaminants from fittings.

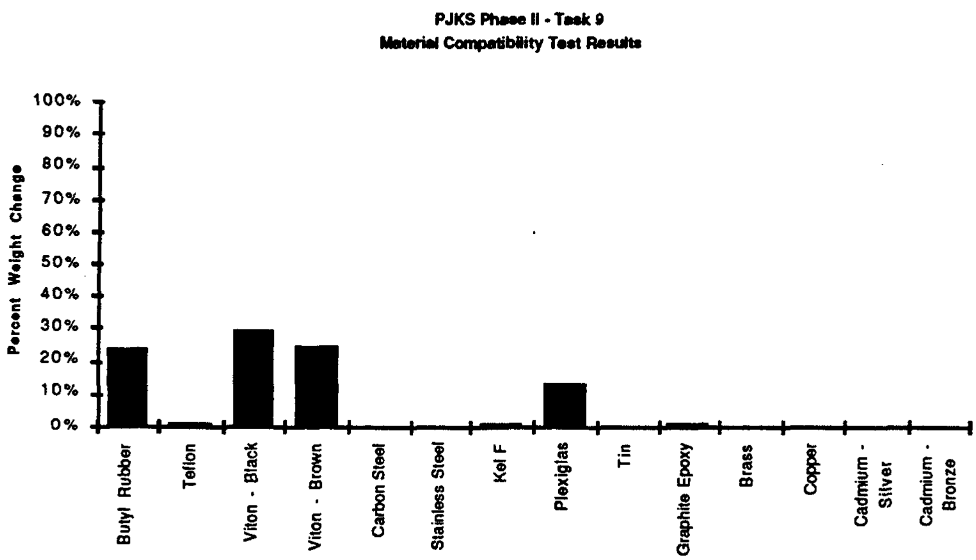
- The fittings were harder to clean than coupons. This is shown by the lower percent removal of EP2 grease by all of the solvents. The geometry and small openings of the fittings reduce the mechanical agitation and allow the EP2 grease to become trapped.

Ethyl acetate was chosen as the final solvent because it removed the contaminants tested at least as well as CFC-113. MTBE and tetrahydrofuran were effective solvents, but are not chemically stable when exposed to air over a period of time. They will form peroxides which present an explosion hazard during evaporation.

- Material compatibility

Material compatibility tests were run on various metals and non-metals:

Figure 3 - Material Compatibility Test Results



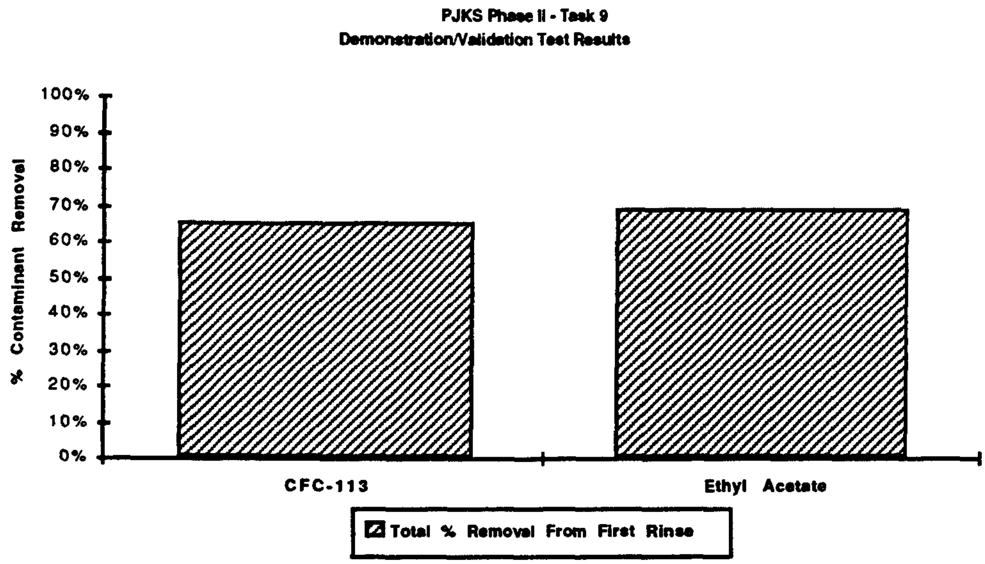
All metals showed no signs of degradation or weight change after 72 hours of exposure to ethyl acetate. The only non metal which showed signs of degradation was Plexiglas. It was noticeably crazed after 1 hour of exposure, and completely crazed and warped after 72 hours. It also had a significant weight change after 72 hours which indicates that the ethyl acetate was absorbed. The o-rings all had weight gains at the end of 72 hours with no visible degradation of the materials. Teflon® showed the smallest weight gain, then butyl rubber, then the Viton o-rings. This indicates that the o-rings are absorbing some ethyl acetate after 72 hours of exposure.

- Propellant compatibility

An initial screening of propellant compatibility was performed. The addition of 1 ml of nitrogen tetroxide to 1 ml of ethyl acetate produced a green solution, but no other reactions were detected. The addition of 1 ml of Aerozine-50 to 1 ml of ethyl acetate produced a two phase solution, with no other reactions. The observed reactions are not a concern for the use of ethyl acetate with propellants.

DEMONSTRATION AND VALIDATION

Figure 4 - Demonstration and Validation Test Results



The results showed that the percent removal of the contaminants from the first rinse was similar for CFC-113 and ethyl acetate, with ethyl acetate being slightly higher. This confirms that ethyl acetate is at least as effective as CFC-113 in removing contaminants from EPL parts. The technicians from PJKS and the Quality Control Laboratory did comment on the strong odor of ethyl acetate. A fume hood should be used whenever possible for personal comfort.

COST ANALYSIS

A cost analysis was completed to show the difference in yearly annual cost and any equipment or disposal costs. The analysis was done on the basis of 32 gallons/year of solvent being used. The cost of CFC-113 was projected for 1995 to be $8000/55 gallon drum.
Projected 1995 Annual Cost of CFC-113:

$8000/55 gallons x 32 gallons/year = $4654.54/year

Annual Cost of Ethyl Acetate (99.9% pure, Omnisolv brand)

$35.83/gallon x 32 gallons/year = $1146.40/year

Annual Cost Savings:

$3508.14/year (75% savings)

There are no anticipated equipment costs associated with changing from CFC-113 to ethyl acetate. Disposal costs should be negligible because the solvent will be evaporated in the NVR analysis and no liquid waste should remain. Any waste that does remain must be treated as a hazardous waste due to the flashpoint of ethyl acetate.

ENVIRONMENTAL, SAFETY AND HEALTH ANALYSIS

The Environmental Management Department of Martin Marietta Astronautics agreed that ethyl acetate is an acceptable alternative. It is not currently a hazardous air or reportable pollutant and the quantity used each year, 238 lbs/year, is well below the VOC non-attainment threshold of 4000 lbs/year. It is a hazardous waste under RCRA ignitability regulations and proper disposal protocol needs to be followed. The only future regulation which may impact its use is the Aerospace NESHAP regulation. This may require an incinerator to be installed in the area of emissions at some future time.

Occupational Safety and Health also agreed that ethyl acetate is a viable alternate. It has a threshold limit value (TLV) of 400 ppm, the same as isopropyl alcohol. This should not be a problem with the quantities anticipated. Ethyl Acetate is not listed as a known or suspected carcinogen. The only concern with ethyl acetate is that it is flammable and proper safety precautions must be taken by personnel.

CONCLUSIONS

The solvent chosen to replace CFC-113 for use in the cleanliness verification process at PJKS was ethyl acetate. It removed the contaminants that were tested at least as well, if not better than CFC-113. It is considered acceptable by both Environmental Management and Occupational Safety and Health Departments of Martin Marietta Astronautics. It is a flammable solvent, flashpoint -3°C, and must be disposed as a hazardous waste. Use of a fume hood is recommended to reduce flammability hazards and reduce the odor of the solvent. The annual cost of ethyl acetate is less than the projected annual cost of CFC-113. No additional equipment or disposal costs are anticipated with its use at PJKS. Implementation of ethyl acetate results in a projected cost savings of $3508.14/year. Material compatibility test showed that ethyl acetate should not be used with Plexiglas, and soft goods, such as butyl rubber, Teflon® and Viton, may absorb some ethyl acetate after prolonged exposure. Propellant compatibility test showed no detrimental reactions with nitrogen tetroxide or Aerozine-50. Detailed propellant compatibility testing will be performed within other PJKS ODC elimination tasks.

Ethyl acetate has been recommended for implementation at Air Force Plant PJKS, valve shop operations, at Martin Marietta Astronautics for cleanliness verification. Demonstration and validation tests should be performed in areas where other contaminants are to be cleaned or for unique applications not addressed here. A fluorinated solvent is required for cleanliness verification of parts contaminated with fluorinated greases.

AN ALTERNATIVE, NON-ODC SYSTEM FOR ELECTRONICS CLEANING

By Larry Lowe, General Manager
CHEM-TECH International
1800 Diagonal Rd. Suite 600
Alexandria, Va 22314
Telephone (703) 360-8004

Perhaps we will never find a more convenient product than CFC-113, but many of the jobs it did can be matched or even exceeded by other cleaners. This paper will present one alternative system for cost effectively cleaning electronics or meeting other precision cleaning requirements without the use of solvents containing ODC's. Not just an alternative, for some applications the result is superior to cleaning with CFC-113. Using chemical cleaners that have been safely used for more than 15 years, the system has positive environmental implications from the perspective of recycling heretofore discarded electronics and hazardous waste minimization.

Although rightly described as a cleaning system, there are several possible variations, depending upon the degree of cleanliness required and the equipment available. Using a biodegradable, long-lasting aqueous solution without hazardous ingredients for the primary cleaning and a hydrocarbon blend for final cleaning and water displacement, the system is currently being used for a variety of precision cleaning applications. These include computers, aircraft instruments, telecommunications equipment, avionics, photographic equipment, precision machined metal parts, etc.

As with all aqueous cleaning systems, the final stage is drying. This may be as simple as air drying when time and conditions permit or the driving factor for high throughput manufacturing requirements. The number of steps in the cleaning process is determined primarily by the degree of cleanliness required. Normally, the second step is a water rinse; however, if time is of the essence, this step can be skipped when a final rinse in the hydrocarbon solution is used. This saves even more time than one might expect since the drying phase is also shortened.

The workhorse of the cleaning system is a complex aqueous blend. Performing best when heated, it removes a variety of soils. Besides the normal dirt, grease, and grime, it removes lapping compounds; silver, metal polish and asphalt residues; corrosion of all types; plus water and hydrocarbon-based cutting oils. Forming a solution with polar substances and emulsifying non-polar substances, the use of this cleaner followed only by a water rinse produces a satisfactory result for some applications.

For more demanding requirements, one or more rinses with the hydrocarbon based cleaner is required. This cleaner forms a solution with non-polar substances and emulsifies polar substances, exactly the opposite of its aqueous companion. A light degreaser with water displacement properties, for some applications this cleaner can also be used alone; however, it is ordinarily used as a final rinse.

For difficult cleaning, such as with heavy corrosion, a soaking period in the aqueous solution is necessary. Ultrasonics or other agitation decreases the cleaning time. In this environment which is more typical of overhaul and repair facilities, the cleaner maintains its potency for long periods of time. By following a few simple practices to minimize the losses from evaporation and drag out, the cleaner can be used for periods of six months or more.

If the cleaning requirement is less demanding, this cleaner can be sprayed but a defoamer must be added. Although not a mandatory requirement, a higher temperature of 180°F is recommended for spraying instead of the normal 120-140°F.

A test program conducted with a major U.S. electronics company's pager repair facility describes the procedure followed for cleaning printed circuit boards. Cleaning of these water-damaged boards from paging devices commenced in January 1993. Previously, the pagers could be restored to service only by replacing the board. This was not cost effective. The test showed not only that it was feasible to clean the water-damaged boards, but cost effective as well.

Over several months, more than 100 boards from inoperable pagers were cleaned with a 55% recovery rate to operating standards. Advanced life-cycle testing simulating five years of normal operation produced results which were comparable to new units.

The initial cleaning was accomplished using the aqueous solution in an ultrasonic bath which was followed by three rinses, the first in deionized water and two in the hydrocarbon based water displacement agent. Initially, the boards were placed in a rack which holds a maximum of 72 boards and then submerged in the 130°F aqueous solution. Using ultrasonics at 40khz in a five gallon tank with 450 watts of power, cleaning time averaged about five minutes. Cleaning time naturally varied depending upon the condition of the boards. Those that are heavily corroded take five-ten minutes, while it might only take two-three minutes for boards with less severe corrosion.

Although the next step can be direct rinsing in the hydrocarbon blend, in this case the boards were soaked in deionized water for two minutes. Rinsing first in water prolongs the life of the hydrocarbon cleaner making the cleaning process more cost effective. The trade off is it takes more time; however, this is usually not a major consideration since drying is the controlling time factor.

Next, the boards were soaked in the hydrocarbon product for two minutes, continuing the cleaning process while initiating water displacement. At this point, visual observation with the naked eye, in most cases, would indicate that the boards are quite clean.

For some applications, this might be the last rinse, since the boards are now clean and generally residue free. For more complicated configurations where there is the possibility of trapped fluids, however, an additional step is required. This is always recommended for boards with surface mount components, . In our test, the boards (still in the rack) were placed in a spray washer which uses the same hydrocarbon blend. A two minute spray at 90 psi completed the rinsing.

The greatest difference between cleaning with CFC's and most other products is the requirement for drying. In this application, the drying time was about 30 minutes at a temperature of 130°F using a convection oven with a fan added to increase the air flow. Thus, drying is the time controlling factor. A vacuum oven or one with higher air flow decreases drying time but adds to the expense of the cleaning system.

While this process may appear to be quite time consuming, rather large numbers of circuit boards can be cleaned. Let's assume that we wish to continuously clean the boards used in this test program at the maximum possible rate with only one worker. The operator inserts the maximum of 72 boards into the rack in one-two minutes, mentally noting the condition and placing the most difficult to clean in a predetermined part of the basket. With very little experience, he will soon be able to predict the proper cleaning time. At the end of the selected cleaning time, he inspects one or two of the most difficult boards while draining is in progress. If the boards appear to be clean, he then proceeds to the next step. If not, the basket is placed back into the solution for additional cleaning.

While the first batch is being cleaned, the operator fills another rack for the next batch to be cleaned. Next, he lifts the first basket from the ultrasonic tank and after a brief period of draining to minimize drag out, places it in the tank of deionized water. The operator then loads the second batch into the ultrasonic tank, after which it is time to take the first batch from the water. Again, using the same procedure to minimize drag out, he places the first basket in the tank containing the hydrocarbon water displacing solution and commences filling a third rack, finishing at approximately the right time to remove the second batch from the ultrasonic tank.

Rather than go through each and every possibility, one can readily calculate that more than 1000 boards could be cleaned in one eight-hour work day by using a drying oven that could hold twice as many boards as the ultrasonic tank.

If the operator is called away, there would be no concern other than efficiency, since continued exposure during any of the stages will not damage the items. Of course, the process may be automated for increased productivity.

This case involved cleaning with ultrasonics in the initial step. However, the same result could have been achieved using a heated soak tank without agitation; however, the soaking time would be increased by approximately a factor of five for the first soak only. Some hand work would likely be required as well. Otherwise, the process would be the same.

In the process just described, solids tend to accumulate in the bottom of the tank containing the aqueous solution. The hydrocarbon soak tank accumulates primarily water, again at the bottom. Draining off these wastes extends the life of the cleaners.

The spray washer that we used employs a series of filters which allow continuous recycling of the hydrocarbon cleaner. Compressed air may also be sprayed in the machine. The air is primarily used to blow off excess fluid after the cleaning is completed. This not only helps conserve the cleaner but helps minimize drying time.

When removing primarily cutting oils, the cleaning process needs to be slightly modified because oil will begin to float on the top of the aqueous solution. By using a cascade overflow rinsing system with an oil separator, the best result is obtained. An oil skimmer is an acceptable alternative.

In summary, for cleaning electronics and other precision cleaning applications, this aqueous/hydrocarbon chemistry combination produces a result which is comparable to, and in some cases surpasses the result which might be obtained with CFC-113 or methyl chloroform. The process can be adapted to several types of equipment and cleaning requirements.

Recyclability of a Terpene-Based Replacement Cleaner for 1,1,1 Trichloroethane

Carl Fromm, P.E.
Mike Callahan, P.E.
Mark Loftin

Jacobs Engineering Group Inc.
Pasadena Operations
251 S. Lake Ave.
Pasadena, CA 91101
(818) 449-2171

The halogenated solvent 1,1,1 trichloroethane (TCA) is widely used for general purpose and electrical equipment cleaning throughout industry. Due to its potential for depleting stratospheric ozone, production of TCA will be halted by the end of 1995. A project was undertaken to identify, field test, and select a viable replacement cleaner for the cleaning of electric cables and switch gear. The cleaner selected is a blend of the terpene solvent d-limonene (a naturally derived solvent extracted from orange peels) and a highly purified aliphatic distillate free of aromatic compounds. This same product has been issued a National Stock Number and is actively being adopted for use by the Department of Defense as an ODS alternative.

The methodology employed to identify and select this cleaner has been documented in a recent article (Pollution Prevention Review, Winter 93/94). As noted in the article, a comparison of TCA to the replacement cleaner showed many environmental benefits. However, three outstanding issue areas remained following the selection process: solvent recyclability, biodegradability, and aquatic toxicity. Rather than rely on vendor information, independent studies were undertaken to verify this information.

For each study, extensive literature searches were conducted and the quality of available information assessed. Three independent laboratory test programs were then conducted to develop experimental data. The general findings are that a reusable cleaner can be recovered using vacuum distillation, that the d-limonene component is readily biodegradable while the distillate component is moderately biodegradable, and that the cleaner demonstrates a high level of aquatic toxicity. Therefore, uncontrolled release of this solvent to the environment could result in major short-term impacts on aquatic biota. Long-term impacts would be mitigated by its tendency to volatilize and biodegrade.

This paper presents the results of an investigation and experimental study into the recyclability of a terpene-based substitute for a 1,1,1-trichloroethane cleaning solvent. The study found that spent terpene-aliphatic hydrocarbon blends can be recovered using vacuum distillation. The study consisted of modeling the distillation process, bench testing, system scale-up, and economic analysis. Each step is discussed in the following sections.

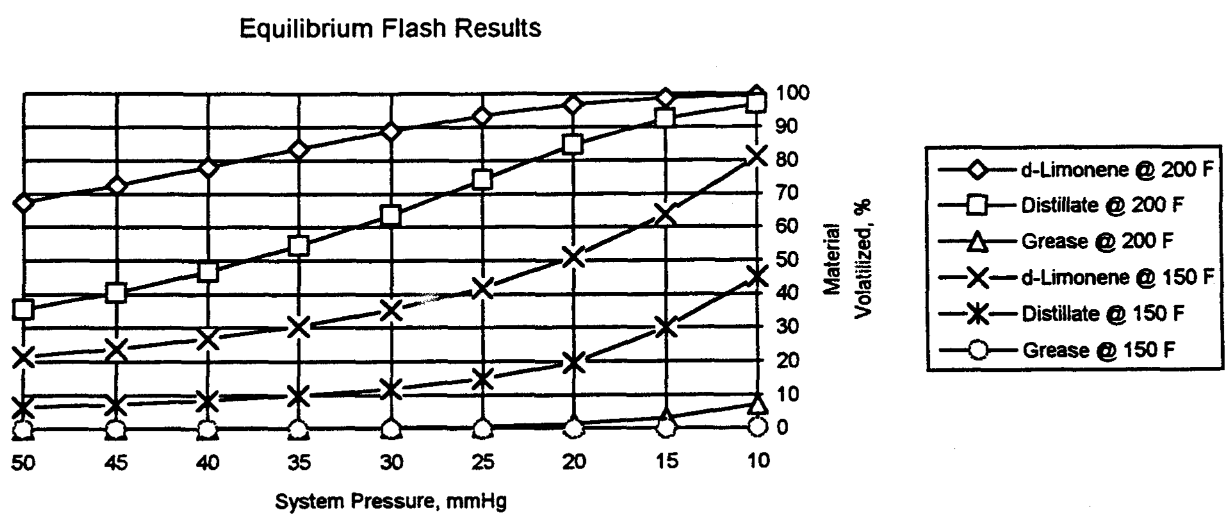
BASIS FOR MODELING

The physical properties of the compounds were based on available simulation program library data, appropriate equations of state (Modified Soave Redlich Kwong equation), and correlations developed by the American Petroleum Institute (API) for hydrocarbons. The d-limonene was modeled as a pure compound while the distillate was modeled by pseudocomponent characterization, a technique commonly employed in the simulation of petroleum fractions. The distillation range for the type of distillates typically employed was 370 to 500 °F. The total volume of distillate in the clean solvent was taken to be 85 percent by volume, the d-limonene component constitutes 15 volume percent of the clean solvent.

Grease compounds were modeled as a cut of heavy vacuum gas oils. Their concentration was taken to be 5 volume percent of the dirty feed stock. Heavy vacuum gas oils are typical of viscous lube oils used in many industrial lubrication services. It was also assumed that 5 volume percent of the waste would be water. Water contamination may occur during waste material collection, handling, and/or storage while awaiting processing. Nonvolatile waste contaminants such as dirt, dust, and salts were assumed to remain with the bottoms in the stillpot and hence, were not modeled.

SINGLE-STAGE EQUILIBRIUM FLASH

The first simulation runs employed "Pro/II" (Version 3.1.1) from Simulation Sciences Inc. to model an equilibrium flash separation of the waste material. An equilibrium flash simulation rigorously computes the vapor and liquid phase composition of a mixture at equilibrium for a given set of conditions (i.e., pressure and temperature). The model is commonly used to estimate the relative volatility of compounds in a boiling liquid. The equilibrium flash simulation was performed at two temperatures (150 and 200 °F) over a range of vacuum conditions (50 to 10 mmHg absolute). The results of these two runs have been plotted below as percent of each waste feed component volatilized as a function of system pressure.



As shown, 81 percent of the d-limonene and 45 percent of the distillate would be volatilized at a flash temperature of 150 °F and vacuum level of 10 mmHg absolute. By increasing the flash temperature 50 °F, a significant improvement in solvent recovery can be achieved. Volatilization of d-limonene would be nearly 100 percent and the volume of distillate volatilized would be 97 percent. Since volatilization of both components would be nearly complete, the relative percentage of d-limonene to distillate in the condensed vapor would be similar to that of the starting feed material. The downside to increased recovery is that the concentration of grease in the recovered solvent would increase from 72 parts per million by weight (ppmw) to 4,145 ppmw.

Most of the water present in the waste will boil and volatilize during the initial stages of the distillation (water will boil at 190 mmHg with-out heating). At flashing conditions of 150 °F and 50 mmHg, 99.8 weight percent of the water and 11.3 percent of the solvent, mainly d-limonene, is removed. This initial cut could then be phase separated and the d-limonene returned to the system. Processing of the dirty solvent at 200 °F and 15 mmHg would recover 0.66 pounds of water and 5,549.2 pounds of solvent (assuming the initial solvent removed is not returned to the system). This equates to a maximum water concentration of 120 ppmw in the recovered solvent. The actual water content will be less since this estimate assumes that all of the water vapor condenses.

From this data it can be clearly seen that operating temperatures around 200 °F and vacuum conditions of 10 to 20 mmHg would achieve a very high level of product recovery. Operation at higher temperatures which could lead to polymerization of the d-limonene does not appear to be necessary. Operation at higher temperatures would also increase the amount of grease recovered. Removal of this grease from the vapor can be achieved by installing several trays or packing inside the column to improve fractionation. This can be demonstrated in the next modeling simulation discussed below.

BATCH DISTILLATION

The computer simulation of a batch distillation process operating under vacuum conditions was performed using "Process" (Version 4.01) from Simulation Sciences Inc. This simulation can provide estimates of the overall distillate composition and process heat duties required. Feed material was assumed to be 150 gallons of d-limonene, 850 gallons of distillate, and 50 gallons of grease. Water was excluded from the simulation runs because of model limitations.

Unlike a flash equilibrium model which only predicts the vapor and liquid compositions at a given set of conditions for a closed system, batch distillation involves a continuous process of volatilization and product removal. As the distillation proceeds, volatile components are continuously removed from the stillpot. Hence, the composition of the liquid with which the vapor is in equilibrium continuously changes over time.

The basis of the model involves charging a fixed volume of material into a three-stage theoretical equilibrium batch distillation unit. The first stage consists of the overhead condenser where heat is removed to condense the vapor, the second stage is a one tray fractionating column above the charge or still pot, and the third stage is the still pot where heat is added to effect volatilization. The pressure profile used for the simulation run was 15 mmHg of vacuum at the condenser stage, 17 mmHg in the column stage, and 19 mmHg in the still pot. The condenser outlet temperature was set to 80 °F.

Since very little fractionation was believed necessary to keep all of the grease in the still pot, the operating reflux ratio was set to 1 percent. Reflux is condensed solvent vapor that is returned to the column as liquid for further processing. The more reflux returned to the column, the more selective the separation will be. Reflux ratio is defined as the amount of liquid returned to the column divided by the amount of recovered solvent removed from the system. The simulation run was continued until the inlet temperature to the condenser tray reached 230 °F. Modeling results are as follows:

Component	Feed	Product	Bottoms
d-Limonene	1035.9 lbs	1034.0 lbs	1.9 lbs
Distillate	5486.3 lbs	4128.5 lbs	1357.9 lbs
Grease	370.9 lbs	1.4 lbs	369.5 lbs

As shown, carryover of grease compounds was slight. Actual carryover would be highly dependent on the volatility of the grease present with the heavier greases most likely showing no carryover. While the flash equilibrium model predicted a grease concentration in the recovered solvent of 889 ppmw at 200 °F and 20 mmHg, the batch simulation model predicted 270 ppmw at 230 °F and 20 mmHg. This concentration of grease is lower and at a higher operating temperature. Further improvement in grease rejection could be achieved by increasing the reflux ratio and/or by adding more trays to the column. While improving grease rejection, these actions will also serve to reduce the recovery of distillate.

LABORATORY TESTING

Although the model runs indicate that very high recoveries of d-limonene and distillate are possible, the models cannot predict the potential for degradation and break-down of the materials during recovery. Break-down of the solvent may occur due to localized heating effects in the still pot or to reactions with contaminants. Polymerization and auto-oxidation of the d-limonene is of concern. If excessive degradation occurs, product recovery will be low and the recovered product may not be suitable for reuse. The primary objectives for laboratory testing of the process were to: 1) validate the results of the simulation models, 2) qualitatively determine if degradation of the solvent occurs during recovery, and 3) establish a reliable method for evaluating the quality of the recovered solvent.

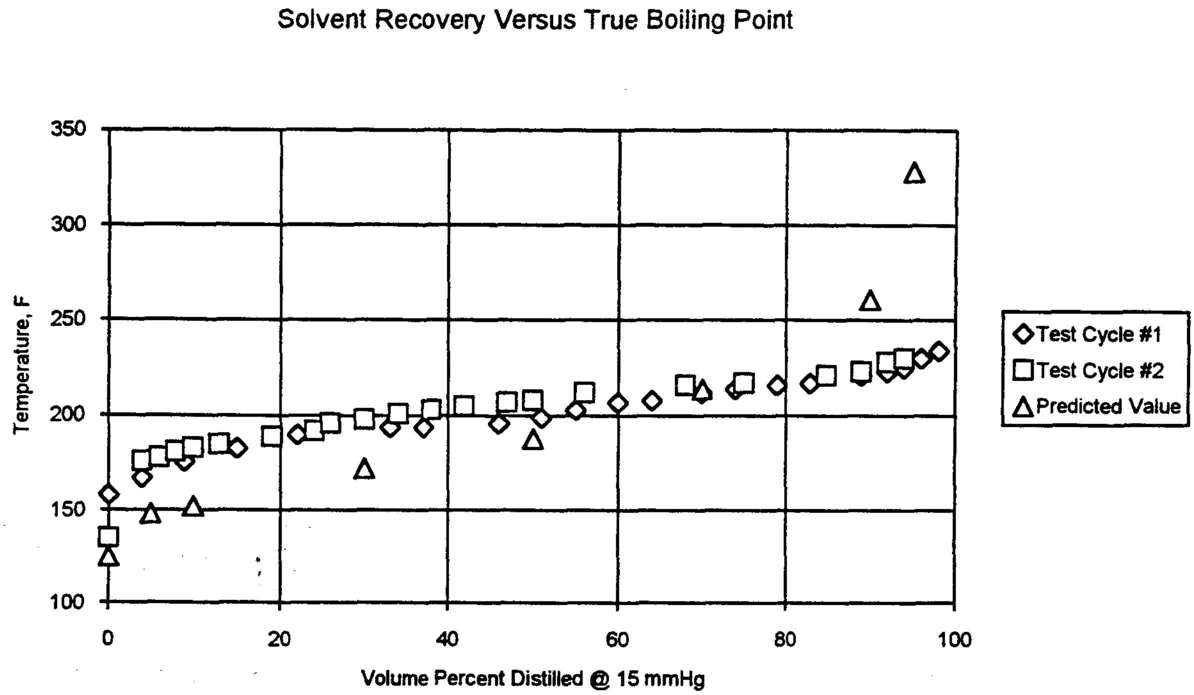
In this study, no actual waste solvent from a facility was collected or tested. Instead, a surrogate waste solvent comprised of d-limonene, severely hydrotreated aliphatic distillate, a gear oil, and a lithium-based bearing grease with graphite was used. The gear oil and grease materials were purchased at an automotive supply store and are believed to be representative of the types of contaminants likely to be encountered. The bearing grease was selected because it contains soaps which can form emulsions, metals which can catalyze reactions, and graphite particles which simulate dirt contamination. Water was included in the mix since it is a potential contaminant if the waste is recovered from open sumps or if collection drums are left open in the rain.

The distillation tests first involved preparing a 500 milliliter (ml) mixture of 15 volume percent d-limonene and 85 volume percent distillate. This material was then mixed with 5 volume percent industrial bearing grease / gear oil and 5 volume percent water. This waste material was charged to a 1000 ml holding flask which was used as the still pot. The system was then purged with nitrogen to minimize the potential for d-limonene degradation.

Testing of the laboratory distillation system glassware with the above mixture showed that the 1000 ml holding flask was not large enough to prevent liquid carry-over. The rapid generation of water vapor as vacuum was applied, combined with the presence of organics and soaps in the waste, resulted in excessive foaming. This foam quickly carried the waste out of the holding flask and contaminated the column, condenser, and receiver. Use of a larger still pot and a slow application of vacuum would minimize this problem in a commercial system.

A new batch of waste solvent without water was formulated and successfully distilled under vacuum conditions without incident. Distillation was continued until more than 95 percent of the charge mixture had been recovered. Samples of recovered solvent were collected for analysis and then the recovered solvent was recombined with fresh make-up solvent. This mixture was again spiked with grease and redistilled. Due to time constraints, the number of test cycles was limited to two.

The figure presented on the following page compares the true boiling point (TBP) values as a function of solvent volume distilled for the laboratory runs and computer simulation. The test run data was generated by taking readings of the temperature at the inlet to the condenser versus approximate estimates of solvent volume collected in the collection flask over time. The computer simulation curve is calculated at 10 mmHg by an API method for determining TBP and corrected to the system pressure of 15 mmHg. The data shows good agreement between the two test cycles, but the TBPs calculated from the simulation deviates from the two runs. This deviation may be attributed to the use of a broad range distillate in the simulation run.



Three different tests were conducted to assess the quality of the recovered solvent. The first test employed the use of a gas chromatograph / mass spectometer or GC/MS. This equipment is capable of identifying unknown compounds in the solvent from the chromatographic peaks plotted. For the recovered solvent, the GC/MS plots did not identify any oxygenated derivatives such as carvone or carveol which would have indicated degradation of the d-limonene. Comparison of the recovered solvent plots with the virgin solvent plots showed good agreement.

The second test performed was a trace residue analysis. The trace residue analysis was performed to verify on a qualitative basis whether or not the recovered solvent contained any visible residues. This test involved placing a drop of recovered solvent on a pre-cleaned glass microscope slide and allowing it to evaporate. The slides were then examined under a microscope to see if any visible residue or particulate matter remained. Testing of the recovered solvent showed no signs of visible residue or particulate matter.

The final test performed on the virgin and recovered solvent was dielectric strength. Dielectric strength testing followed ASTM D877-87 which is the method typically employed for analyzing dielectric fluids such as distillates. Tested samples included virgin solvent and the combined distillate from the second distillation. The dielectric strength of the virgin solvent was reported to be 21.6 kV while the recovered solvent was 14.4 kV. While the dielectric strength of the virgin and recovered solvent are in fair agreement, there are a number of factors that make both of these readings suspect (i.e., low). The amount of recovered solvent available for testing was insufficient to fully fill the testing equipment. While enough sample was available to cover the electrodes, it was approximately 20 percent less than that needed to completely fill the holding cup. For testing of the virgin solvent, sufficient sample was available. However, independent testing by the solvent supplier shows the dielectric strength of his product to be 46 kV. The exact reason for the low reading is unknown, but sample contamination is one potential cause.

SYSTEM DESIGN & PRELIMINARY ECONOMICS

Laboratory testing has shown that the results of the computer simulation models are reasonable and that a material suitable for use as a general purpose cleaner can be recovered (for reuse in cleaning electrical equipment, the testing results were inconclusive). A process flow diagram of a typical vacuum distillation unit applicable to this system was prepared and costed. The waste solvent charge would be pumped or gravity fed into the still pot. The system would then be sealed and a mechanical vacuum pump activated. The system pressure would be taken down in steps to flash-off water and dehydrate the waste. If necessary, a small amount of absorbent could be added to control the small amount of water that remained. Most water will leave the system as a noncondensible vapor at 190 mmHg and below.

After the initial dehydration stage, the vacuum level would be reduced to 15 mmHg and the mixture would be heated to its boiling point (some heat may be applied during the dehydration stage). When the charge mixture reaches 120 °F, the condenser water would be turned on. This step will remove any remaining water from the system before the condenser is activated. The overhead distillate would be collected until the still pot temperature reaches 230 °F. This temperature would shut off the reboiler and allow cooling of the system to begin. The vacuum pump would be shut off and nitrogen would be bled in to break the vacuum. While the still bottoms cool to a safe handling temperature, the collected distillate would be sampled for analysis. The final step would be to pump out the still bottoms into a collection drum for off-site recovery of heating value.

For purposes of this study, it was assumed that 5,000 gallons per year of the spent solvent will be available for recycling. The purchase cost to replace this cleaner amounts to $45,000 (5,000 gallons per year of waste at 90 percent solvent at $10 per gallon). Costs associated with collection and handling are ignored since they will be similar in both cases (collection for recycling versus collection for use in network as a fuel). No disposal cost for the dirty solvent is incurred since it will be reused in network for its fuel value.

Recycling of this waste will recover 4,000 gallons per year of solvent (5,000 gallons of waste at 90 percent solvent and 90 solvent recovery). The remaining 1,000 gallons will consist of water vapor vented from the system and still bottoms recycled in network as a fuel. Assuming a processing cost of $0.50 per gallon recovered, annual costs for materials, supplies, and utilities amounts to $2,000. Operator labor is taken to be 4 hours per day, 2 days per week. This is for a 55 gallon batch still processing 5,000 gallons per year. Hourly rates are assumed to be $25 per hour, fully burdened. Therefore, operating labor amounts to $10,400 per year. The final cost is for 500 gallons of fresh solvent to maintain the balance. Recycling will recover 4,000 gallons of clean solvent while the amount used is 4,500 gallons. This results in a solvent purchase cost of $5,000. Annual savings would be $27,600 ($45,000 - $2,000 - $10,400 - $5,000).

Based on previous project experience, the cost for a complete packaged vacuum distillation unit is assumed to be $50,000 installed. This cost gives an estimated payback of 1.8 years. Since the payback is less than 3 years, the recycling of spent cleaner appears to be economically viable. A detailed economic analysis requires further vendor contact and determination of operating costs associated with an optimally designed distillation unit. The issue of permitting, both "Permit by Rule" for the recycling of waste and the potential need for an air quality permit to release the water vapor directly to atmosphere remains to be addressed. Further work would be required to determine the composition and quality of spent solvent that will be generated in the field and assess how this will impact the ability of a recycling system to produce a high quality recovered solvent.

SESSION IV

HAZARDOUS MATERIAL CONTROL & TRACKING

Session Chairpersons:
Beth Davis, HQ AFCEE/EP
Lt Daniel Lockhart, Dover AFB, DE

Environmental Process Assessment Database System(EPADS)

David L. Bury, Acting Chief, Pollution Prevention Division,
WR-ALC/EMP, Robins AFB, GA

Robins Air Force Base, located in Middle Georgia 15 miles south of Macon, is home for one of five Air Logistics Center-- Warner Robins Air Logistics Center (WR-ALC). WR-ALC provides depot level structural, avionics, and electronic support maintenance for the F-15, C-130, and C-141 aircraft. Robins AFB also hosts other major tenants such as the 19th Air Refueling Wing, the 5th Combat Communications Group, and the 9th Space Warning Squadron (PAVE PAWS). The base is the largest industrial complex in Georgia, employing over 10,000 civilians and 3,000 military personnel.

As with all Air Logistics Centers, the industrial workloads present unique environmental challenges in trying to keep missions and the environment on the same team. WR-ALC was faced with bringing their industrial processes in line with federal, state, local, and Air Force environmental policies. Eliminating the dependence on Class I Ozone Depleting Chemicals (ODCs) by the end of CY95 and reducing or eliminating the use of hazardous materials (primarily the EPA-17 Industrial Toxics) by the end of CY96 requires a monumental change in business practices which are nearly fifty years old. In most cases these industrial processes took engineering decisions to implement and require an engineering decision to change.

To assist weapon system managers in implementing more environmentally friendly processes, the Pollution Prevention Division of the Environmental Management Directorate contracted with the McDonnell Douglas Aerospace-East (MDA-E) in Jun 1992 to perform a study of industrial processes. Of primary concern was collecting key process data necessary to determine what hazardous materials were being used, the magnitude, and the waste generated. This data was necessary for making sound engineering and economic decisions on how best to change the Depot's industrial process base. Thus MDA-E put together an Industrial Process Improvement(IPI) Team to study processes that generate solid/hazardous waste, air emissions, and wastewater with a goal of producing mass balanced processes. MDA-E, under Task Orders WR-47 and WR-55 of the IPI contract, focused on processes that were significant users of hazardous materials. Currently, Robins AFB has 2700 uses of the EPA-17 and 600 uses of the ODCs in industrial processes.

To capture and manipulate the process data, MDA-E developed a database called EPADS. EPADS was developed to provide the capability to pull out data on processes and materials which use a particular chemical(EPA-17, ODCs, SARA, etc.). Data includes types, amounts, and where the chemicals are used by process. For the remainder of this paper, what EPADS is, how it is structured, and its capabilities will be discussed.

WHAT IS EPADS?

EPADS was developed around standard Paradox Version 3.5 relational database software and operated on DOS based PC computers. The system is menu driven to facilitate data entry, retrieval, and reporting. System users do not have to know Paradox commands or programming.

HOW IS EPADS STRUCTURED?

EPADS is a system of tables each having specific functions: (Refer to Fig 1 for table relationships)

- **Activity Table:** Contains high level activity demographic information such as function and location (i.e. Painting in Bldg 180).

- **Process Table:** Contains processes within the higher level activities (Surface preparation, masking, etc. within the painting activity). This table is the central table for EPADS application providing the link between the process, incoming material, and generated waste (air, water, and solid).

- **Task Table:** Contains discrete tasks which further detail discrete processes.

- **Material Table:** Contains high level material information (manufacturer, vendor, etc.) commonly found in Material Safety Data Sheets (MSDSs), Hazardous Material Information System (HMIS), and DM-HMMS.

- **Material Composition Table:** Contains detailed material composition data (material components and percentage by weight in parent stock number).

- **Solid Waste Table:** Provides detailed information about process generated solid waste (hazardous or municipal)

- **Water Table:** Provides detailed information about process generated waste water.

- **Air Table:** Provides detailed process air emissions information.

- **Waste Table:** Provides subcomponents or ingredients of the parent waste.

- **Usage Table:** Provides improved electronic data exchange between EPADS and DM-HMMS. Key common data used by both systems is stored here (i.e. stock number, amounts used in process, manufacturer, etc.). Currently, the link between EPADS and DM-HMMS has not been established.

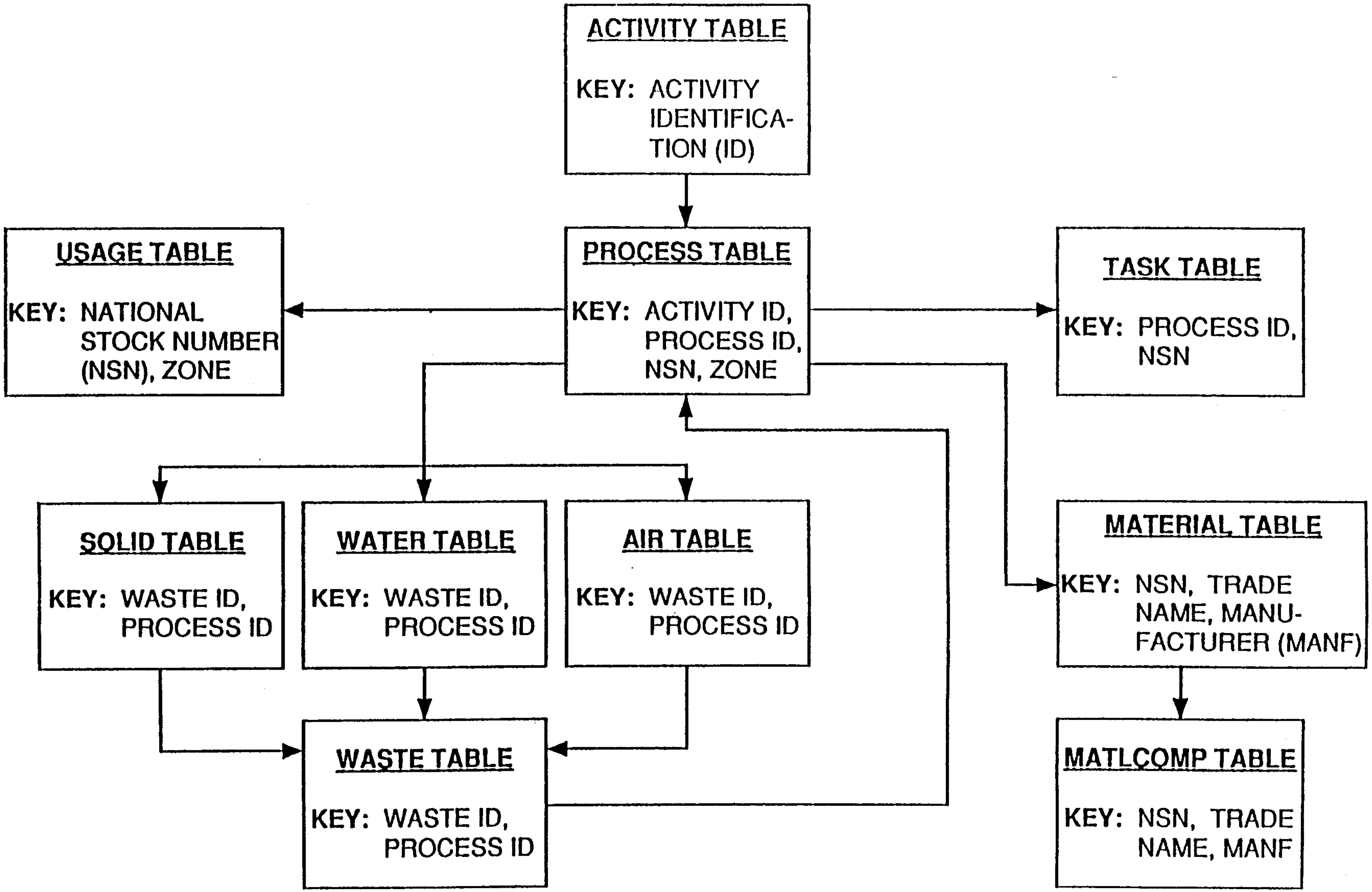
What are the capabilities of EPADS?

The real power of EPADS is its ability to relate data between individual tables using key link fields. The following capabilities result from relating data between tables:

- **Activity to Process:** User able to collect and report on detailed activity information available via the process table links to lower tables (i.e. air, water, etc.).

- **Process to Material:** User can determine what materials are used in the process and additionally view detailed material information.

- **Material to Material Composition:** A given stock number can have many manufacturers and trade names. Each combination has a specific mix of



EPADS TABLE RELATIONSHIP

FIG 1

ingredients. By linking the process, the material and the material composition tables, the user can determine material ingredient subcomponents for any process.

- **Process to Waste:** User can link waste data to process.

- **Waste Composition to Waste:** Simplifies isolating a waste stream subcomponents to a specific process by eliminating the requirement to direct link to waste tables.

- **Process to Task:** User can link process to its discrete steps.

- **Process to Usage:** User can determine how much of a material has entered a DM-HMMS zone of a process. Note: Amount of material used by a process cannot be identified using this link. Currently this relationship is not possible due to no link between EPADS and DM-HMMS.

EPADS reports are redefined and invoked with little or no user input. Report formats are modified using the Paradox Reports menu option. Examples of EPADS reports follow:

- **DATA ENTRY** (Identify missing data in lower or detailed data tables)

  -- **Material:** Lists material records that require composition data in the material composition table.

  -- **Waste:** List waste records that are missing waste composition data in the waste table.

- **INFOREPORTS** (Reports based on user defined selection criteria)

  -- **Material:** Provides a cross reference between selected material stock numbers and process that use the material. Report includes Stock Number, Trade Name, Process ID, DM-HMMS Zone, and Estimated Usage for a specific process.

  -- **Process:** Provides a cross reference between a selected Process ID(s) and materials used in the process. Report includes Process ID, Stock Number, Trade Name, DM-HMMS Zone, and the Estimated Usage of material.

  -- **Chemical:** Provides a cross reference between selected SHOP(s) and the internal processes with related material information. Report includes Shop Name, Process ID, Stock Number, Trade Name, Subcomponent, DM-HMMS Zone, Resource Control Center (RCC), and the Estimated Usage of each subcomponent used by a process.

  -- **Waste:** Provides a cross reference between selected Waste ID(s), associated subcomponents, and the process that generated the waste. Report includes Waste ID, Component, Component Percentage, Chemical Abstract Service (CAS) Number, Profile Number, Process ID, and DM-HMMS Zone.

SUMMARY

Industrial process data, though very difficult to obtained, is crucial to the decision making process. Its the goal of the Pollution Prevention Division to continue where MDA-E left off and assess all industrial processes which use hazardous materials. EPADS, along with the IPI methodology of gathering data, provides a powerful tool necessary in mapping the monumental and aggressive agenda of changing WR-ALC's industrial process base before the turn of the century.

ACKNOWLEDGMENT

A special thanks to the McDonnell Douglas Aerospace- East, St. Louis, Missouri, especially the Industrial Process Improvement Team (Task Orders WR-47 and 55) of Dave Hallam, Mary (Cuthill) Kicklighter, Kelly Williamson, Gene Evans, and Sheldon Toepke.

REFERENCE

Information specific to EPADS was derived from the EPADS User's Guide developed by McDonnell Douglas for WR-ALC under Task Order No. WR-55, Contract No. F33600-88-D-0567.

FOR ADDITIONAL INFORMATION

For additional information on this contractor developed, government owned software, contact Dave Bury at DSN 468-1124 or (912) 926-1124 and Fax DSN 468-9642 or (912) 926-9642.

Biographical Sketch: *David L. Bury, Acting Chief, Pollution Prevention Division, Warner Robins Air Logistic Center, Robins Air Force Base, Georgia*

Since May 1993, David L. Bury has served as Acting Chief of the Pollution Prevention Division, at WR-ALC, Robins AFB, GA. He entered Civil Service as an Environmental Engineer in December 1992.

He was born June 8, 1952 in Peoria, Illinois.

Prior to entering Civil Service, Mr Bury served 20 years active duty in the Air Force entering in July 1972. While on active duty, he served 11 years as a Ballistic Missile Analyst Technician on a Titan II launch crew at Little Rock AFB, Arkansas. In December 1980, he entered the University of Arkansas at Fayetteville, Arkansas under the Airmans Educational Commissioning Program(AECP) and received a Bachelors of Science Degree in Electrical Engineering in January 1983.

Dave entered Officers Training School in January of 1983 and received a commission in April 1983. Until retirement in March 1993, he served as an Electrical Engineering Design Officer at Little Rock AFB, Arkansas, Osan AB, Korea, and Robins AFB, Georgia. His last assignment prior to retirement was as Chief of Engineering, 9th Space Warning Squadron (PAVE PAWS), Robins AFB, Georgia.

Mr Bury is registered as an Engineer in Training (EIT) in the State of Arkansas.

HAZMART

Capt Ardyce M. Clements
Air Combat Command, Civil Engineering
129 Andrews Street, Suite 102
Langley AFB, VA 23665-2769
Voice (804) 764-3252; FAX (804) 764-8033

MSgt Joan L. Glover
Air Combat Command, Logistics
130 Douglas Street, Suite 210
Langley AFB, VA 23665-3320
Voice (804) 764-7817; FAX (804) 764-3320

The Situation. Air Force-wide we are spending millions of dollars in hazardous waste disposal costs. On the average, Air Combat Command (ACC) bases dispose of 72 tons of hazardous waste annually. At the ever-rising cost of $1.50 per pound, this equates to nearly $6 million for ACC alone. Studies show that 10 percent of the hazardous waste we dispose of is unopened containers of hazardous material (HM), disposed of due to expired shelf-life. An additional 50 percent were only partially used. Reports indicate that benchstocks are maintained at over 200 percent of actual usage levels. And what about the costs we incur before we dispose of the material as waste? Not only is the purchase costs for HMs high and rising, but so are the costs associated with a worker using the HM. Occupational Safety and Health Act (OSHA) Hazard Communication (HAZCOM) standard requires that employers train workers on the hazards associated with HMs used in the workplace, including proper use of engineering controls and protective equipment. If protecting our human resources weren't reason enough to limit our use of HMs, the cost of handling or mishandling HM/hazardous waste can be quite expensive. The U.S. Environmental Protection Agency can assess a maximum of $25,000 per day per violation. When you consider that approximately half of our enforcement actions are related to hazardous waste and HMs, the potential for a fine from the state or federal EPA becomes more clear.

Air Force, Department of Defense, and Executive Branch leadership, has recognized these factors and have increased emphasis on reducing and controlling HMs. The 7 January 1993 Action Memorandum signed by the Air Force Secretary and Chief of Staff, set out specific goals for reduction in purchase, use, and disposal of HMs/ hazardous waste. Executive Orders signed by the President this fall, sets the stage for reducing at the source, reusing, recycling, and, as a last resort, disposing. It also requires that federal facilities comply with Emergency Planning and Community Right-to-Know Act (EPCRA) requirements pertaining to the presence, use, and release of HMs.

The Strategy. Increased concern over the environment in general and HMs specifically has driven us to develop a strategy by which Headquarters ACC and its installations can reduce the amount of HM purchased, provide a mechanism for reissue of unused HM and effectively track the use of HM from acquisition to disposal. In ACC, we call this strategy "HAZMART".

The Concept. HAZMART is the base focal point for the management of HM. It offers centralized HM control and a single point of contact for base customers. HAZMART is dynamic and will depend on the installation implementing this concept to tailor it to meet their mission.. However, the heart of the HAZMART will be the same at all bases. The HAZMART, as a minimum, will be responsible to: control/authorize purchases; issue/reissue; offer non-hazardous alternatives; monitor shelf-life; analyze data for accuracy and trends; flag training/safety requirements; store HM; accomplish tracking/reporting; and manage hazardous waste. HAZMART will accomplish these tasks under a cross-functional team concept.

The Structure. Under the cross-functional team concept, each member from the various organizations on base, will provide their expertise in a particular aspect of HM management. Each organization involved with HM today, will continue to work their HM processes in support of the HAZMART. Members from Base Supply, Contracting, Civil Engineering (CE), Bioenvironmental Engineering (BEE), and Transportation, make up this unique team. Using this broad knowledge base, HAZMART personnel develop the best method of performing these required tasks and pull together all aspects of HM management. The roles outlined below show where traditional responsibilities lie and provide the framework for implementing a HAZMART.

Base Supply

- Manage HM ordering, storage, and issue processing.
- Perform HM stock control functions.
- Break down some bulk items into smaller units.
- Load Issue Exception Codes as prescribed by the BEE.

Civil Engineering

- Review environmental regulations to ensure environmental compliance.
- Identify "environmentally friendly" substitutes.
- Prepare regulatory reports.
- Program funds for HAZMART support.
- Develop emergency response plans and submit all reports required under EPCRA.

Base Contracting

- Administer and monitor all HAZMART local purchase actions, blanket purchase agreements, credit cards, etc.
- Enforce contractual provisions and requirements.
- Ensure vendors provide Material Safety Data Sheets (MSDS) prior to award of contract.
- Assist customers in obtaining MSDS information for first time requisitions.
- Develop/report affirmative procurement programs.

Bioenvironmental Engineering

- Determine which chemicals present either a health or environmental hazard.
- Identify "environmentally friendly" and less toxic chemical substitutes.
- Conduct the base HAZCOM program.
- Approve all new chemical use requests before an order is placed.

- Determine who is authorized to use which HM.
- Establish workplace-specific maximum allowable storage quantities for each HM used.
- Ensure only authorized and properly bar coded HMs are in use.
- Ensure maximum allowable storage quantities are not exceeded.
- Ensure engineering controls and protective equipment are adequate to protect workers.
- Review workplace waste disposal procedures.
- Perform waste characterization, sampling, and analysis.

As HAZMART develops, overlapping responsibilities will be apparent and these roles and responsibilities may change in favor of a more efficient way to do business.

The Resources. Manpower for the HAZMART will come from existing resources, mainly from those agencies that have a stake in HM management (Supply, CE, BEE, Contracting, and Maintenance). Base Supply will act as the overall manager. Physical positioning of cross-functional team members within HAZMART facilities should be based on the workload and/or availability of local/wide arean networks, etc. The degree of representation (full-time/part-time) by team members should be determined locally. Depending on the volume of work, some team members could provide support to the HAZMART from their traditional work places. Ideally, both the administrative offices and warehouse space for a HAZMART would be in a single facility.

Authorization. Prior to ordering HMs, units must be authorized by HAZMART personnel. During the enrollment process, the unit is set up with a unit authorization listing. This is a listing of HMs for specific processes that a shop has been pre-approved to purchase on a routine basis. Each unit will consult this list prior to ordering to ensure they are authorized. If the item is not on the list or quantity requested is above what is authorized, the purchase request must be authorized by the HAZMART.

HAZMART personnel will screen issue requests to ensure the organization is authorized to use items requested. BEE will provide HAZMART with user authorization listings and maximum allowable storage quantities. The quantity requested should not exceed the assigned maximum allowable level, unless the customer is supporting a surge or some other unforecasted requirement. If the customer needs the material and is not authorized to use it, BEE will be contacted to assess the situation.

An inventory list of used products will be available, so that when a customer needs a particular item, they can be issued the used, "free" material first, as opposed to opening new containers. HAZMART and CE/Trans. Material Control personnel should check the free issue list as a first source of supply.

Ordering. After the organization verifies that they are authorized and has checked with the HAZMART to see if the item is available for free-issue, the HM may be placed on order. The Standard Base Supply System (SBSS) will be the primary ordering system. Exceptions to this are HMs ordered through GOCESS/COCESS/COPARS contracts and medical items. All other HM, coded with an Issue Exception Code 8, 9, or M will be ordered through the HAZMART, utilizing SBSS.

CE/Transportation Material Controls *can* continue to requisition HM through CEMAS (COCESS/GOCESS/SBSS) and COPARS. However, they must first receive approval from the HAZMART to preclude dual stockage. CE/Transportation Material Controls will review HM residue stocks prior to ordering to see if there is material available to reissue. Once authorized, Material Control may order, and schedule delivery as usual.

Issue and Delivery. When material arrives on base and is delivered to Central Receiving, the receipt will be processed and property moved to the HAZMART. HAZMART personnel will bar-code the property, enter data into the IMMS, and either move the property to the storage location or release the property to the customer.

In some cases, such as CE and Transportation Material Control, the material will be delivered to, or picked up by Material controls, and then issued out to a specific user (i.e., CE Material Control would receive the material from Base Supply and would then issue it to the Zone I or Heavy Repair Shop.) In this case, Material Control would enter the shop information into the tracking system.

Once the bar-code and data entry is complete, the material is ready to be issued/released to the customer. Containers not immediately issued to a user will remain in a HM storage area under the control of the HAZMART or Material Control. When the HM is issued, the tracking system will be updated to ensure proper tracking of containers. Method of delivery for HM will be determined locally. Items may be delivered by HAZMART personnel, or shops may elect to pick them up.

Report. When an organization no longer needs a particular HM, the container can be returned to the HAZMART. At this time, the user must be able to report where the HM was used or spent (i.e., used in process, spilled, released as an air emission, or requires hazardous waste disposal action). Disposition of contents must be entered into the tracking system. This can be accomplished by returning the container to the HAZMART or by using a remote terminal. The can will then be disposed of properly. For CE and Transportation, the partially used/empty container is returned to Material Control where the tracking system would again be updated with the required information. Partially used containers will be made available for reissue.

Reuse, Recycle, Dispose. HAZMART personnel will determine whether the item(s) should be reused, recycled, or disposed of when material is returned to the HAZMART. Reusable material will be made available for "free issue". The HAZMART will keep customers informed of the "free issue" HMs by means of a distributed listing. Recycled material will be processed to a local contractor according to applicable contracts. Hazardous waste will be stored in established on-base accumulation point and processed to the local Defense Reutilization and Marketing Office.

Inventory Control. HAZMART's stockage philosophy is to meet customer requirements while minimizing the amount of HM stored on the base. Each base will decide which items will be stored in their HAZMART.

The HAZMART personnel, in coordination with the shop supervisor, will determine the maximum allowable quantity to be stored in each shop (i.e., a one week, one month supply, etc.). As materials are used, and empty containers returned to the HAZMART, the shop will be authorized to order replacement materials to meet their requirements.

Base Contracting will set up contract instruments with vendors for local purchase items. Contract instruments should be designed to accommodate a "just in time" inventory concept that keeps HM on the vendor's shelf until the customer needs it.

HAZMART personnel and their customers should determine units of issue that best suit the overall needs of the base. For example, if one customer prefers issue of a hazardous commodity in one gallon quantities and another prefers issue by the quart, the base would generally assign quart as the unit of issue. HAZMART personnel will break down bulk items into smaller units of issue (e.g., cases to cans; box to each, etc.). However, HM transfer from one container to another is not recommended.

Tracking. Tracking is a closed-loop process. HM entered into the tracking system remains a "loose end" until the disposition information is entered, showing 100 percent of the material being used or disposed of (i.e., used in process, spilled on the ground or in the water, released as an air emission, or disposed of as a hazardous waste). Bar-code technology is a tool that will help HAZMART personnel track HM. This technology relates a unique bar-code number to a corresponding data file where information specific to that bar-code number is recorded. Each container can be identified and tracked to a specific user and process.

Exceptions to Tracking. All HMs within installation boundaries, except for those listed below will be accounted for and tracked. This includes assets owned by the wing, tenant organizations, contractors, and deployed organizations.

As a minimum HAZMART will track HM that is either reportable or must be managed in order to meet minimization goals. The following items will not be tracked:

- personal / household HMs and office supplies.
- retail items sold in commissaries, exchanges, and MWR activities.
- substances present as a solid in any manufactured items, where exposure to the substance does not occur under normal conditions of use (i.e., thermometers).
- items stocked in the CE Self-help store.
- substances used in a medical facility under the supervision of a technically qualified individual.
- any chemicals or paints not assigned an Issue Exception Code 7, 8, 9 or M.
- other items specifically exempted by BEE

The Enrollment Process. The enrollment process is a series of three simple steps. First, determine the shops requirements. The HAZMART personnel will go to the shop and validates their requirements. They set up the unit's list of authorized HMs and quantities. They determine how much material the unit needs to do their job for a certain amount of time. Second, reduce inventory down to the minimum. All HM remaining in the shop will be bar-coded. Excess material (unopened and serviceable) will be turned into Base Supply for full credit . Partially used material which will no longer be used by that organization will be turned in to the HAZMART and be made available for "free issue". Third, reinforce the ordering procedures. HAZMART personnel and the shop go over the new ordering procedures to ensure that the shop understands what is expected.

The Results. HAZMART is a valuable tool for both installation commanders and for HM users. For commanders, it will provide centralized control of the area for which he/she is most vulnerable to violations and potential fines from regulatory agencies. For the base customers, it will be a one-stop shop for all of their HM requirements.

PREVENTING LABORATORY WASTES

Prepared by:
Thomas F. Stanczyk, Sr. Vice President
Recra Environmental, Inc.
10 Hazelwood Drive
Amherst, NY 14228

INTRODUCTION

Webster defines a laboratory as a 'place used for experiments or research in science, pharmacy, etc. or for manufacture of chemicals in industry'.

According to the American Chemical Society, there are over 200,000 laboratories in the United States, including laboratories engaged in research and development; chemical and drug formulation; health sciences (i.e., hospitals, clinics, etc.); process and product quality control; technology evaluation; environmental testing; risk determination; remediation and construction; and education (i.e., universities, schools).

Even though there is a wide range of experimental activities differentiating the functionality and design of each laboratory operation, there are a number of common issues and requirements dealing with chemical purchasing policies and practices; chemical reagent selection and use; inventory management; experimental design and test methodology protocol; material storage and distribution; accident and spill prevention; hazard awareness and employee training; material tracking and cost allocation; waste management; and regulatory compliance.

Nearly all laboratories generate waste or pollution. In this regard, waste and pollution may include inefficient use of resources including utilities and labor; lost production or research time; discarded inventory and equipment; solid debris; air emissions; and wastewater.

Taking into account the categorical variances in waste characteristics, laboratory managers and employees are being challenged to continuously improve the quality of their operations in a concerted effort to:

- Maintain customer satisfaction
- Improve the efficiency and results of ongoing research
- Optimize the use of available resources
- Minimize excess waste including discarded inventory
- Reduce capital expenditures and operating costs
- Minimize the risks posed by the uncontrolled release of toxic chemical compounds
- Reduce the lab's reliance on landfills for the disposal of solid waste
- Ensure compliance with the ever-increasing number of environmental and OSHA regulations

Pollution prevention is viewed by many waste generators as a 'preferred' environmental management strategy. In addition to minimizing the volume and toxicity of regulated waste, pollution prevention can provide numerous opportunities for improving the quality of lab operations. Recognizing the benefits attributed to pollution prevention, this paper summarizes some of the documented strategies and opportunities having applicability to laboratory operations and wastes.

LABORATORY MATERIALS ACCOUNTING

A centralized chemical and waste information management system can help lab facilities minimize the:

- Purchase of <u>excess</u> and, in many cases, unnecessary quantities of chemical reagents.
- Disposal of unused chemicals because they exceeded shelf-life.
- Time and effort typically allocated to tracking inventory and waste generation.

0170.air

- Environmental and workplace liabilities generally attributed to:
  - lack of conformity in how materials are identified/managed, and
  - non-compliance with regulatory standards
- The potential for waste management problems by using information to proactively preventing them rather than react to them.

Effective environmental information management systems utilizing chemical measurements and progress reports drive environmental results. Many generators are recognizing that the single largest obstacle to effective environmental management is "the absence of cost accounting system that accurately documents the true costs associated with inefficient use of resources and waste". Total materials accounting is an effective process for defining pollution prevention opportunities. Figure 1 schematically illustrates a number of viable laboratory materials accounting relational analyses.

A laboratory materials accounting system is a management tool that can be defined as:

- A total materials, tracking and waste accounting information management system.
- A data management system documenting characteristics of reagents, wastes and products.
- An electronic deliverable for analytical and process measurements.
- A cost allocation and financial analysis information support system.
- A compliance support system.
- An analytical tool supplementing the measurement, progress reporting and communication elements of a pollution prevention program resulting in waste avoidance.

The analyses generated by this system will help identify the sources as well as causes of waste generation, for example:

- Unused inventory
- Excess reagent quantities
- Inadequate experimental controls
- Test protocol dictating chemical use
- Lack of attention to detail
- Spillage
- Pollution abatement systems
- Economic constraints
- No Standard Operating Procedures
- Reagents exceeding shelf-life
- Mismanagement of chemicals and instrumentation
- The experimental design consumes excess chemicals
- Glassware cleaning
- Housekeeping
- Maintenance (building, equipment, etc.)
- Material handling
- Inadequate training
- Required health and safety precautions

DEFINING VIABLE TECHNIQUES

Figure 2 summarizes a hierarchy of laboratory waste minimization strategies and techniques. Some of the specific strategies warranting consideration include:

- Inventory Control: Viable techniques include establishing a centralized chemical storage and distribution center; reviewing purchasing policies and practices; cross-referencing reagent characteristics with applicable regulatory listings; tracking chemical inventory; using bar-code labels and data management systems; allocating costs to departments; tracking shelf life; assessing packaging and material handling; justifying reagent selection as well as reagent quantities; and establishing partnerships with vendors.

- Chemical Selection and Use: There are opportunities for reducing waste quantities and hazard that would entail the controlled distribution of chemicals; the selection of non-hazardous substitutes; doing more with less; purifying discarded solvent; and justifying experimental protocol.

- Experimental Design and Test Protocol: Systems need to be established that would require documentation of experimental objectives; operating procedures, waste management practices; hazard determination; stock requirements; experimental scale; and chemical use requirements.

- Good Operating Practices: Hazard awareness, material tracking, cost allocation, material segregation, waste separation, employee training are among the number of good operating practices that can effect waste generation.

Some examples of specific opportunities are as follows.

MICROWAVE ASSISTED SOLVENT EXTRACTION

The CEM Corporation has recently introduced a microwave system designed specifically for solvent extraction of organic compounds. The MES-1000 has been used successfully for extractions of general organic compounds such as: pesticides, total petroleum hydrocarbons, herbicides and polynuclear aromatic hydrocarbons by conventional analytical methods. In comparison to soxhlet extractions, microwave assisted solvent extraction can save time for all types of samples. The following table provides a comparison of the time savings for select types of samples.

Parameter	Extraction Times	
	MEC-1000	Soxhlet
PAH	15 minutes	8 hours
TPH	5 minutes	8 hours
Polymers	5 minutes	4 hours

The benefits attributed to CEM's MES-1000 can be summarized as follows:

- Extraction times for an array of sample types, i.e., chemical/petrochemicals, environmental and food, can be reduced to less than 30 minutes.
- Required solvent volumes can be reduced significantly to less than 50 mls.
- The system can improve extraction efficiency while controlling extraction conditions for all compounds.
- The equipment allows 12 samples to be extracted per run.

MICROWAVE SOLUTIONS TO SAMPLE PREPARATION

Microwave sample preparation systems are affording many solutions to complex sample preparation problems in many fields of analytical chemistry. Among the documented applications for microwave sample preparation systems are:

- Acid digestion for atomic absorption (AA) and emission ICP spectroscopy
- Polymer dissolution for viscosity or molecular weight determination via GPC
- Protein/peptide hydrolysis for amino acid analysis
- Acid digestion of composites for gravimetric determination of fill materials
- TPN-Total Persulfate Nitrogen and phosphorous determinations
- Solvent extraction for gas or liquid chromatography
- Sample drying and moisture determination
- Organic synthesis reactions

These systems have applicability to a wide array of sample matrices, i.e., agricultural, biological, environmental, food, metallurgical, oils, plastics, organics, oxides and sulfides.

CEM's MDS-2100 Microwave Sample Preparation System is designed to perform microwave assisted acid digestion of multiple, large volume aqueous and strictly inorganic samples such as sediment in accordance with USEPA, NPDES, CLP, SW-3015 and SW-3051 methods. The CEM MDS-2000 system is primarily used with organic sample matrices, i.e., oils, sludges, solvents and hazardous wastes.

CEM has recently developed a fully automated, continuous flow microwave sample preparation system, SpectroPrep™. This new technology has the following unique features:

- The system automatically digests, cools and filters samples so they are ready, without further treatment, for analysis on ICP, AA, FIA or other detection and quantitative systems.
- The system can be controlled for unattended microwave sample preparation.
- The SpectroPrep™ processes up to 180 samples per run.
- No glassware or vessels to clean.
- No sample carryover.
- In as little time as 6 minutes, the sample is digested, cooled, filtered and ready for direct injection to an ICP/AA.
- Acid concentrations as low as 1-10% can be used to digest samples. The result is improved recoveries with lower detection limits, less contamination and better working conditions.
- The system minimizes acid fumes and emissions improving workplace conditions while preventing releases of toxic chemicals to air.

SPE-DEX™ AUTOMATED EXTRACTOR SYSTEM

Horizon Technology has developed a laboratory workstation that was specifically designed and engineered to automate the solid phase extraction process of organics from aqueous samples by using the 3M EMPORE™ 47mm SPE disk. The SPE-DEX™ Extractors, under the direction of the SPE-DEX™ Controller, will automatically:

- Dispense multiple solvents to wash and soak the disk
- Utilize internal liquid sensors to monitor and control all liquids
- Collect all of the organic solvents and wastewater in individual waste containers
- Dispense the water sample onto the disk
- Rinse the sample container with the extracting organic solvents
- Extract the disk and collect the extracting solvents in a KD tube
- Wash the entire assembly between water samples

SOXTEC® SYSTEMS - EQUIPMENT ALTERNATIVE TO SOXHLET SYSTEMS

Tecator, a Perstorp Analytical Company, has commercialized the Soxtec® Systems as an alternative solvent extraction system.

The soxhlet systems have a number of reported applications including, but not limited to, the extraction of fats and oils, petroleum, resins, additives and organics form a wide variety of natural, man-made or processed samples. Among the reported list of sample possibilities are: plastics and rubber, textiles, plants, animal tissues, packaging, paper pulp, pharmaceuticals, chemicals, agricultural crops, soils and sediments, food and feed products, and wastewater.

The system provides great flexibility in the choice of solvents and sample holders. Among the typical solvent used are acetone, heptane, carbon tetrachloride, hexane, chloroform, methanol, diethyl ether, petroleum ether, dichloromethane, toluene, ethanol, trichloroethylene, and water.

The following table compares the reductions in extraction time for various applications using soxhlet systems as conventional techniques.

Application	Extraction Time (hrs.)	
	Soxtec	Soxhlet
Finish on textiles	0.6	3 - 6
Pesticides in soils and foods	0.6 - 2	6 - 20
Sediments and core material	2 - 3	15 - 30
Resins in paper pulp	0.8	3
Additives in plastics and rubber	0.3 - 2	6 - 10
Fats in food and feed	0.8 - 2	6 - 8
Oil in oil seeds	0.6 - 4	8 - 20

0170.air

Benefits

- Extraction times can be reduced from days to hours, and from hours to minutes, without loss of accuracy.
- The Soxtec HT2 and HT6 make batch handling an easy task.
- The Soxtec systems are equipment with a solvent recovery feature reducing the cost for solvent by up to 65%.
- The extraction units are heated indirectly by circulating oil from an electronically controlled service unit.

ORGANIC VAPOR RECOVERY SYSTEMS

J&L Scientific Products has designed vapor recovery systems that can be efficiently used with the following organic extraction procedures:

- EPA Methods 3510, 3520, 3540 and 3550
- EPA Method Gravimetric 413.1 and other concentration blow down procedures
- PCB, pesticide and herbicide analyses
- Acid/base/neutrals, phenols and other concentration or solvent exchange organic extraction procedures

The recovery systems are designed to be compatible with most extraction glassware and equipment. The process uses a series of condensers, chambers and gravity drain passages to return the vapor to its original liquid state for recycling.

The vapor recovery systems have the following capabilities:

- The system can recovery 95-98% of hazardous solvent vapors
- The performance efficiency of the system can assist labs comply with emerging regulations and standards governing air emissions of toxic chemicals
- The system can minimize laboratory background contamination levels of extraction solvents associated with GC and GCMS analyses
- The recovered solvent can be recycled

PYREX® ACCELERATED ONE-STEP™ EXTRACTOR CONCENTRATOR

VWR Scientific has commercialized the Pyrex® Accelerated One-Step™ Extractor Concentrator as an equipment substitute meeting the testing requirements of EPA SW-846, Method 3520 in accordance with Section 2.1. This apparatus is designed to perform extraction, concentration and drying all in one system.

Among the documented benefits are:

- The system significantly reduces extraction time:
  - Extraction/concentration can be done in 1/3 of the time of a normal liquid-liquid extraction
  - For pesticides and PCB's, the reduction has been reported from 18 to 5.5 hours
  - For semi-volatile extractions, the time can be reduced from 36 to 12 hours

- The system significantly reduces solvent use:
  - The extraction process needs only 100ml of solvent instead of 500ml, an 80% savings. This reduction in solvent usage also reduces excess solvent costs, solvent disposal requirements, and solvent emissions since solvent recovery is built in

- The system eliminates the drying step:
  - No separate extract drying is required due to the use of a hydrophilic membrane
  - No transfer of extract for macro-concentration

BLOCK DIGESTIONS

Lachat International's BD26 enables digestion of samples prior to the determination of metals by AA or ICP. The unit was specifically designed to meet the analytical and QC protocol requirements of the USEPA's CLP inorganics statement of work for determining metals in water, soil, sediment, sludge and oil.

The BD46 performs high temperature Kjeldahl digestions in 75ml tubes primarily on water samples for the determination of total nitrogen and total phosphorous.

Both the BD26 and BD46 incorporate several innovative features including:

- Cold fingers to condense and recovery virtually all acid fumes
- Anti-foaming bulb to reduce boil-over due to sample surfactants
- Integral programmable controller mounted high on a flexible arm to improve visibility and prevent damage due to spillage
- 26 x 250ml tube positions

Benefits

- Evaporation is minimized, thus reducing risks posed by hazardous acid fumes
- Cold fingers condense fumes as well as reduce the potential for cross contamination
- Contamination from room air is prevented
- Combined features improve accuracy and precision of the metals digestion

MICRO-DISTILLATION

Lachat Instruments has made available the MICRODIST® System for the rapid distillation of cyanides, phenolics, sulfides, ammonia and other volatile analyses.

Conventional analyses for the determinations of cyanides and total recoverable phenolics and other volatile analytes pose a significant impediment to productivity by requiring pre-distillation of samples using expensive, large volume glassware that is time-consuming for set-up and maintenance.

The MICRODIST® System quantitatively reduces the volume of samples and reagents specified in USEPA Methods 335.2 for cyanides and 420.1 for phenolics delineated in "Methods for Chemical Analysis of Waters and Wastes".

The MICRODIST® System is a batch micro-distillation system using sample volumes of about 6ml.

Benefits

- Very short distillation times (30 minutes for cyanides and 90 minutes for phenolics)
- Distillation of up to 21 samples simultaneously
- Increased ease of use with minimal setup time and no tear down required
- Disposable distillation tubes so there is no glassware to wash and maintain
- Improved precision since all samples are treated identically

SUMMARY

Most laboratories are confronted with reduced operating budgets and increased work loads, forcing employees to do more with less. Within a laboratory environment, there are many opportunities for improving productivity while reducing operating costs typically assigned to the management of waste. The available techniques may dictate changes in culture, operating protocol, regulatory standards, economic determination on return on investment, and waste management practices. To proactively deal with these changes, pollution prevention should be incorporated within the framework of ongoing quality improvements.

FIGURE 1

TOTAL MATERIALS ACCOUNTING

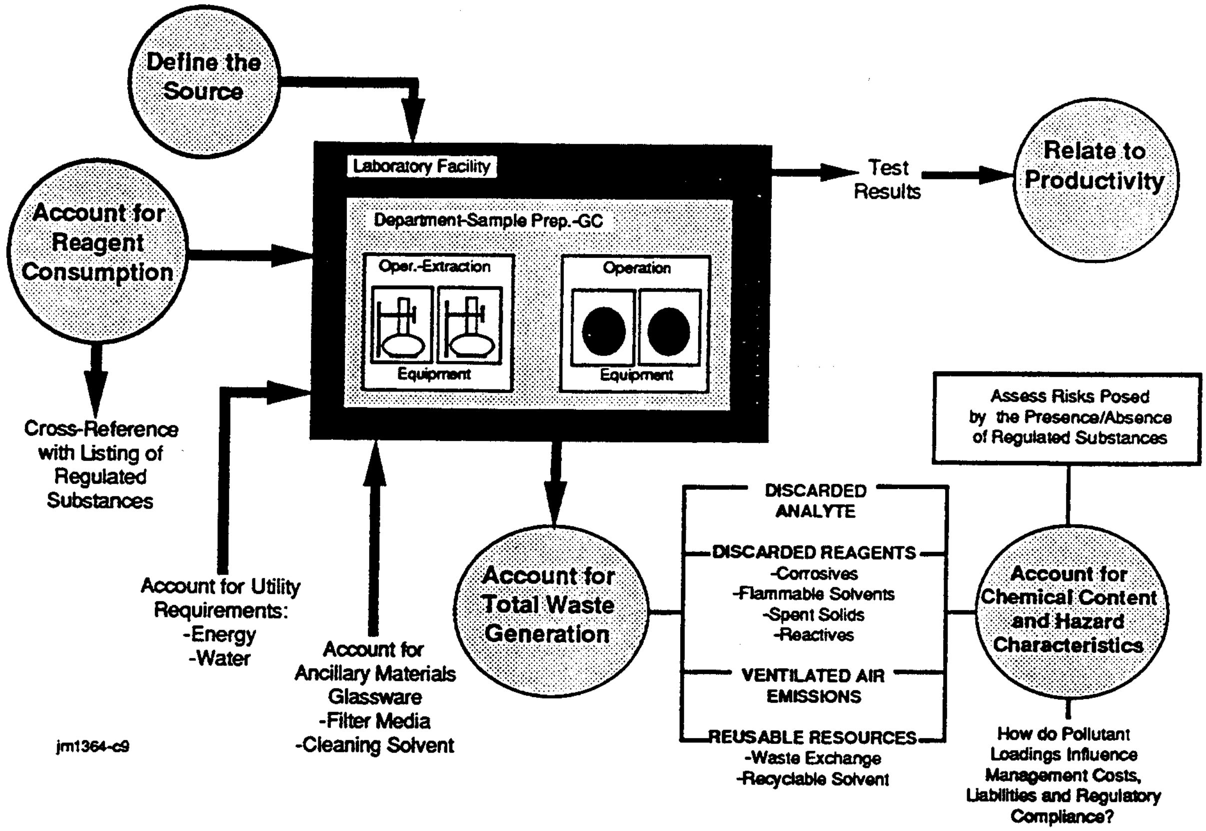
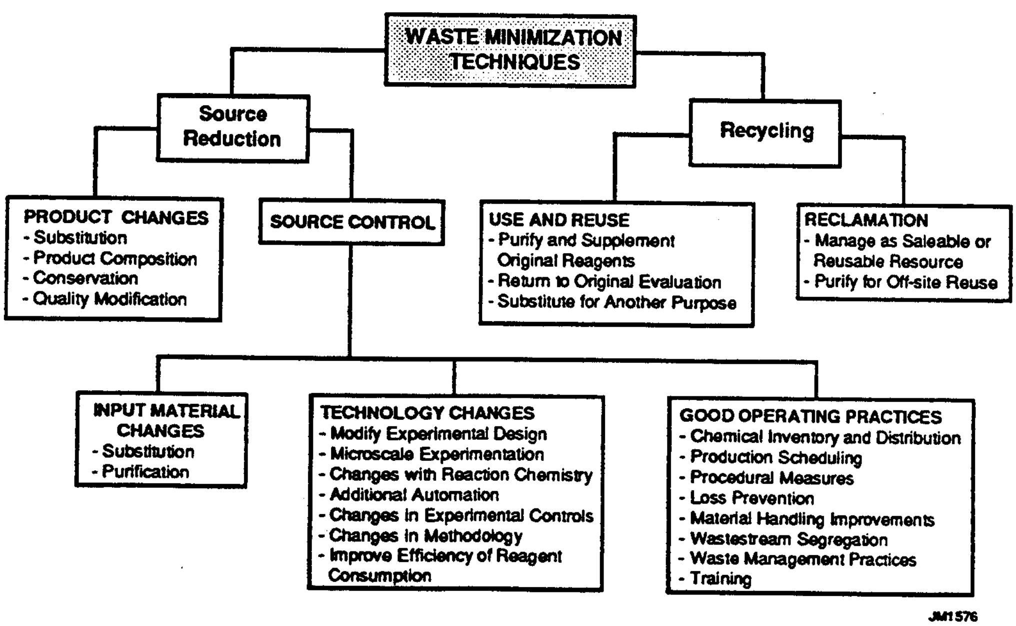


FIGURE 2

WHAT IS THE HIERARCHY OF LABORATORY WASTE MINIMIZATION TECHNIQUES?



170.air

USING A RELATIONAL DATABASE TO STREAMLINE DATA REDUCTION IN A POLLUTION PREVENTION PROCESS ASSESSMENT

Mary Ann Hopkins, Christine LaFleur, and Sudhir Murthy
Engineering-Science, Inc
10521 Rosehaven Street
Fairfax, VA 22030
(703) 591-7575

ABSTRACT

Performing a pollution prevention process assessment at a Department of Defense (DOD) facility requires collecting an enormous amount of information and data. Collecting process specific information is the first step. This data must then be reduced and manipulated into a format which can be used to help analyze pollution prevention opportunities. Engineering-Science, Inc. (ES) is performing process opportunity assessments at a number of DOD facilities. To facilitate collecting and analyzing data, ES is using portable "pen-activated" computers (electronic clipboards) and a relational database.

The electronic clipboards are programmed to accept data written directly on a worksheet set over a pressure sensitive pad. The data are stored for each process site in a record until it is uploaded into the relational database. All data are presented on the process level. That is, material inputs and waste outputs are computed for each individual process. Data can then be summed for like processes or for the entire facility. The tables generated for each facility may be linked to allow formation of material accounting reports, target chemical usage and fate reports, process prioritization reports, as well as many others. The ability to add cost data and future process baselines make relational databases an attractive tool for analyzing and reducing data from process assessments and for future applications such as tracking pollution prevention progress.

INTRODUCTION

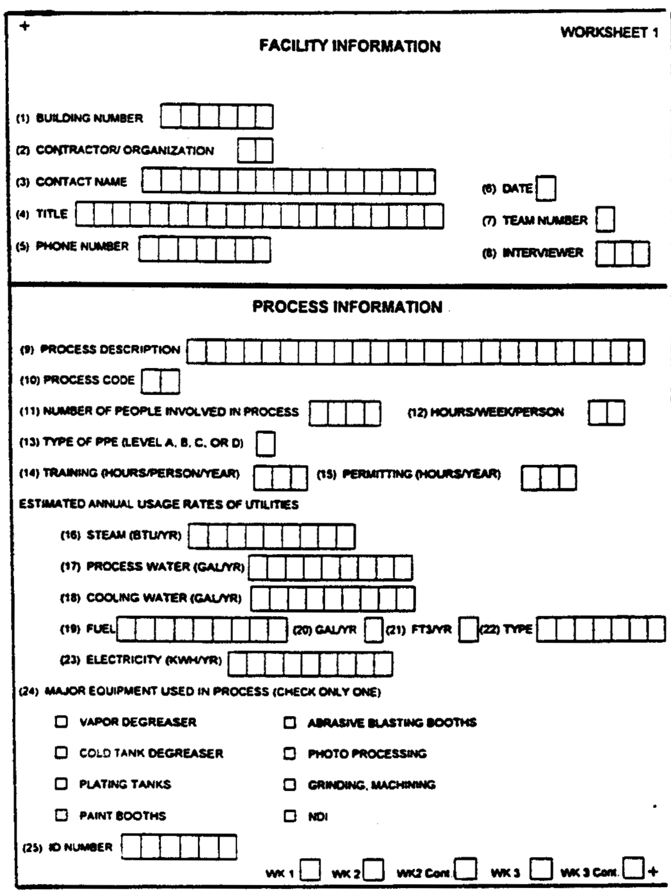
Pollution prevention opportunity assessments require collecting and analyzing numerous process data. The data can include material input rates, waste generation rates, utility requirements, and unit costs. These data are usually recorded on worksheets to ensure all necessary data are collected for each process location. Worksheets have been developed for use on electronic clipboards that allow data to be stored in files for uploading into tables in a database. Once the data are uploaded, the procedure of building on the originally collected data begins. The relational database can then be used to perform queries and link tables allowing process data to be sorted and presented in a number of ways. This paper summarizes how initial data can be collected and stored electronically and uploaded into a database. Then by adding general information to database tables, these data can be manipulated through a series of queries to provide process inputs and outputs, target compound usage, and process prioritization.

COLLECTING DATA

The data collection process is time consuming in that it relies on interviewers asking the right questions and interviewees possessing the knowledge (and the data to back it up) to give an accurate response. The interview process is aided by developing and using worksheets to collect process information. Worksheets provide structure to the interview and can be used as a checklist to ensure that all the questions have been asked and that all the possible information has been gathered. When information is collected on worksheets it is then usually entered manually into some database format. To delete this data entry step and the quality control checks that go with it, electronic clipboards are used to collect process data.

Once the worksheets have been designed, a "forms builder" software is used to generate the hardcopy of the worksheet. The worksheets must be formulated with blanks, separated into appropriately sized blocks, to accept the information from the interviewee. Figures 1 and 2 are examples of process information and process material worksheets. The hardcopy worksheet is then placed over the pressure sensitive pad of the electronic clipboard. The form location is then calibrated and the answer blanks are programmed into the electronic form.

The electronic clipboard are then taken into the field and the data collected by writing directly on blank worksheets. When completed, the collected data is stored as an ASCII file in the clipboard, which can be uploaded directly into the database. A hardcopy backup of the worksheets is also retained.



WORKSHEET 1

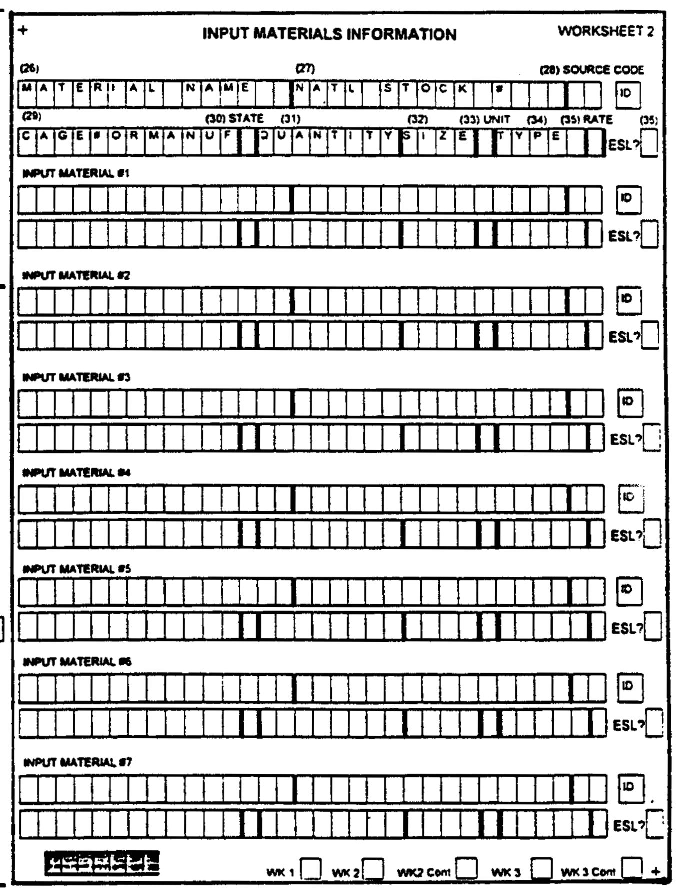
FACILITY INFORMATION

(1) BUILDING NUMBER
(2) CONTRACTOR/ ORGANIZATION
(3) CONTACT NAME
(4) TITLE
(5) PHONE NUMBER
(6) DATE
(7) TEAM NUMBER
(8) INTERVIEWER

PROCESS INFORMATION

(9) PROCESS DESCRIPTION
(10) PROCESS CODE
(11) NUMBER OF PEOPLE INVOLVED IN PROCESS
(12) HOURS/WEEK/PERSON
(13) TYPE OF PPE (LEVEL A, B, C, OR D)
(14) TRAINING (HOURS/PERSON/YEAR)
(15) PERMITTING (HOURS/YEAR)
ESTIMATED ANNUAL USAGE RATES OF UTILITIES
(16) STEAM (BTU/YR)
(17) PROCESS WATER (GAL/YR)
(18) COOLING WATER (GAL/YR)
(19) FUEL (20) GAL/YR (21) FT3/YR (22) TYPE
(23) ELECTRICITY (KWH/YR)
(24) MAJOR EQUIPMENT USED IN PROCESS (CHECK ONLY ONE)
VAPOR DEGREASER
ABRASIVE BLASTING BOOTHS
COLD TANK DEGREASER
PHOTO PROCESSING
PLATING TANKS
GRINDING, MACHINING
PAINT BOOTHS
NDI
(25) ID NUMBER
WK 1 WK 2 WK2 Cont WK 3 WK 3 Cont

Figure 1
Example Process Information Worksheet



INPUT MATERIALS INFORMATION

WORKSHEET 2

(26) (27) (28) SOURCE CODE
MATERIAL NAME NATL STOCK # ID
(29) (30) STATE (31) (32) (33) UNIT (34) (35) RATE (35)
CAGE # OR MANUF QUANTITY SIZE TYPE ESL?
INPUT MATERIAL #1 ID ESL?
INPUT MATERIAL #2 ID ESL?
INPUT MATERIAL #3 ID ESL?
INPUT MATERIAL #4 ID ESL?
INPUT MATERIAL #5 ID ESL?
INPUT MATERIAL #6 ID ESL?
INPUT MATERIAL #7 ID ESL?
WK 1 WK 2 WK2 Cont WK 3 WK 3 Cont

Figure 2
Example Process Material Worksheet

BUILDING DATABASE TABLES

The initial database tables are generated from data collection on the electronic clipboards and include basic process information (Figure 3), input materials used (Figure 4), and wastes generated (Figure 5). The common field to all these tables is a unique process identification number. The input material and waste generation information is in the same format as the data collection worksheets. For example, a material usage rate for a process may have been recorded as 2 5-gallon cans per week. Because materials and wastes will eventually be accounted for on a weight basis, all information collected in the field are converted to pounds. To aid this conversion, a "general" hazardous material table is constructed that includes the hazardous material name, the NSN, the specific gravity, and the percentage of any target compounds.(Figure 6) The target compounds for the opportunity assessments have included the Environmental Protection Agency (EPA) 17 Industrial Toxics Project Chemicals and ozone depleting chemicals (ODCs). The specific gravity and target compound information is obtained from the Hazardous Material Information System (HMIS) for supply-issued items and from manufacturer Material Safety Data Sheets (MSDSs) for local purchase items.

The general hazardous waste table includes the waste name, the waste code (assigned during data collection), and the average density (Figure 7). Average densities for wastes types are based on numerous hazardous waste manifest data. The average densities are only used if the waste quantities were not recorded in pounds during data collection.

ID Number	Building	Contractor/ Organization	Title	Phone	Interview Date	Process Description
ASSO01	HANGER	AS	ENVIRONMENTAL HEALTH & SAFETY	8531542	4-Apr-94	AEROSTAT EQUIPMENT MAINTENANCE
BIPX01	1805	BI	HAZ WASTE COORDINATOR	8537071	4-Apr-94	MOTION PICTURE FILM PROCESSING
CRBO01	44633	CR	SUPERVISOR	8535839	7-Apr-94	PESTICIDES HERBICIDES
CSBA01	HANGER	CS	CHIEF TECHNICIAN	8539625	28-Mar-94	RADIO MAINTENANCE
CSER01	HANGER	CS	PRODUCTION ENGINEER	8535987	28-Mar-94	CIRCUIT BOARD FABRICATION
CSPX01	HANGER	CS	PRODUCTION ENGINEER	8535987	28-Mar-94	CIRCUIT BOARD FABRICATION
GDAB01	HANGER	GD	FACILITIES ENGINEER	7305030	6-Apr-94	BEAD BLASTING GLOVE BOX
GDAB02	LC	GD	FACILITIES ENGINEER	7305030	31-Mar-94	SAND BLASTING
GDFC01	HANGER	GD	FACILITIES ENGINEER	7305030	6-Apr-94	VEHICLE FLUID CHANGE
GDFC02	LP 36	GD	FACILITIES ENGINEER	7305030	7-Apr-94	COMPRESSOR OIL CHANGE
GDFC03	HANGER	GD	FACILITIES ENGINEER	7305030	6-Apr-94	MISSLE ENGINE SOLVENT FLUSH
GDIM01	HANGER	GD	FACILITIES ENGINEER	7305030	6-Apr-94	GAUGE SOLVENT CLEANING
GDMS01	HANGER	GD	FACILITIES ENGINEER	7305030	6-Apr-94	PHOSPHORIC ACID BATH
GDMS02	LP 35	GD	FACILITIES ENGINEER	7305030	7-Apr-94	DELUDGE BASIN
GDMS03	LP 36	GD	FACILITIES ENGINEER	7305030	7-Apr-94	MISSLE STAGE MATING CLEAN
GDMS05	LC36	GD	FACILITIES ENGINEER	7305030	7-Apr-94	FUELING OF MISSLE
GDPO02	LC	GD	FACILITIES ENGINEER	7305030	31-Mar-94	PAINTING
GDSO01	HANGER	GD	FACILITIES ENGINEER	7305030	6-Apr-94	SOLVENT PARTS SPRAYING
JCAB01	44609	JC	SUPERVISOR, CORROSION CONTROL	8533682	31-Mar-94	ABRASIVE BLASTING
JCFC01	1708	JC	SUPERVISOR, AC SHOP	8538122	30-Mar-94	AIR CONDITIONING MAINTENANCE
JCFC02	44625	JC	FOREMAN, GENERATOR SHOP	8537077	31-Mar-94	PORTABLE GENERATOR MAINTENANCE

Figure 3
Process Information Table

ID Number	Material Name	NSN	Manufacturer/ Cage	Source Code	State	Quantity	Size	Unit	Type	Rate
JCPO01	THINNER DOPE LACQUER	8010001605787	SW216	1C	L	200	1	G	BOTTLE	Y
JCPO01	MARTYTE PART C	CAPJCPO010040	UNITED TECH	1C	L	1000	1	G	BOTTLE	Y
JCPO01	PAINT ALKYD GLOSS ENAMEL	8010002982287	72688	1C	L	75	1	G	CAN	Y
JCPO01	PAINT POLYURETHANE	CAPJCPO010062	DEFT	1C	L	50	1	G	CAN	Y
JCPO01	PAINT EPOXY	CAPJCPO010061	SHERWIN-WILLIAMS	1C	L	400	1	G	CAN	Y
JCPO01	MARTYTE PART A	CAPJCPO010038	UNITED TECH	1C	S	1000	20	L	BAG	Y
JCPO01	MARTYTE PART B	CAPJCPO010039	UNITED TECH	1C	L	1000	1	G	BOTTLE	Y
JCPO01	PAINT ORANGE LATEX	CAPJCPO010043	SHERWIN-WILLIAMS	1C	L	250	1	G	CAN	Y
JCPO01	MINERAL SPIRITS	8010010213320	7L600	1C	L	100	1	G	CAN	Y
JCPO01	THINNER WINTER	CAPJCPO010057	PROTECTIVE COATING	1C	L	2	1	G	BOTTLE	Y
JCPO02	HARDENER	8040010319656	18563	2A	L	220	1	O		Y
JCPO02	BASE COAT PAINT	CAPJCPO020069	MARTIN-SEMOUR	2A	L	235	1	G	CAN	Y
JCPO02	WATER	CAP000000099	NA	2A	L	235	1	G	CAN	Y
JCPO02	THINNER	8010001605787	SW216	2A	L	226	1	G	CAN	Y
JCSO01	KLEER-FLO	6850006061221	16640	1B	L	1	20	G	TANK	Y
JCSO01	RAGS	CAP000000088	NA	1B	L					
JCSO01	SUNETHANE	CAPJCSO010050	NA	1B	G	12	16	O	CAN	M
JCSO01	FILTER	CAP000000087	NA	1C	L	1	20	G	TANK	Y
JCSO01	DIRT & GREASE	CAP000000086	NA	1C	G	12	16	O	CAN	M
JCSO02	KLEER-FLO	6850006061221	16640	1B	L	4	55	G	DRUMS	Y
LMAB01	SAND	5810000F012317	28588	1B	S	58000	1	L	BAG	Y

Figure 4
Process Material Table

ID Number	Waste Name	Waste Stream	Source Code	Disposition	Triggered	Disposal Method	Destination	Quantity	Size	Unit	Type	Rate
JCFC04	USED ANTIFREEZE	10	1B	R	CHANGEOUT	D	N	2	55	G	DRUMS	Y
JCFC04	WASTE OIL	8	1B	R	CHANGEOUT	D	F	3	750	G	TANK	Y
JCFC04	USED OIL FILTERS	25	1B	S	CHANGEOUT	D	F	8	55	G	DRUMS	Y
JCPO01	PAINT WASTE	17	2C	H	CLEANING	D	F	8	500	L	DRUM	Y
JCPO01	PAINT RAGS	24	2C	H	CONTAMINATED	D	F	35	250	L	DRUM	Y
JCPO02	WASTEWATER	31	1B	W								
JCSO01	WASTE SOLVENT	22	1B	H	DIRTY	D	F	1	20	G	CONTINOUS	Y
JCSO02	WASTE SOLVENT	21	1B	H	WASHING	D	F	4	55	G	DRUMS	Y
LMAB01	SAND AND PAINT CHIPS	44	1C	A	USED	D	N					Y
LMAB02	SAND AND PAINT CHIPS	44	1C	A	USED	D	N					Y
LMFC01	DIESEL FUEL CONTAM	9	1B	H	CONTAMINATED	D	F	5	50	G	DRUM	Y
LMFC01	USED OIL	8	1B	R	PREV MAINT	D	F	1	3600	L		Y
LMLA01	FREON TF	21	1B	H	TEST COMPLETE	D	F					
LMPO01	WASTE PAINT	16	1B	H	LEFT OVER	D	F	2	50	G	DRUM	Y
LMPO02	PAINT WASTE	16	1B	H	LEFT OVER	D	F	2	50	G	DRUM	Y
LMPO02	RAGS	24	1B	H	CLEANUP	D	F	2	50	G	DRUM	Y
LMPO02	SOLVENT WASTE	17	1B	H	CLEANUP	D	F	1	50	G	DRUM	Y
LMPO03	PAINT WASTE	16	2B	H	LEFT OVER	D	F	2	50	G	DRUM	Y

Figure 5
Process Waste Table

NSN	MANUFACT-URERCAGE	NAME	FAMILY	GROUPING	SPG	BENZENE	CADMIUM	CARBONTET-RACHLORIDE	CHLORO-FROM	CHROMIUM
8040002629011	0HZU1	GENERAL PURPOSE ADHESIVE	ADHESIVE	V	0.89	25				
8040003629025	31711	MILA 5 ADHESIVE	ADHESIVE	V	0.78	25				
8040002738716	76381	CONTACT CEMENT	ADHESIVE	V	0.83	75				
8040002981946	0HZU1	SYNTHETIC RUBBER ADHESIVE	ADHESIVE	V	0.89	25				
8040004334065	56800	RESIN ADHESIVE	ADHESIVE	V	0.7	100				
8040003132246	59888	ADHESIVE	ADHESIVE	V	0.86					
8040007542685	OHZV1	CONTANCT CEMENT	ADHESIVES	V	0.78	75				
8040008253621	18565	SILVER EPOXY/HARDENER	EPOXY HARD	V	1.5	10				
8040008779872	01139	RTV SEALANT	ADHESIVE, SI	V	1.2	70				
8040009146970	71984	RED PRIMER	PAINT, PRIME	P	0.9	80				
8040009957080	4E001	SPRAY TRIM ADHESIVE	ADHESIVE, A	V	0.99	100				
804000B120028	05972	LOCTITE 242 THREADLOCKER		V	1.1	100				
804000F004752	90300	CONTACT ADHESIVE	ADHESIVE	V	0.8	85				
804000F005372	25589	FRANKLIN TITEBOND WOOD GLUE	WOOD GLUE	V	1.1	90				
804000F015785	84794	HERCULES PVC CLEANER	CLEANER	V	0.91	25				

Figure 6
General Hazardous Material Table

WASTESTREAM	SUMMARY	STATE	DENSITY
01	ABRASIVE BLAST RESIDUE	SOLID	15
02	WASTE BATTERY	SOLID	30
03	WASTE BATTERY ACID	LIQUID	11
04	WASTE CHEMICAL PAINT STRIPPER	LIQUID	7.5
05	CHEMICAL PAINT STRIPPER SLUDGE	SEMISOLID	7.7
06	PLATING BATH SLUDGE	SEMISOLID	8.8
07	WASTE MASKANT	SOLID	6.9
08	WASTE OIL/PNEUDRAULIC FLUID	LIQUID	7.1
09	DRAINED FUEL	LIQUID	5.6
10	WASTE ANTIFREEZE	LIQUID	8.8
11	CONTAMINATED OIL	LIQUID	7.9
12	CONTAMINATED FUEL	LIQUID	5.7
13	WASTE MACHINE COOLANT	LIQUID	8.2
14	METAL SHAVINGS/RESIDUE	SOLID	16
15	WASTE NDI FLUID	LIQUID	8.3
16	WASTE PAINT REMNANT	SOLID	15
17	WASTE PAINT/CLEANUP SOLVENT	LIQUID	7.5
18	WATER WALL PAINT BOOTH SLUDGE	SEMISOLID	8.8
19	PARTIALLY FILLED AEROSOL CANS	SOLID	3.7
20	WASTE FIXER/DEVELOPER	LIQUID	9.1
21	WASTE CLEANING SOLVENT	LIQUID	6.4
22	WASTE PETROLEUM-BASED SOLVENT	LIQUID	6.4
23	WASTE AQUEOUS-BASED CLEANER	LIQUID	8.5
24	USED RAGS	SOLID	2.3
25	USED FILTERS	SOLID	5
26	USED ABSORBENTS	SOLID	9.3
27	WASTE SOLID ROCKET FUEL	SOLID	6.7
28	STILL BOTTOMS	SEMISOLID	9
29	DEGREASER SLUDGE	SEMISOLID	11
30	LABORATORY TESTING CHEMICALS	LIQUID	9.2
31	WASTEWATER-PAINT SPRAY BOOTH	LIQUID	8.4
32	WASTEWATER-PRINTED CIRCUIT BOARD	LIQUID	8.3
33	WASTEWATER-AIRCRAFT/VEHICLE CLEANIN	LIQUID	8.4
34	WASTEWATER-ELECTROPLATING RINSE	LIQUID	8.4
35	WASTEWATER-ELECTROPLATING BATH	LIQUID	8.8
36	WASTEWATER-PHOTOGRAPHY SHOP	LIQUID	8.3
37	WASTEWATER-NDI SHOP	LIQUID	8.3
38	*WASTEWATER-OTHER RINSING OPERATIONS*	*LIQUID*	8.3
39	WASTE COOLING WATER	LIQUID	8.4
40	OTHER WASTEWATER	LIQUID	8.3
41	STACK-VOC EMISSION	GAS	
42	STACK-PARTICULATE EMISSION	GAS	
43	FUGITIVE-VOC EMISSION	GAS	
44	FUGITIVE-OTHER EMISSION	GAS	

Figure 7
General Hazardous Waste Table

LINKING DATABASE TABLES

Once the general material and waste tables have been constructed, they can be linked through a series of queries to the process specific material and waste tables. A table including the pounds of target compounds used by each process can be generated by linking the process hazardous material table to the general hazardous material table. The quantity of input material used is converted to pounds per year by a series of calculations using specific gravity, rate, etc. and this quantity is then multiplied by the percentage of each target compound. All percentages greater than zero are recorded on the target compound table (Figure 8).

The second set of queries generate the material accounting reports for each process (Figure 9). The purpose of the material accounting reports is to give the data collector a printout of the pounds of input and pounds of output that he/she recorded during data collection. The input side of the material accounting report is generated by again linking the process hazardous material tables with the general hazardous material table. The output side of the material accounting report is generated by linking the process waste table with the general waste table. The data collector reviews the input and output totals and determines if additional accounting for materials and wastes is necessary. This is often the case for processes using volatile organic compounds (VOCs). The inputs will far outweigh the outputs on the material accounting report because fugitive air emissions were not accounted for during data collection. The data collector uses engineering assumptions to calculate the pounds of material lost to fugitive air emissions and adds them to the waste side of the material accounting report in the "change" column. Another example of data that may not have been collected in the field are rags as inputs. Because used rags with paints and solvents are disposed as hazardous waste their amounts are collected in the field and recorded on the waste side of the material accounting report. The amount of virgin rags used must be added during materials accounting to the input side to help balance the inputs and outputs.

ID Number	Material Name	NSN	Manufacturer/ Cage	Toluene	Trichloroethane	Trichloroethylene	Xylene
JCPO01	THINNER DOPE LACQUER	8010001606787	SW216	20			
JCPO01	THINNER WINTER	CAPJCPO010057	PROTECTIVE COATINGS				100
JCPO02	BASE COAT PAINT	CAPJCPO020058	MARTIN-SEMOUR	5			30
JCPO02	THINNER	8010001606787	SW216	20			
JCSO01	SUNETHANE	CAPJCSO010060	NA				
LMFC01	FREON 12	6830001061656	18873				
LMFC01	FREON 22	6830001061659	73925				
LMLA01	FREON TF	6830006510654	73925				
LMPO01	PRETREATMENT PAINT	CAPLMPO030035	DEXTER				
LMPO01	TRICHLOROETHANE	CAPGDMS030037	J T. BAKER		100		
LMPO02	PRETREATMENT PAINT	CAPLMPO030036	DEXTER				
LMPO02	TRICHLOROETHANE	CAPGDMS030037	J T. BAKER		100		
LMPO03	PRETREATMENT PAINT	CAPLMPO030036	DEXTER				
LMPO03	TRICHLOROETHANE	CAPGDMS030037	J.T. BAKER		100		
MOFC03	TRICHLOROETHANE	6810005640067	18837		86		
MOFC06	TRICHLOROETHENE	6810001844794	47886			100	

Figure 8
Target Compounds Table

Material Name	NSN	Manufacturer	MSC	MQuantity lb/yr	Change lb/yr	Total Quantity lb/yr	Waste Name	WS	WSC	Disp	WQuantity lb/yr	Change lb/yr	Total Quantity lb/yr
FREON 22	6830001061659	73925	18		150	150	CFC-EMISSIONS	43	3A	A		400	400
FUEL AND OIL FILTERS	CAP000000997	NA	18		200	200	USED FILTERS	25	38	S		500	500
FREON 12	6830001061656	18873	18		250	250	OIL LEAKS	99	38	N		500	500
RAGS	CAP000000998	NA	18		420	420	USED RAGS	24	38	S		520	520
WATER	CAP000000998	NA			420	420	USED ANTIFREEZE	10	38	W	2000	-1100	900
ANTIFREEZE	6850001817940	19630	18	460		460	DIESEL FUEL CONTAM	9	18	H	1400		1400
OIL	9150001869858	29700		5200		5200	USED OIL	8	18	R	3600		3600
TOTAL				5700		7100	TOTAL				7000		7900

Figure 9
Example Materials Accounting Report

During materials accounting, the input target compounds environmental fate is also estimated. The percentage of each target compound used in a process is subdivided into five possible fate categories including hazardous waste, non-hazardous solid waste, air emissions, wastewater, consumed in process, and recycled. These percentages are recorded in a target compound fate table in the database. The fate table is linked with fields from the process specific and general hazardous material tables to calculate the pounds of each target compound in the fate categories. Figure 10 shows the table resulting from this linkage for an example organization.

Once material accounting has been performed, the database tables must be updated with any changes that were made to the inputs and outputs. These updated tables are then used to produce final data tables. These tables can be produced for an organization, a process type, or the entire base. Typical tables include:

- o types and yearly quantities of hazardous materials (Figure 11);
- o types and yearly quantities of wastes produced, including hazardous wastes, air emissions, wastewater, nonhazardous solid wastes, and recycled wastes (Figure 11);
- o types and yearly quantities of target compounds used; and
- o environmental fate of each target compound in pounds per year, including hazardous waste, air emissions, wastewater, consumed in the process, nonhazardous solid waste, and recycled wastes.

ID Number	Target Compound	Hazardous Waste	Waste-Water	Air Emission	Nonhazardous Waste	Recycled Waste	Consumed in Process	Total Quantity
LMAB01	NA							
LMAB02	NA							
LMFC01	DICHLORODIFLUOROMETHANE			250				250
LMFC01	CHLORODIFLUOROMETHANE			150				150
LMLA01	TRICHLOROTRIFLUOROETHANE	120		12				130
LMPO01	CHROMIUM	1					6	7
LMPO01	TRICHLOROETHANE	230		40				270
LMPO02	TRICHLOROETHANE	230		40				270
LMPO03	CHROMIUM	0					3	3
LMPO03	TRICHLOROETHANE	14		130				140
LMSO01	NA							

Figure 10
Target Compounds Fate Table

DESCRIPTION	LMAB01	LMAB02	LMFC01	LMLA01	LMPO01	LMPO02	LMPO03	LMSO01	TOTAL
HAZARDOUS MATERIAL									
PETROLEUM PRODUCTS/ANTIFREEZE			5,700						5,700
PAINTS/COATINGS/THINNERS/STRIPPERS					140	200	280		600
DEGREASERS/SOLVENTS/ALCOHOLS			400	130	270	270	140	500	1,700
TOTAL	0	0	6,100	130	410	470	420	500	8,000
HAZARDOUS WASTE									
DRAINED FUEL			1,400						1,400
WASTE PAINT REMNANT					1,500	1,500	1,500		4,500
WASTE PAINT/CLEANUP SOLVENT					230	230	190		650
WATER WALL PAINT BOOTH SLUDGE					5				5
WASTE CLEANING SOLVENT				120					120
USED RAGS					64	120	120		300
TOTAL	0	0	1,400	120	1,800	1,900	1,800	0	7,000
WASTEWATER									
WASTE ANTIFREEZE			900						900
WASTEWATER-PAINT SPRAY BOOTH					5,800				5,800
TOTAL	0	0	900	0	5,800	0	0	0	7,000
AIR EMISSION									
FUGITIVE-VOC EMISSION			400	10	120	150	140		820
FUGITIVE-OTHER EMISSION	65,000	65,000							65,000
TOTAL	65,000	65,000	400	10	120	150	140	0	130,000
NONHAZARDOUS WASTE									
USED RAGS			520						520
USED FILTERS			500						500
TOTAL	0	0	1,000	0	0	0	0	0	1,000
RECYCLED WASTE									
WASTE OIL/PNEUDRAULIC FLUID			3,600						3,600
TOTAL	0	0	3,600	0	0	0	0	0	3,600

Figure 11
Example Organization Hazardous Material Usage/Waste Generation Table

The final step in the data reduction process is prioritizing the process sites for further evaluation. A binary prioritization scheme is used to assign 0, 1, or 2 points in eight categories. The ranges for the points assignment are part of a query that automatically generates the process ranking. Figure 12 shows the prioritization categories, the quantities calculated for each of the categories for an organization, and the points automatically assigned based on set ranges.

Process ID Number	Hazardous Material Quantity (lb/yr)	Hazardous Waste Quantity (lb/yr)	Waste-Water Quantity (lb/yr)	Air Emission Quantity (lb/yr)	ODCs Quantity (lb/yr)	EPA 17 Quantity (lb/yr)	Persons	PPE Type	
LMAB01	0	0	0	65,000	0	0	4	D	
LMAB02	0	0	0	65,000	0	0	2	B	
LMFC01	6,100	1,400	900	400	400	0	10	D	
LMLA01	130	120	0	10	130	0	2	D	
LMPO01	410	1,800	5,800	120	270	280	2	D	
LMPO02	470	1,900	0	150	270	270	4	D	
LMPO03	420	1,800	0	140	140	140	2	B	
LMSO01	500	0	0	0	0	0	10	D	
Process ID Number	**Hazardous Material Points**	**Hazardous Waste Points**	**Waste-Water Points**	**Air Emission Points**	**ODCs Points**	**EPA 17 Points**	**Person Points**	**PPE Type Points**	**Total Points**
LMAB01	0	0	0	2	0	0	1	0	3
LMAB02	0	0	0	2	0	0	0	2	4
LMFC01	2	1	0	1	1	0	2	0	7
LMLA01	0	0	0	1	1	0	0	0	2
LMPO01	0	1	1	1	1	1	0	0	5
LMPO02	0	1	0	1	1	1	1	0	5
LMPO03	0	1	0	1	1	1	0	2	6
LMSO01	0	0	0	0	0	0	2	0	2

Figure 12
Example Organization Process Prioritization Table

CONCLUSIONS

The data collection and data reduction steps in a pollution prevention opportunity assessment are labor intensive. A methodology has been developed to collect process data on electronic clipboards, upload the collected data directly into tables of a relational database and then construct general material and waste tables in the database. The general tables are built by recording hazardous material information from HMIS and manufacturer supplied MSDSs and historically-based waste densities. These tables are then linked to provide material accounting reports for each process site and summary tables that allow streamlined evaluation of process data. Using a relational database also provides the opportunity to add data tables such as material unit costs and waste disposal costs to calculate a rough estimate cost for operating the process. These cost estimates can prove useful for calculating payback periods of pollution prevention opportunities for a process site or group of common process sites. Costs are just one example of data that can be added to the database to expand it usefulness in providing process specific data.

SHELF LIFE SPECIFICATIONS FOR HAZARDOUS MATERIALS

Paul Farmanian
Engineering-Science, Inc.
199 South Los Robles Avenue
Pasadena, California 91101
818.585.6148

Hazardous chemical systems ranging in form from simple materials to compounded products and complex natural mixtures constitute an important asset in the Navy's daily operations. These materials include but are not limited to paints, solvents, soaps, resins, adhesives, pesticides, printing materials, petroleum products, and photographic chemicals.

The short lived availability of hazardous materials that are suspected of or known to degrade over time imposes a unique burden on the Navy's procurement and hazardous waste disposal systems. Hazardous Materials whose shelf life's have expired are processed for disposal as hazardous wastes. In addition, these expired hazardous materials must be replaced with new materials.

Many shelf life codes are based solely on the recommendations of suppliers, and are not critically subjected to scientific study. **The important goal of this project is to conduct a comprehensive study of the degradation of a given hazardous material to determine the true shelf life.**

Engineering-Science, a full service environmental consulting firm, is under contract with the Naval Facilities Engineering Services Center and the Naval Supply Systems Command to determine the true shelf life term of many common materials currently procured and stored by the US Navy.

In order to properly study the degradation of a hazardous material, two important factors must be considered: (1) the chemical degradation of the material, independent of its packaging, and (2) the material's packaging and how it may contribute to the material's degradation.

The Engineering-Science project team is comprised of senior chemists and chemical engineers. For each material, numerous data sources are employed, including manufacturer data, commercial and open literature data, Department of Defense material test data, and military specification data.

It is the responsibility of each project team member to make recommendations regarding the proper shelf life term for selected materials under study. The recommendations undergo a peer review in which the project team scrutinizes the recommendation to ensure that it is scientifically valid. Final recommendations will be made only if all project team members concur with the recommendation.

160 hazardous materials commonly procured by the Navy are currently under study. The goal of this project is to determine the true shelf life of each material. In some cases, a recommendation may be made to shorten a material's shelf life term. However, it is anticipated that for many hazardous materials recommendations will be made to lengthen the shelf life terms. If these recommendations are implemented throughout the Navy system, the savings in disposal costs and new materials purchases will be significant.

Currently, Engineering-Science has made final recommendations for 64 materials. Of these 64 materials, the following is a summary of the recommendations:

- Shelf Life Extensions = 40 materials
- Shelf Life Unchanged = 22 materials
- Shelf Life Reduced = 2 materials

A summary table of these recommendations is presented below. This summary table provides the identity of the material, it's current shelf life term, the recommended shelf life term, and the applicable military specification.

When these recommendations are implemented, the reduction in waste generated and disposal costs, as well as the reduction in cost for the purchase of new materials will be very significant. This reduction in pollution generated and associated costs is the ultimate objective of this important project.

Summary Table of Recommendations

NSN	Material Name	Shelf Life				Specification	Spec. Prep. Activity	Item Manager[1]	Current Status	Page #
		Current		Recommended						
		Code	Month	Code	Month					
6810-000430780	Disodium Phosphate (X2)	Q	36	Q	36	8723-0111	SPCC	Cynthia Cross	Final[2]	1
6810-001450477	Hydrochloric acid (X2)	M	24	Q	36	8723-0004	Unknown	Cynthia Cross	Final[2]	4
6810-001450478	Silver Nitrate (X2)	M	24	Q	36	8723-0005	SPCC	Cynthia Cross	Final[2]	7
6810-001487150	Chloride Indicator (X2)	Q	36	Q	36	MIL-W-15000K	Navy-SH	Cynthia Cross	Final[2]	10
6810-001492020	Hydrazine (X2)	M	24	Q	36	MIL-H-22251	Navy-SH	Cynthia Cross	Final[2]	12
6810-001818321	Ion Exchange Resins (X2)	S	60	R	48	MIL-R-24119	SPCC	Cynthia Cross	Final[2]	16
6810-002388119	Aliphatic Naphtha	7	36	9	60	TT-N-95B	Navy-SA	Cynthia Cross	Final	22
6810-002550471	Calcium Hypochlorite	7	36	4	12	O-C-114B	GSA-FSS	Cynthia Cross	Final	26
6810-002812002	Toluene Technical	7	36	8	48	TT-T-548F	Army-EA	Cynthia Cross	Final	30
6810-008507787	Potassium Hydroxide Solution	6	24	7	36	MIL-P-11751D	Army-EA	Cynthia Cross	Final	35
6810-009124766	Ion Exchange Compound	6	24	7	36	O-I-1279B	Navy-SH	Cynthia Cross	Final	39
6810-009857093	Sodium Hydroxide Solution (X2)	Q	36	Q	36	8723-0021	SPCC	Cynthia Cross	Final[2]	44
6810-010186726	Ammonium Hydroxide (X2)	M	24	P	30	MIL-STD-1218M	Unknown	Cynthia Cross	Final[2]	47
6810-010189769	Ammonium Hydroxide (X2)	M	24	P	30	MIL-STD-1218M	Unknown	Cynthis Cross	Final[2]	47
6810-010444188	Hydrogen Peroxide (X2)	H	12	H	12	8723-401	SPCC	Cynthia Cross	Final[2]	50
6810-010444218	Mercuric Nitrate Solutions (X2)	M	24	M	24	MIL-W-15000K	Navy-SH	Cynthia Cross	Final[2]	53
6840-005987326	Disinfectant/Detergent	5	18	7	36	A-A-1439	GSA-FSS	Cynthia Cross	Final	56
6840-009856895	Disinfectant	0	-	8	48	A-A-1442	GSA-FSS	Cynthia Cross	Final	60
6850-001817933	Ethylene Glycol	7	36	8	48	MIL-A-46153C	Army-ME	Cynthia Cross	Final	64

1. John Louth: (804) 279-3024; Cynthia Cross: (804) 279-3540.
2. "X2" materials study was terminated in February '94 as per Ross Thompson's request.
3. Final recommendation is for spec version D. Spec is currently being amended. Recommend 8=48 month shelf life for amended specification.
4. Blank fields denote data unknown at the time of publication

Summary Table of Recommendations

(Continued)

NSN	Material Name	Shelf Life				Specification	Spec. Prep. Activity	Item Manager[1]	Current Status	Page #
		Current		Recommended						
		Code	Month	Code	Month					
6850-002097230	Aircraft Engine Corrosion Preventative	7	36	7	36	MIL-C-6529C	Air Force	Cynthia Cross	Final	68
6850-002444892	Skin Protective Compound	5	18	5	18	A-A-50169	Army-GL	Cynthia Cross	Final	72
6850-002709986	Sea Marker, Fluorescein	6	24	6	24	MIL-S-17980D	Navy-AS	Cynthia Cross	Final	75
6850-004195004	Cleaning Compound (Flux Remover)	5	18	6	24	P/N MS-190	None	Cynthia Cross	Final	78
6850-011210952	Liquid Penetrant Inspection Material	H	12	H	12	MIL-I-25135E	Air Force-11	Cynthia Cross	Final	83
7930-008684736	Metal Polish	6	24	8	48	P-C-1121	GSA-FSS	Unknown	Final	86
8010-005587026	Thinner, Paint Products	7	36	8	48	TT-T-219F	GSA-FSS	Unknown	Final	88
9150-001450268	Grease, Aircraft, General Purpose	6	24	9	60	MIL-G-81322E	Navy-AS	John Louth	Final	91
9150-009448953	Grease, Aircraft, General Purpose	6	24	9	60	MIL-G-81322E	Navy-AS	John Louth	Final	91
9150-001491593	Grease, Ball and Roller Bearing	7	36	8	48	DOD-G-24508A	Navy-SH	John Louth	Final	97
9150-011172928	Grease, Ball and Roller Bearing	7	36	8	48	DOD-G-24508A	Navy-SH	John Louth	Final	97
9150-001806381	Aeroshell Grease 6	6	24	7	36	MIL-24139A	Navy-SH	John Louth	Final	101
9150-001806382	Aeroshell Grease 6	6	24	7	36	MIL-24139A	Navy-SH	John Louth	Final	101
9150-001806383	Aeroshell Grease 6	6	24	7	36	MIL-24139A	Navy-SH	John Louth	Final	101
9150-001866681	Lubricating Oil, Internal	6	24	8	48	MIL-L-2104F	Army-ME	John Louth	Final	106
9150-001900905	Lubricating Grease	6	24	7	36	MIL-G-10924F	Army-ME	John Louth	Final	110
9150-002234129	Lubricating Oil, Instrument	6	24	8	48	MIL-L-6085C	Air Force-11	John Louth	Final	114

1. John Louth: (804) 279-3024; Cynthia Cross: (804) 279-3540.
2. "X2" materials study was terminated in February '94 as per Ross Thompson's request.
3. Final recommendation is for spec version D. Spec is currently being amended. Recommend 8=48 month shelf life for amended specification.
4. Blank fields denote data unknown at the time of publication.

Summary Table of Recommendations

(Continued)

NSN	Material Name	Shelf Life				Specification	Spec. Prep. Activity	Item Manager[1]	Current Status	Page #
		Current		Recommended						
		Code	Month	Code	Month					
9150-002319071	Silicone Brake Fluid	7	36	9	60	MIL-B-46176	Army-ME	John Louth	Final	118
9150-002355555	Grease, General Purpose	6	24	6	24	MIL-G-23549C	Navy-AS	John Louth	Final	122
9150-008238047	Grease, General Purpose	6	24	6	24	MIL-G-23549C	Navy-AS	John Louth	Final	122
9150-009857316	Grease, General Purpose	6	24	6	24	MIL-G-23549C	Navy-AS	John Louth	Final	122
9150-002359061	Lubricating Oil, Steam Turbine	6	24	8	48	MIL-L-17331H	Navy-SH	John Louth	Final	129
9150-002359062	Lubricating Oil, Steam Turbine	6	24	8	48	MIL-L-17331H	Navy-SH	John Louth	Final	129
9150-002402235	Lubricating Oil, Combustion Engine Gear	7	36	8	48	MIL-L-6086D	Air Force-11	John Louth	Final	134
9150-002500926	Petrolatum, Technical	6	24	8	48	VV-P-236A	Navy-AS	John Louth	Final	138
9150-002618317	Hydraulic Fluid	6	24	7	36	MIL-F-17111	Navy-OS	John Louth	Final	142
9150-002698255	Grease, Aircraft	6	24	8	48	MIL-G-4343C	Navy-AS	John Louth	Final	147
9150-002732388	Jet Engine Lubricating Oil	7	36	9	60	MIL-L-6081C	Air Force-11	John Louth	Final	151
9150-002929657	Lubricating Oil, Refrigerant	7	36	8	48	VV-L-825	Navy-SH	John Louth	Final	155
9150-004580075	General Lubricating Oil	6	24	6	24	VV-L-800C	Army-ME	John Louth	Final	159
9150-005306814	Grease, Wire Rope and Exposed Gear	6	24	9	60	MIL-G-18458B	Navy-SH	John Louth	Final	163
9150-005842560	Hydraulic Fluid	7	36	7	36	MIL-H-17672D	Navy-SH	John Louth	Final	167
9150-007534799	Hydraulic Fluid	7	36	7	36	MIL-H-17672D	Navy-SH	John Louth	Final	167
9150-009857231	Hydraulic Fluid	7	36	7	36	MIL-H-17672D	Navy-SH	John Louth	Final	167

1. John Louth: (804) 279-3024; Cynthia Cross: (804) 279-3540.
2. "X2" materials study was terminated in February '94 as per Ross Thompson's request.
3. Final recommendation is for spec version D. Spec is currently being amended. Recommend 8=48 month shelf life for amended specification.
4. Blank fields denote data unknown at the time of publication.

Summary Table of Recommendations

(Continued)

NSN	Material Name	Shelf Life				Specification	Spec. Prep. Activity	Item Manager[1]	Current Status	Page #
		Current		Recommended						
		Code	Month	Code	Month					
9150-009857232	Hydraulic Fluid	7	36	7	36	MIL-H-17672D	Navy-SH	John Louth	Final	167
9150-009857234	Hydraulic Fluid	7	36	7	36	MIL-H-17672D	Navy-SH	John Louth	Final	167
9150-009857237	Hydraulic Fluid	7	36	7	36	MIL-H-17672D	Navy-SH	John Louth	Final	167
9150-009652303	Lubricating Oil, Aircraft Engine	7	36	9	60	MIL-L-22851D	Navy-AS	John Louth	Final	172
9150-009857246	Grease, Aircraft and Instrument	6	24	7	36	MIL-G-23827B	Navy-AS	John Louth	Final	176
9150-010355392	Lubricating Gear Oil	6	24	6	24	MIL-L-2105	Army-ME	John Louth	Final	187
9150-010536688	Cleaning Compound	7	36	7	36	MIL-L-63460D	Army-AR	John Louth	Final[3]	193
9150-010546453	Cleaning Compound	7	36	7	36	MIL-L-63460D	Army-AR	John Louth	Final[3]	193
9150-011045227	Lubricant, All-Weather	6	24	8	48	DOD-L-85336A	Navy-AS	John Louth	Final	199
9150-011313324	Hydraulic Fluid Synthetic HC Base	6	24	8	48	MIL-H-46170B	Army-ME	John Louth	Final	203
9150-012101938	Lubricating Oil, Helicopter	7	36	8	48	DOD-L-85734	Navy-AS	John Louth	Final	207

1. John Louth: (804) 279-3024; Cynthia Cross: (804) 279-3540.
2. "X2" materials study was terminated in February '94 as per Ross Thompson's request.
3. Final recommendation is for spec version D. Spec is currently being amended. Recommend 8=48 month shelf life for amended specification.
4. Blank fields denote data unknown at the time of publication.

SESSION V

AUTOMATED SYSTEMS

Session Chairpersons:
Karen Kivela, HQ AFCEE/EP
Dan Moyes, Labat Anderson

The Environmental Cyber-Surfer:
Riding the Wave on
Environmental Electronic Bulletin Boards

Dirk J. Bouma, P.E.
Dynamac Corporation
2275 Research Boulevard
Rockville, MD 20850-3268
(301) 417-9800

And you can fly
High as a kite, if you want to.
Faster than light, if you want to.
Speeding through the universe
Thinking is the best way to travel.

It's all a dream
Light passing by on the screen,
And there's you and I on a beam
Speeding through the universe
Thinking is the best way to travel.

We ride the waves
Distance is gone. Will we find out,
How life began, will we find out;
Speeding through the universe
Thinking is the best way to travel.

-Mike Pinder
from "In Search of the Lost Chord", The Moody Blues

Background

Cyber-surfing is a recent concept that has become popular with those who use telecommunication in their daily lives. The idea behind cyber-surfing is quite simple using computers, modems, and existing telephone lines, we can share our conceptual experiences and knowledge through these electronically based extensions of ourselves and our worlds. We can conceptually place ourselves at different points on the globe, alongside other "surfers", and ride the same waves of information that are accessible through our computers.

Because of the relative newness of the medium, metaphors have been used to describe it in terms that are recognizable to those new to the medium. Cyber-surfing is useful as a metaphor, because it denotes a few characteristics that both telecommunications by modem and normal surfing have in common:

- Both require a little equipment, which is relatively inexpensive.
- Both require an initial investment of time to learn.
- Both can provide satisfaction, remove barriers between people, and offer a better understanding of the worlds in which we live and work.

Electronic bulletin board systems (BBSs) are computerized systems that allow the exchange of information, files, data, programs, and the like between all kinds of people. They form a part of the telecommunications seascape that helps us overcome the tyranny of distance. Concepts of a true global village are sustained in the BBSs, where barriers of sexism, ageism, and racism are absent, since you can't see the person to whom you're "speaking".

This article addresses the BBSs that are publicly accessible and that have environmental forums, files, and other information, especially those with pollution prevention information. It targets those BBSs that offer "free" information, that is, information provided for the cost of the telephone call connecting the computer, via modem, to the BBSs.

For the purpose of this article, two types of sources for environmental BBSs have been explored. These include those that are funded, developed, and/or operated under the auspices of Federal or state governmental organizations and BBSs that are privately funded, developed, and/or operated. No cases of joint Federal-private ownership of the BBSs were noted in those that were visited, but Federal-state collaboration was found (e.g., the Colorado Center for Environmental Management).

Governmental BBSs--Overview

Probably the largest national repository of pollution prevention and environmental information resides, not surprisingly, with the U.S. Environmental Protection Agency (EPA). Under various offices, departments, and various contracts, the EPA has developed many BBSs dealing with topics including cleanup of hazardous waste sites, alternative treatment technologies, non-point sources of pollution, risk reduction and treatability, Superfund, wastewater treatment, and drinking water information, among others. Access to the EPA BBSs can be made either through modem-direct-dialing a BBS's commercial telephone connection, through direct-dialing a gateway such as FEDWORLD, or through Internet[1] access. A modified listing of Governmental BBSs that are provided through FEDWORLD is shown in Table 1. It should be noted than not all Governmental BBSs can be reached through a server with gateways such as FEDWORLD[2]. For instance, the EPA Non-point Source Program Electronic Bulletin Board, one of the more useful BBSs for information on pollution prevention, was found in a separate listing and accessed only through direct dial-up.

Governmental BBSs--Resources Not Currently Available

This section describes access to pollution prevention information through a system that is currently disconnected; it is included because EPA anticipates it will return to service. Pollution prevention information used to be most conveniently accessed through a BBS known as the Pollution Information Exchange System (PIES) developed by the Pollution Prevention Information Clearinghouse (PPIC), of EPA's Office of Program Management and Technology. The clearinghouse provided access to pollution prevention information, technical experts, a calendar of events, case studies, program summaries, and documents.

[1] The Internet has been described as an interlinking of thousands of different sizes and types of networks from all over the globe; it is a coordinated multitude of networks. Based on the U.S. Department of Defense's ARPANET (1969), Internet was formed by linkage with other major networks having little to do with ARPANET, providing a cross section of public and private networks. Currently, an estimated 10,000 networks make up the Internet. For further information, the reader is referred to Hytelnet, a program that describes hundreds of remote systems and their contents, the Yanoff and December Lists of major interest areas, or any of the many texts published on the subject.

[2] Gateways provide access to other BBSs in a manner similar to dialing up the other BBSs individually.

Table 1. Governmental BBSs--Abbreviated Listing

The following bulletin board systems are available on the FEDWORLD BBS. FEDWORLD is a free BBS operated by the National Technical Information Service (NTIS). You can access FEDWORLD by calling 703-321-8020. This is an abbreviated list of the 123 BBSs currently available through FEDWORLD. Listings in **bold** indicate those of particular relevance to researchers in pollution prevention, based on research conducted.

###:Name	:Comment
7:CLU-IN (EPA)	**:Superfund Data and Information**
16:EPUB (DOE)	:Energy information and data
22:FEDERAL BBS (GPO)	:GPO and Govt Data (Fee Based)
37:WTIE-BBS (EPA)	:Wastewater Treatment Info Exchange
39:SALEMDUG-BBS (FEMA)	:State and local FEMA user groups
45:TELENEWS (DOE)	:Data and info on Fossil fuels
48:USGS-BBS (USGS)	:Geological Survey BBS/CD-ROM Info
56:PPIC-BBS (EPA)	**:Pollu. Preven, Clean Product, Ozone**[1]
57:Gulfline (EPA&NOAA)	**:Gulf Coast Pollution Information**
59:NTIS QuikSERVICE (NTIS)	:Order NTIS Documents Online
61:STIS (NSF)	:Science & Technology Information System
63:TECH SPECS (NRC)	:Technical Specifications Improvement Pr
66:NOAA-ESDD (NOAA)	:NOAA Environmental Services Data Direct
67:Offshore-BBs (DOI)	:Off Shore Oil & Gas Data
74:ATTIC (EPA)	**:Alternative Treatment Tech Info Center**
76:DRIPSS (EPA)	:Drinking Water Info Processing Support
77:PIM BBS (EPA)	:Pesticide Information Network
78:SWICH BBS (EPA&SWANA)	**:Solid Waste Management**
79:NPS-BBS (EPA)	**:Nonpoint Source Program BBS**
80:OEPC BBS (DOI)	:Interior's Off of Environment. Affairs
94:ORDBBS (EPA)	**:EPA Office of Research & Development BB**
98:AEE BBS (FAA)	:FAA Office of Environment & Energy
134:CSO BBS (EPA)	:Cleanup Standards Outreach BBS

[1] PPIC was not accessible at the time the article was written (see text).

The PIES BBS provided expansive access to the PPIC through System Operator, Mr. Myles Morse. It provided toll free access to state agencies and access to others through a toll line with six nodes. Information was divided into mini-exchanges such as the EPA Office of Pollution Prevention and Toxics' 33/50 Mini-Exchange (containing information about the objectives and progress of the 33/50 Program and information about how industry participates in this initiative). Other mini-exchanges were developed to support the communication needs of various regions, exchange of enforcement information, grant information, and other pollution prevention information. The BBS contained listings of publications available from other pollution prevention clearinghouses (i.e., Northeast Multi-Media Pollution Prevention (NEMPP) Clearinghouse), listings of experts available to assist in providing technical information on pollution prevention techniques and concepts, a case study data base, a message center, an international contact list, pollution prevention law (i.e. The Pollution Prevention Act of 1990), and Federal Register notices.

Typical publications that were available through the PPIC included those issued by EPA's Office of Pollution Prevention, such as: "Pollution Prevention 1991: Progress on Reducing Industrial Pollutants," "Pollution Prevention Program Report," "Pollution Prevention Resources and Training Opportunities in 1992," "Pollution Prevention Guidance Manual for the Dye Manufacturing Industry," "Pollution Prevention Options in Wood Furniture Manufacturing," "Pollution Prevention Options in Metal Fabricated Products Industries", and similar reports. It also contained bibliographic reports developed by EPA to assist manufacturers in these respective industries in developing cost-effective pollution prevention practices to reduce or eliminate their releases of the 17 chemicals targeted for reduction in EPA's 33/50 program.

The PIES 800 numbers and direct dial numbers have been disconnected. Access through FedWorld is no longer available. The CLU-IN BBS reports, "We are getting many calls about the Pollution Prevention Information Center and its electronic bulletin board. The PPIC/PIES system has been experiencing technical difficulties. EPA's Research Office is sorry for any inconvenience. We understand that ORD expects that PPIC/PIES will be up again by the end of May. If you need to talk to someone, call Mr. Myles Morse at EPA's Office of Environmental Engineering and Technology Demonstration, 202-260-3161." Calls were placed to the system operator, but currently no additional information has been provided.

Sometimes systems are taken down for technical reasons and later brought back up, as the CLU-IN message indicates. If this BBS does come back up, it should be of interest to those involved with pollution prevention.

Governmental BBSs--Resources Currently Available

A multitude of information is available in the government-run BBSs. FEDWORLD's main menu contains a help/information center, public mail/forums, FEDWORLD marketplace, private mail, a gateway system, utilities, library of files, who's on, subsystems/databases, NTIS quick bulletins, a FEDWORLD Newsroom, and Federal job openings. The index alone for the library of files takes up slightly less than 3 Mb, and the public E-mail, contains conferences on subject topics with files covering questions and answers about FEDWORLD, electronic education (resources/comments/information), government conferences, comments and concerns about the FEDWORLD gateWay system, NTIS connection, network and computer technologies, government E-mail and directory services, government newsletters, discuss and locate government information or interests, and other conferences. Everyone involved with government contracting for pollution prevention or other environmental work should be aware of this resource.

Typical examples of information from these BBSs is described in the following paragraphs.

From ATTIC, Engineering Bulletins: *"The Engineering Bulletins are a series of documents that summarize the latest information available on selected treatment and site remediation technologies and related issues. They provide summaries and references for the latest information to help remedial project managers, on-scene coordinators, contractors, and other site cleanup managers understand the type of data and site characteristics needed to evaluate a technology for potential applicability to their Superfund or other hazardous waste sites. Those documents that describe individual site remediation technologies focus on remedial investigation scoping needs. Addenda will be issued periodically to update the original bulletins...*

"Selection of Control Technologies for Remediation of Lead Battery Recycling". *The objective of this bulletin is to provide remedial project managers (RPMs), potentially responsible parties (PRPs), and their supporting contractors with information to facilitate the selection of treatment alternatives and cleanup services at lead battery recycling sites (LBRS). This bulletin condenses and updates the information presented in the EPA technical resource document (TRD) entitled, "Selection of Control Technologies for Remediation of Lead Battery Recycling Sites," EPA/540/2-91/014, July 1991...."*

Also from ATTIC: *"EPA's Office of Air Quality Planning and Standards announces a new database on air pollution prevention. See Main Board Bulletin 123 for more information."*

From the Colorado Center for Environmental Management Information System (CCEMIS) Bulletin Board: *"The Colorado Center for Environmental Management awarded the First Annual Awards for*

Excellence in Environmental Management April 16 at its 1993 Annual Conference, "The State of the West's Environment." Five companies were recognized for their outstanding work in research and development for pollution prevention or waste minimization in 1992..." (companies' contributions are explained).

Also from CCEMIS, a news article on the Colorado Pollution Prevention Act by Amelia Dawson: *"The goal of the 1992 Colorado Pollution Prevention Act is to promote prevention as the first choice in helping solve the state's pollution problems. Instead of recycling and control programs, Colorado will attempt to prevent pollution through education, according to Kate Kramer, Program Manager of the Colorado Department of Health (CDH) Pollution Prevention Unit... The bill establishes a grants program to give money to providers of technical assistance programs, which will disseminate information to small businesses and generators and users of hazardous waste and toxic substances. Recipients of the grants will include academic institutions, trade associations, and environmental or engineering firms with a knowledge of pollution prevention techniques and processes..."*

A 01/92 Bulletin in NPS BBS contains an abstract: *"Using Market Incentives to Promote Nonpoint Source Pollution Prevention and Control" - from Managing Nonpoint Source Pollution: Final Report To Congress on section 319 of the Clean Water Act (1989). U.S. EPA. January 1992. EPA-506/9-90. "Federal, state and local agencies currently have a mix of regulatory and nonregulatory tools they can use to prevent and control nonpoint source pollution. Included among these tools is the use of market forces to achieve desired pollution reduction. There are a range of economic approaches to address nonpoint source pollution...."*

Various other pollution prevention information is available across these networks, providing opportunities and resources for managers, scientists, engineers, and other professionals or casual cyber-surfers.

Private BBSs

There are many private BBSs with local, regional, national and international concerns. The private BBSs often have goals that are environmentally based and/or have specific doors, conferences, etc. that deal with the environment, including pollution prevention issues. Often, for local information about a particular problem, there is no better source than one of these private BBSs. The trick, of course, is finding it.

For instance, ABALONE, a San-Francisco based BBS, is known to have a library containing extensive documents on energy issues. Similarly, PUFFIN, based on the Chesapeake Bay, was found to have unique discussions on pollution prevention. Articles from the Anne Arundel Environmental News provide an example of the information that can be carried on local BBSs. "EPA Letter to Hazardous Waste Generators Offers Opportunity For County Government, Community Organizations And Citizen Based Groups To Act To Reduce Pollution at Its Source!" In a letter dated November 22, 1993, Carol Browner, Administrator of the Federal Environmental Protection Agency, reminded some 20,000 businesses of the requirement that they have a program to reduce the quantity and toxicity of waste generated. This requirement, defined in the Resource Conservation and Recovery Act (RCRA) Sections 3002(b) and 3005(h), and detailed in EPA Regulations 40 CFR 262.23 and 264.73.b9, applies to all businesses that are either large quantity generators of hazardous waste, or who operate a RCRA permitted treatment, storage, or disposal facility for hazardous wastes, where waste is generated on site. In Glen Burnie 2 such enterprises exist, with 6 in Pasadena, and 124 in Baltimore City. Bordering on the old industrial area of Baltimore to the north and next to the industrial sites of Curtis Bay, Hawkins Point and Sparrow Point, the northern part of Anne Arundel County has the sixth highest cancer rate in the nation. While a strict correlation between the toxic waste produced by these industries and the high incidence of cancer has not been scientifically established, the county and the residents of these areas should have an interest in any means available that will result in the reduction of toxins that could affect their air and water.

A summary listing of private "Green BBSs" was found at the Earth Art BBS (GreenNet). A portion of this listing is shown in Table 2. GreenNet is run by Bob Chapman and can be accessed at 803-552-4389. Generally, these BBSs take a less governmental approach to environmental management. The partial listing shown in Table 2 has an explanatory note indicating it is a "short, easy to follow, and powerful in its mission to help preserve our environment for future generations." After saluting system operators who "have gone out of their way to provide you the chance to truly make a big difference," it concludes with the statement "all of us can help and, if we all work together, nothing's impossible!"

Table 2. Private BBSs–Abbreviated Listing

GreenNet (tm) GREEN BBS List For Environmental Bulletin Board Systems!

NAME OF BULLETIN BOARD	PHONE NUMBER	BAUD	HR	NAME OF SYSOP	BBS
Abalone Alliance (Calif)	415-861-2510	14400	24	Roger Herried	MAX
Alternatives BBS(Canada)	604-430-8080	9600	24	Bob Lyons	MAJ
CCS BBS (For Eco-Topics)	410-476-5098	9600	24	Jo Campbell (Mod.)	PCB
Canadian EarthCare Socy.	604-765-5097	14400	24	Jim Dixon(ENVIRON)	MAX
Classroom Earth BBS (MI)	517-797-2737	14400	24	Dennis Hauser	TBB
Continental Divide BBS..	601-957-3016	14400	24	Mike Seal	AUN
Coyote Gulch (Colorado).	719-578-1340	14400	24	Scott Robert Ladd	MAX
EEC (EnviroEquipment/CA)	714-644-4181	14400	24	Bjorn Sundbakken	PCB
EPA Online Library (OLS)	919-541-4642	9600	24	Joe Steigerwald	(7E1)
Earth Art BBS (GreenNet)	**803-552-4389**	**21600**	**24**	**Bob Chapman (GND)**	**PCB**
Eco-Link (Massachusetts)	207-353-7670	9600	24	Rob Waite	REN
Electric Ideas (Wash.ST)	206-586-6854	14400	24	Greg Ware	MAJ
Environaut BBS (Florida)	407-872-8590	14400	24	David Duckworth	ROB
Environment Arkansas!...	501-570-2868	9600	24	Tom Ezell	WIL
Environmental Action BBS	207-439-0633	16800	24	John Burns	RA
Enviro BBS (Eco-Science)	703-524-1837	14400	24	Kurt Riegel	RBB
Fish House BBS (EcoGulf)	601-460-5970	16800	24	Rick Cooke	MAX
Garden Pond BBS (Oregon)	503-735-3074	16800	24	Jack Honeycutt	MAX
Georgia Sierra Club(Hub)	404-634-0304	14400	24	Mike Witten	PCB
HOME BBS (Organic/Agric)	317-539-6579	9600	24	Cissy Bowman	QBB
Hazardous Material(HMIX)	708-972-3275	9600	24	Cathy Gerard	PCB
Home Power Communication	707-822-8640	14400	24	Michael Welch	TBB
HOTLine BBS/Fido SIERRAN	318-255-4710	14400	24	Eddie Rowe	RBB
MN-Lakes BBS (Minnesota)	612-296-8811	9600	24	Bruce Wilson(MPCA)	PCB
Makaao BBS (Eco-Hawaii).	808-672-8276	14400	24	Dennis Leong	PCB
One World (Fido/Usenet).	310-372-0987	14400	24	Larry Fletcher	MAX
Penguin Point(Fido Ecol)	414-338-4897	16800	24	Lon Levy	RA
Puffin's Nest(MD/BayCon)	410-437-3463	16800	24	Dave Bealer	MAX
Save The Earth BBS (CA).	805-833-1437	14400	24	Michael Holland	WIL
Solutions-Net (Florida).	407-321-6119	14400	24	Dan Slage	MAJ
Sprawl (GTNet Envi-Echo)	606-278-9709	14400	24	Scott Estes(Bridge)	GT
The Green Machine/Canada	705-721-9508	9600	24	John Winslow	RA
Timberline Online/Canada	416-537-1242	14400	24	Christine Morte	ROB
Tranquility Base (Texas)	210-699-1710	14400	24	Shannon Blackburn	EZY
Colo. Center Enviro-Mgt.	800-677-4184	9600	24	Sheila Conway	TBB
EPA Cincinati PAD (Ohio)	800-258-9605	2400	24	Unknown(Multiple)	X-25
Florida Recycling Market	800-348-1239	2400	24	Paul Still	RBB
WTIE (Waste Water Info!)	800-544-1936	2400	24	Harry Kidder	PCB

COTS-Based Management Tools for Pollution Prevention

by

Alan Rockswold, McClellan Air Force Base
Kenneth Smarkel, Ph.D., The MITRE Corporation
Craig Koralek, The MITRE Corporation
5050 Dudley Boulevard, Suite 3
McClellan Air Force Base, CA 95652-1389
(916) 643-3341, extension 351

The McClellan Air Force Base (AFB) Pollution Prevention Program is ambitious, as evidenced by the number of projects that have been proposed and implemented thus far. Projects vary in size and scope, ranging from inexpensive paper studies to the design and construction of new processes and equipment. The direction of the program and mix of projects must be reevaluated frequently in response to funding constraints and other changing priorities. The Environmental Management Directorate's Pollution Prevention Branch (EMP) must be able to analyze data and prepare reports quickly to ensure that the goals and objectives of the Pollution Prevention Program are met.

To aid in the management of the program, EMP relies on the following set of tools to run the program:

- Economic and Evaluation Comparison Model (EECM)
- Pollution Prevention Project Prioritization Model (P4M)
- Pollution Prevention Users Tracking Tool System (PPUTTS)
- Pollution Prevention Road Maps

These tools are used to obtain and evaluate information on proposed projects, prioritize projects to make the best use of limited funds, and track incremental progress toward meeting both the base's and the Air Force's pollution prevention goals. The tools are linked to each other and are integral to McClellan AFB's Pollution Prevention Program.

Projects are usually proposed by the directorates. A worksheet is submitted to EMP describing the project and its costs and benefits. The costs are derived from the EECM. The projects are then evaluated by EMP using the P4M and taking into consideration the estimated cost and payback of the project, environmental benefits, contribution to meeting pollution prevention goals, and other predetermined criteria. The preliminary data are then stored in the PPUTTS and merged with other fiscal and technical information to evaluate program status via road maps and other data analyses.

EMP submits requests for funding of the top-ranked priority projects to the Air Force Materiel Command. Once funds are made available, EMP administers the funds, ensuring that projects are implemented successfully by the directorates within budget and on schedule.

These tools are designed primarily to compare all of the projects that have been proposed to EMP so that EMP selects the best set of projects to achieve the program's objectives. However, many of the tools—most notably the EECM and P4M—are also effective during the opportunity assessment (OA) process.

All of the tools are based in commercial-off-the-shelf (COTS) software. This paper describes the use and operating characteristics of each tool.

Economic Evaluation and Comparison Model

To aid the directorates in estimating the cost and economic value of their proposed projects, McClellan AFB utilizes the EECM. This tool is used by the directorates as a structured approach for estimating the cost of proposed projects. The EECM helps maintain a "level playing field" by ensuring that a consistent analytical approach is used by the pollution prevention coordinators in the various directorates.

The model can also be used during the OA process to aid in evaluating the economics of the various pollution prevention options being considered. The preferred project from both a technical and economic standpoint is added to the list of proposed projects that EMP evaluates in making its implementation decisions.

The EECM is an adaptation of an economic model, "Engineering Analysis Spreadsheet (EAS)," developed by Captain Rich Anaya, Headquarters, AFMC/CEVV. EAS has been converted into a Microsoft® Excel spreadsheet with modified menus and command functions to facilitate the user interface and protect the tool from unintended corruption.

The EECM has two major components—a solution component and a reporting component. The solution component calculates the present value, the internal rate of return, and a simple payback period for the project based on proposed investment costs and estimates of the net annual savings that will be realized in operation costs. The reporting component comprises two parts—a summary of current and proposed investment costs and the results of the economic comparison and data forms that capture construction and start-up costs, annual operation and maintenance (O&M) costs for the current operation, and annual O&M costs for the proposed project.

The model first calculates the total (initial) cost of changing the process (or procedure or operation) to the proposed project. These costs are calculated considering the following:

- Equipment
- Installation
- Training
- Start-up
- Salvage

The EECM then tallies the annual savings that will be generated by the new project by subtracting the annual cost of the proposed project from the current annual cost of the process that will be replaced. The model addresses the following contributory costs that are calculated into a total for both pre- and post-project conditions:

- Waste disposal/treatment
- Labor
- Utility
- Transportation
- Materials
- Maintenance and repair
- Support

Using the initial investment costs and the annual savings for the project, several economic indicators that are useful to the directorates are calculated by the model when comparing projects. The calculated initial investment and annual savings are also used as input to the prioritization model used by EMP.

Pollution Prevention Project Prioritization Model

More projects are proposed to EMP than can be implemented with the limited funds available. The P4M is used by EMP personnel to prioritize the projects that are competing for funds that will be available in the next fiscal year.

Written in Microsoft® Excel, the P4M uses the Displaced Ideal Model (DIM)[1] to calculate project priority ranking scores based on six prioritization criteria, some of which are composites of multiple subcriteria. The main advantage of DIM is that it allows both quantitative and qualitative forms of information to be used in the prioritization matrix. Wherever possible, raw data are used as input to the model because those data are less likely to be influenced by an intermediate scoring system that involves data manipulations and hidden calculation algorithms. For example, the actual initial investment value for a project is used as a criterion in the same matrix with a calculated score that reflects progress in achieving the Air Force's pollution prevention goals. This is possible because all criteria are nondimensionalized as the calculation begins.

McClellan AFB has established the following qualitative goals for pollution prevention:

- Reduce risk to base employees and adjacent residents
- Reduce releases and potential releases of pollutants into the environment

[1] Described in an Air Force Institute of Technology master's thesis, *Prioritization of Pollution Prevention Projects Using the Displaced Ideal Model for the Allocation of Limited Funds*, Mr. Scott W. McPherson and Capt. Debra J. Watts, AFIT/GEE/CEV/92S-14, Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio, 1992.

- Achieve/ensure compliance with environmental laws
- Insert available pollution prevention technology
- Develop new pollution prevention technology

In developing the six prioritization criteria for the P4M, special attention was given to meeting McClellan AFB goals while maintaining consistency with existing Air Force, federal, and state regulations, policies, and guidance governing pollution prevention. These included the suggested U.S. Environmental Protection Agency (EPA) prioritization criteria[2], ranking criteria required by the California Hazardous Waste Source Reduction and Management Review Act of 1989, and numeric Air Force goals contained in Directive 19-4.

The model determines the deviation of a given project from the "best project" for each criterion. The user weighs the scores for the six criteria so that the criteria considered to be most important are given priority in the model. Thus the project with the lowest overall score (i.e., the lowest deviation from a hypothetical "best project") is ranked first, the project with the second lowest score is ranked second, etc.

The six criteria used to evaluate the projects are as follows:

- Achievement of Air Force goals, as stated in Directive 19-4

- Environmental benefits

- Compliance with environmental health and safety laws

- Economic feasibility, as measured by internal rate of return

- Initial investment (capital outlay) required to accomplish the project

- Technical feasibility (i.e., the likelihood that the project can be brought on line and meet production requirements)

Pollution Prevention Users Tracking Tool System

The PPUTTS is the third in this series of computer-based tools generated to aid McClellan AFB in obtaining, evaluating, and maintaining information concerning the waste-generating processes on base; determining the most effective use of limited resources to minimize waste generation; and implementing projects designed to meet both McClellan AFB and Air Force goals. Specifically, the PPUTTS was developed to aid in tracking the funding, contracting, and pollution prevention goal information for pollution prevention projects that are competing for limited funds. The PPUTTS is an extension of the P4M and EECM.

[2] *Facility Pollution Prevention Guide*, EPA A/600/R-92/088, May 1992.

The PPUTTS represents a consolidation of the major information sources within EMP for the pollution prevention projects. It includes all of the information contained in the P4M, including the DIM prioritization algorithm; all of the information contained currently in individual word processor files for each project (the one-page summaries); and the fiscal and contractual information that is contained currently in a spreadsheet maintained within the Environmental Management Support Office.

After a project is funded by the Air Force Materiel Command, it must be implemented by the directorates. However, funding and contracting are administered through EMP, which is also responsible for tracking progress toward meeting the Air Force's goals for pollution prevention.

The database allows tracking of the obligation rate for pollution prevention funds, and it produces standard reports for management use and export to the Air Force Materiel Command and Air Staff. This allows managers within EMP and at Command to monitor the progress of the projects and the obligation cycle..

Perhaps most importantly, the PPUTTS allows EMP to measure and review the projected progress toward reaching the basewide and Air Force goals. Once McClellan AFB's hazardous substance tracking system is on line, its data concerning hazardous substance use and disposal can be integrated into the database to produce reports that reflect actual progress toward meeting goals.

A suite of predefined reports is provided with the current system. Managers can determine the progress toward achieving a pollution prevention goal by showing basewide annual achievements, progress by an individual directorate, or progress toward reducing or eliminating a specific pollutant. Other available reports track the obligation rates of pollution prevention funds. A specially designed report generates one-page summaries that have to be submitted to Command.

Pollution Prevention Road Maps

As one of its innovative approaches for tracking pollution prevention progress, EMP has developed a series of road maps in Microsoft® Excel that display graphically how individual pollution prevention projects and the mix of projects contribute to the achievement of the various pollution prevention goals. This information can be used to evaluate the status of the overall pollution prevention goal, ability of the current pollution prevention project "mix" to achieve the stated goals, areas where additional projects are needed, and areas where duplication of effort may occur. In the process of presenting the information, the road maps provide a means for analyzing data by breaking down the SM-ALC into its various activities, pollution sources, hazardous materials used, etc.

The road maps are designed to be presented on large (24- x 36-inch) paper suitable for posting on walls or using as flip charts. At a glance, a manager can see the "big picture" concerning the status of the program, ability of the program to achieve pollution prevention goals, and areas where additional projects are needed.

The following road maps have been developed:

- **Goal road maps**—A goal road map has been developed for each pollution prevention goal. Each map shows the contribution of individual pollution prevention projects and the project mix toward meeting the particular goal. The map provides (by project) estimated reductions in use, release, or disposal of a baseline material or waste. The estimated reductions are totaled across projects for insight into the extent that the mix of projects can successfully address the pollution prevention goal. These road maps are based currently on Microsoft® Excel and are updated on a periodic basis so that they reflect the most current information available to EMP. The possibility of further automating the goal road maps is being investigated.

- **Project-goal summary matrix**—The project-goal summary matrix summarizes effectively the information presented in the goal road maps into one large table that lists each project and identifies the goals that it affects. The project-goal summary matrix is a table listing the various goals across the top and the projects down the side, with bullets identifying projects that contribute to meeting each goal.

A third set of road maps (the pollution prevention status reports) have been designed to present actual reductions achieved by implemented projects rather than the projected reductions that are provided in the prevention projection matrices. The pollution prevention status reports will be developed when a sufficient number of projects have been implemented and data on the amounts of pollution that were prevented become available.

Acknowledgments

The pollution prevention management tools presented in this paper were developed to compliment the *Management Action Plan For Pollution Prevention* (MAP3) for McClellan AFB. MAP3 and the tools were developed by the MITRE Corporation under contract with McClellan AFB for On-Site and Technical Support (Contract no. FO4699-91-D-0065).

HAZARDOUS MATERIAL PERSONAL COMPUTER LOCAL AREA NETWORK

LT COL JOHN JOYCE, USAF, BSC
Director, Bioenvironmental
Engineering Services
645th Medical Group
Wright Patterson AFB, OHIO 45433
(513) 255-6815

INTRODUCTION

The Air Force Material Command (AFMC) is responsible for the distribution of HAZARDOUS MATERIAL information. An information system has been developed to comply with Hazardous Materials information availability requirements established by Occupational Safety and Health Administration (OSHA) Hazard Communication standard 29 CFR 1910.1200. To fully meet the requirement established by the OSHA standard, AFMC has developed, and implemented a centralized on-line system, accessible from each AFMC base, via local dial-in modems and/or local basewide Broadband Local Area Networks (LAN) connection.

BACKGROUND

The OSHA HAZCOM Standard as well as the Air Force Occupational Safety and Health Standard (AFOSH) 161-21, Hazard Communication Standard, requires that a Material Safety Data Sheet (MSDS) be "readily available" in the "workplace" for all hazardous materials employed on the job. OSHA teams periodically conduct inspections to ensure the availability of these MSDSs in the workplace, emphasizing hazardous materials knowledge, training and supervisor efforts to identify and eliminate hazards within assigned work areas.

To satisfy this requirement to provide MSDSs in the workplace, the centralized HAZMAT PC-LAN has been made available to each center. The long-haul communications backbone needed to support system access is achieved via the AFMC Virtual Circuit Switch (VCS) Network. Access can be obtained by either dial-in modem, or by Broadband LAN connectivity. Upon accessing the HAZMAT PC-LAN, users have the capability to view information, print to a local printer, and download data to a file on their PC. HQ AFMC/SGB is presently pursuing near term enhancements to establish Internet communications capability. Once in place, the HAZMAT PC-LAN system can be made available to a larger user population.

The HAZMAT PC-LAN was initially prototyped at Hill AFB, Utah where the OO-ALC/SC personnel were actively involved with the design, procurement, development, and integration of the Commercial-Off-The-Shelf (COTS) components that comprise the system. State-of-the-art COTS components were evaluated and used to accomplish the overall objectives of the HAZMAT PC-LAN system.

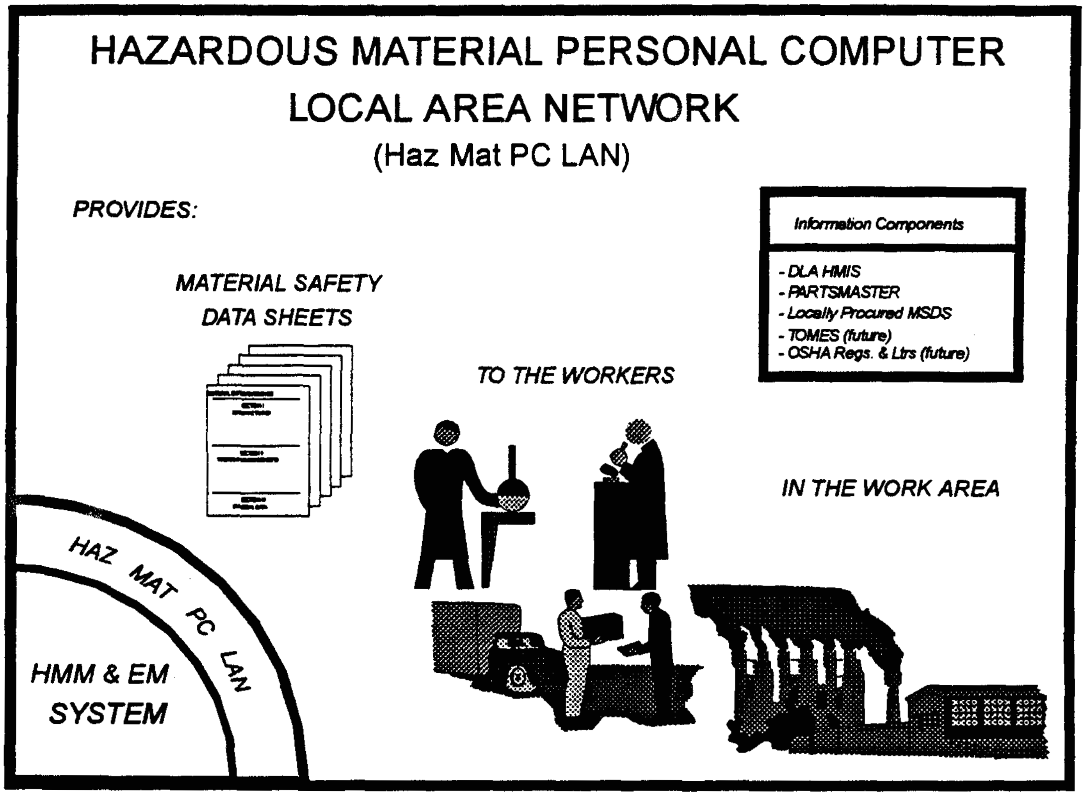
Based on PC-LAN and dedicated server technologies, the HAZMAT PC-LAN has incorporated the use of "Compact Disk-Read Only Media" (CD-ROM) to provide the database and storage necessary to contain the vast amount of information associated with MSDSs.

AFMC's fulfillment of the Standard required approximately 17 months of design, development, and implementation of on-line systems that are now accessible from anywhere on AFMC bases, via modems and/or the basewide Broadband Local Area Networks (LANs). This systems provide MSDS data to base personnel throughout AFMC.

SYSTEM DESCRIPTION

This system, provides access to multiple databases containing HAZARDOUS MATERIAL information from the Defense Logistics Agency Hazardous Material Information System HMIS CD-ROM MSDS database, the Micromedex TOMES Plus CD-ROM database, the OSHA CD-ROM database, and a Folioviews local purchase MSDS database. Procurement data can also be accessed using Information Handling System's PartsMaster CD-ROM database and the FED LOG database. (See Figure 1)

FIGURE 1



HAZMAT MSDS INFORMATION

The Hazardous Material Information System (HMIS) is a Department of Defense electronic database containing Material Safety Data Sheets (MSDS) documents. These documents are mastered on CD-ROM to allow quick access utilizing standard micro computer equipment. This database provides an essential reference information base for the DOD, federal civilian activities, and approved organizations to maintain compliance with strict regulatory controls.

The MSDS provides information regarding specific hazards associated with a given material. The HMIS database offered on the HAZMAT PC-LAN supplies information to assist personnel involved in hazardous material management in decreasing risks to persons potentially exposed to these materials. Material managers can use information contained on an MSDS as additional means to comply with safeguards that apply to safety and health. These documents supply knowledge as to the specific hazards associated with hazardous material.

MSDS's are acquired during the procurement process. The primary purpose of the HMIS is to provide an electronic means of distributing the MSDS information throughout the DOD and other Federal Agencies. The primary objective of the HAZMAT PC-LAN is to provide MSDS access, however as an additional service, other pertinent databases are offered.

Circulation of this data to work areas that require the information within DOD is accomplished according to Service/Agency directives and the Occupational Safety and Health Administration (OSHA) Hazard Communication Standard (29 CFR 1910.1200).

All base personnel within AFMC have access using local dialup modems or their local base wideband LANs. A key element of the system is its foundation of low cost commercial-off-the-shelf equipment and software (COTS). Connectivity from each AFMC site to the centralized system is achieved through the use of the Virtual Circuit Switch (VCS) Network riding Air Force Network (AFNET) trunks.

MSDS (FolioViews)

The HMIS database does not contain MSDSs of all hazardous materials used in DOD. It also often contains edited information of the original MSDS since certain data fields are somewhat limited. The FolioViews Infobase Software is a free-form text retrieval infobase search mechanism. FolioViews enables users to search the entire database on certain keywords or phrases with minimal restrictions. This software has been implemented on the HAZMAT PC-LAN for use in accessing MSDSs not included in the DLA HMIS database and for hazardous items procured locally. Some 20,000 MSDSs have been completely scanned and keyed into this database. This allows for proper and appropriate OSHA HAZCOM compliance since this contains the complete MSDS.

PROCUREMENT INFORMATION (PARTSMASTER & FED LOG)

The PARTSMASTER DB allows access to procurement record data by performing database searches by National Stock Number (NSN), National Item Identification Number (NIIN), Company Number or Commercial and Government Entity (CAGE)code, Army Master Data File (AMDF) Line Item Number, SPCC Navy Item Control Number (NICN), Navy Manufacturers Part Number, MIAPL Identification Number, MIAPL Repair Item Code, and item name, singly or in combination.

The FED LOG System provides access to the Defense Logistics Information System (DLIS) Databases, Supplemental Air Force (AF) Management, AF D043 X-FILE, AF Overlay, and AF Ship to Stock Record Account (SRAN) Databases. In addition, ARMY Master Data File (AMDF) and I&S Order of Use data is available. Also included are the NAVY List of Items Requiring Special Handling (LIRSH), Master Repairable Item List (MRIL), MRIL Shipping, and NAVY Item Control Number (NICN) Information.

The Air Force, as well as many other government agencies, use a variety of codes to describe and catalog material in the supply system, the most familiar of which is the NSN. The NSN is assigned to a particular product which meets a certain specification or military standard. Many supply products, each of which contain a unique composition of hazardous components can all have the same NSN. In addition to the NSN, certain supply systems also track a product by the CAGE code. This code corresponds to a particular manufacturer and its location. A Part Number Indicator (PNI) is also assigned to materials to further delineate components, such as in part kits used in painting operations. The combination of these three numbers can uniquely define a hazardous material.

Once a hazardous material is identified and its components enumerated from an MSDS, material tracking and control systems can trace the material to a particular process. Appropriate controls for authorization to use these hazardous materials can track the hazardous material to individual workers who will require exposure measurement, and training documentation. As a result, this system can provide information on actual material hazards, and work with other systems to provide positive control over ordering and issuance of materials, and data on material quantities used and stored. This will also allow a proactive approach to compliance by identifying hazardous material location and determine where substitutions can take place.

Under the Clean Air Act of 1990, substituting and recycling of chloroflourocarbons (CFCs) has become law. This requires a system to determine the CFC uses and processes installation-wide. Under the Pollution Prevention Act, the Environmental Protection Agency has identified 17 chemicals targeted for removal. The 17 chemicals (consisting of five elements and 12 compounds) quickly expands to over 1000 materials at a typical base. Individual chemical components can be identified by the National Institute of Occupational Safety and Health (NIOSH) Registry of Toxic Effects of Chemical Substances (RTECHs) number, as well as the Chemical Abstract Service (CAS) number. This information previously identified, required information on the MSDS. Once the individual chemical components are determined, the material under consideration can be evaluated according to appropriate methods for substitution.

TOXICOLOGY, OCCUPATIONAL MEDICINE ENVIRONMENTAL SYSTEM (TOMES)

TOMES PLUS is an industrial chemical database that provides access to medical and hazard information necessary for safe management of chemicals in the workplace, evaluating exposures,
right-to-know issues for SARA Title III regulatory compliance and quick response to emergency situations and environmental incidents.

TOMES Plus offers a number of proprietary and government guides providing basic medical and hazard information intended to assist occupational health personnel. Here is an example of some documents and database available in the HAZMAT PC-LAN through TOMES:

The National Institute for Occupational Safety and Health
(NIOSH) Pocket Guide

Chemical Hazard Response Information System (CHRIS)
CHRIS is utilized by emergency response and safety personnelfor first response to marine incidents involving hazardous materials. CHRIS provides details on Response to Discharge; Label; Chemical Designations; Observable Characteristics; Health Hazards; Fire Hazards; Chemical Reactivity; Water Pollution; Shipping Information; Hazard Classifications; and Physical and Chemical Properties.

Registry of Toxic Effects of Chemical Substances (RTECS) RTECS provides industrial hygiene personnel with toxicology information. Information provided by RTECS includes Substance Identification including CAS and NIOSH Numbers; Synonym/Tradename; Health Hazard Data; Standards and Regulation; NIOSH Document; Reviews; and Status in the United States.

Integrated Risk Information Systems (IRIS), IRIS provides EPA staff, industrial hygiene, and environmental remediation personnel with U.S. EPA health risk assessment information useful in determining safe levels of human and environmental exposure to chemicals. IRIS provides detailed information on Chronic Health Hazard Assessments for Non-carcinogenic Effects; Carcinogenicity Assessment for Lifetime Exposure; Health hazard Assessments for Varied Exposure Durations; and U.S. EPA Regulatory Actions.

Department of Transportation Emergency Response Guide (DOT)
The DOT Emergency Response Guide offer emergency response personnel a necessary tool when responding to fires, explosions, and spills involving hazardous chemicals. The DOT Guide contains information needed to identify a

substance, isolate and contain it, and evacuate an area.

Oil and Hazardous Materials/Technical Assistance Data System
(OHM/TADS)
OHM/TADS provides industrial hygiene and environmental remediation personnel with information regarding the health and environmental effects of petroleum products and other substances. OHMS/TADS provides detailed information regarding Transportation/Storage/Handling; Laboratory; Physiochemical Parameters; Fire/Explosions/Corrosion Hazards; Environmental Hazards; Range of Toxicity; Human Health Hazards; Clean-up Procedures; and Data Adequacy Evaluation.

REPRORISK System
The REPRORISK System offers industrial hygienists comprehensive information for use in assessing reproductive risks of substances on unborn children, females, and males.

REPROTEXT Database
The REPROTEXT Database is a reproductive hazard reference offering a collection of reviews on the health effects of industrial chemicals and physical agents encountered in the workplace. Specific issues addressed by REPROTEXT include: Administrative Information; Effects of Acute Exposure; Effects of Chronic Exposure; Carcinogenic Effects; Genetic Effects; Reproductive Effects; and Predisposing Conditions.

TERIS
Teratogen information system developed by the University of Washington Medical School. This module provides current information on the teratogenic effects of more than 700 drugs and environmental agents.

NEW JERSEY HAZARDOUS SUBSTANCE FACT SHEETS
These fact sheets from the New Jersey Department of health offer employee-oriented exposure risk information for industrial hygiene and safety personnel including personal protective equipment (PPE),hazard summary, and emergency information.

OSHA REGULATIONS
The Occupational Safety and Health Administration Database contains text of all OSHA regulations (standards), selected documents, and technical information from the OSHA Computerized Information System (OCIS). Additional offerings include Standards Interpretations, the Federal Register Index, variances, OSHA Documents, Directives, the Field Operations Manual, Chemical Sampling Information, Blood Lead Laboratories and a Library Catalog.

Database information supplied by OSHA include:

APPROVED BLOOD LEAD LABORATORIES
Contains the current OSHA list of laboratories approved for Blood Lead Analysis based on proficiency testing. The file is used for compliance purposes and to assist employers in complying with the provisions of the lead standard for accuracy in blood lead analysis.

CHEMICAL SAMPLING INFORMATION
Contains brief industrial hygiene sampling information for chemicals found in work place environments. The file also includes exposure limits and brief health information abstracted from the NIOSH/OSHA Health Guidelines.

FIELD OPERATIONS MANUAL
Provides the text of the Field Operations Manual (FOM), originally issued as OSHA Instruction CPL 2.45B, June 15, 1989 and includes all changes issued through the date of the CD-ROM. The FOM provides primary guidelines for OSHA compliance safety and health officers (CSHOs) in performance of inspections.

LIBRARY CATALOG
Contains bibliographic information for book holdings of OSHA offices, including the Technical Data Center, Salt Lake Technical Center, and Regional Office and Area Office Libraries.

NATIONALLY RECOGNIZED TESTING LABORATORIES
This database contains independent testing laboratories and their test standards which have been recognized by OSHA under the Nationally Recognized Testing Laboratories (NRTL) Recognition Program, Office of Variance Determination. This program was issued as final rule, 29 FR 1910.7, in the Federal Register, 54:12102-25, April 12, 1988.

NEW/ADDITIONAL MATERIALS
Provides a means for new and/or significant information to be included on the CD-ROM. Additional material may include public domain safety and health related software programs, communications software and WordPerfect files for newly issued standards.

OSHA ACT OF 1970, WITH REVISIONS
Contains the complete text of the Occupational Safety and Health Act of 1970. The Act issued as Public Law 91-596, 91st Congress, S. 2193, approved on December 29 1970, and amended by Public Law 101-552, section 3101,

November 5, 1990.

OSHA DOCUMENTS
Provides a means to search across a variety of agency documents issued by various directorates and offices within OSHA. Compliance memoranda, Standard Interpretation Letters, and Corporate-Wide settlement agreements are included from the Directorate of Compliance Programs. Hazard information bulletins are included from the Directorate of Technical Support.

OSHA ANALYTICAL METHODS
Supplied by the Salt Lake Technical Center (SLTC). The SLTC performs analyses for a wide range of toxic substances and provides analytical services for the federal OSHA program. Many of these procedures represent original work, while others represent methodology extracted from the literature which has been modified and formatted to meet OSHA's requirements. These methods are evaluated by the Organic and Inorganic Methods Branch and are subject to change.

OSHA FEDERAL REGISTER INDEX
Provides an index to notices issued in the Federal Register concerning OSHA activity from 1971 to the date of the CD-ROM. An abstract is provided which summarizes notices on proposed rule making, final rules, changes to existing OSHA standards, hearings, and meetings.

OSHA REGULATIONS (PREAMBLES)
Contains the text for preambles issued in the Federal Register as part of recent OSHA Regulations with changes current through the release date of the CD-ROM.

OSHA REGULATIONS (STANDARDS)
Provides electronic copy of the text of all regulations (standards) applicable to OSHA, which have been published in the Federal Register. The text also reflects the Code of Federal Regulations (CFR) Title 29, Parts 1900 through 1990.

OSHA SAVES
Contains current text for all Standard Alleged Violation Elements (SAVEs) for Regulatory and General Industry, OSHA Instruction CPL 2.35; for Construction, OSHA Instruction, CPL 2.34; for Maritime, OSHA Instruction CPL 2.32A; and for Agriculture, OSHA Instruction CPL 2.36A.

OSHA TECHNICAL MANUAL
Provides the complete text, tables, and illustrations for the OSHA Technical Manual (OTM), issued as OSHA Instruction CPL 2-2.20B, February 5, 1990, and includes all changes issued through the date of the CD-ROM. The manual provides technical guidelines on a variety of occupational safety and health topics for OSHA compliance safety and health officers (CSHOs). The manual also defines the guidelines for equipment and procedures referenced in the Field Operations Manual.

VARIANCES
Provides an index to current OSHA variances (temporary and permanent) from OSHA standards, rules or regulations.

REGULATORY REQUIREMENT ADVANTAGES

Resource Conservation and Recovery Act (RCRA)

Under RCRA, proper hazardous material management minimizes the hazardous waste produced. Identifying hazardous materials, chemical components, and issue amounts, allows for proper segregation, reuse, recycling, usage reduction, and appropriate disposal.

Clean Air Act Amendments of 1990

There are several different monitoring requirements under this act. Major stationary sources that emit hazardous pollutants must be inventoried and monitored by the owner or operator. Under Title III, 189 hazardous air pollutants, are targeted for reduction by 75 percent over the next 10 years. Under Title VI, the Montreal Protocol, control of ozone layers depleting substances (OLDS) (Table I) was enacted. This section of the act requires a phased reduction of these materials over the next several years. Reductions in volatile organic compounds (VOCs) will be required in all ozone non-attainment areas. Our comprehensive system will help define control requirements and provide baseline emission level data for compliance monitoring of existing and planned emitters.

Superfund Amendments and Re authorization Act (SARA) of 1986

SARA Title III is also known as the Emergency Planning and Community Right-to-Know Act. Implementation guidance for SARA requires installations to develop hazardous chemical spill plans and chemical inventories. The main focus of SARA Title IV is to locate hazardous materials that are stored in excess of the extremely hazardous substance threshold planning quantity.

Occupational Safety and Health Act (OSHA) Hazard Communication Standard (HAZCOM)

The OSHA HAZCOM standard complements SARA as the Worker Right-To-Know Act. It requires inventory lists of hazardous materials used in the workplace. For each of the hazardous material products, a Material Safety Data Sheet (MSDS) must be available to the worker at the worksite. The MSDS details material components, percentage composition, and health and safety information. Federal Standard 313 defines all the materials considered hazardous by the federal Government.

Nuclear Regulatory Commission (NRC)

The Air Force is responsible for maintaining its own licensing program for radioactive materials under the NRC. The responsible Air Force agency is known as the Air Force Radioisotope Committee (RIC). To maintain proper control of radioactive materials and commodities which contain radioactive materials, the Air Force must control and track that material from acquisition, through use and, ultimately, to disposal.

CONCLUSION

We believe the HAZMAT-PC LAN will satisfy the need to adequately identify hazardous material used in the workplace. Once this hazardous material is tied to a particular process and worker, we can then concentrate on waste disposal reduction, product substitution, emissions data, and ultimately worker exposure minimization. This system will also serve as a significant management tool for pollution prevention by aiding acquisition and use of hazardous material in both existing and newly developed weapon systems. In this era of environmental awareness, concern over ozone depletion, and worry over chemical carcinogens, this system will place Air Force Materiel Command in the forefront as a champion for the environment.

Disclaimer

The views and opinions expressed in this paper reflect only those of the author and in no way reflect the views or position of the United States Air Force.

The Hazardous Waste and Used Oil Management Database

Kimberly M. Prestbo, ENSR Consulting and Engineering
14715 NE 95th Street, Redmond, WA 98052 (206) 881-7700

Captain Sara Pate, 11th CEOS
21885 2nd Street, Elmendorf Air Force Base, AK 99506 (907) 552 1533

Michael Swayne, Ph.D., Environmental Systems
8041 171st Avenue, NE, Redmond, WA 98052 (206) 882-1221

This paper describes a relational database developed for management of hazardous waste (HW) and used oil (UO) at Air Force installations. Development, implementation, and subsequent accomplishments of the database at three remote Air Force installations in Alaska are described. The objective of the HW/UO management program was threefold: achieve regulatory compliance, improve administrative efficiency, and decrease costs. Air Force, state, and federal environmental regulations produce a quagmire of waste management and reporting protocols. The HW/UO database provides an efficient way to administer these protocols, thereby decreasing Notices of Violation (NOVs) and, ultimately, disposal costs. The database also provides the structure by which to track HW and UO production and disposal, thereby overcoming a major obstacle in evaluation of pollution prevention opportunities.

In the following section, the inherent problems associated with HW and UO management at three remote facilities are described. It is important to realize that the challenges of HW and UO management, as described below, are not unique to remote sites and can be found at all Department of Defense (DOD) facilities. The three phases of database development and implementation will be outlined. Finally, successful implementation of the HW/UO database at these remote facilities will be demonstrated.

The Challenge of Hazardous Waste and Used Oil Management at Remote Sites

In February 1992, when the initial work began on the HW/UO database, none of the three main Alaskan remote sites, King Salmon Airport, Galena Airport, and the Eareckson Air Station (AS) on Shemya Island, were in compliance with RCRA. The main problem was the lack of continuity caused by one-year remote tours. The environmental personnel generally had a broad range of responsibilities, with waste management as one of many duties, and no prior experience. By the time they were trained, the tour was over. Contractors and tenant units operating on the installation typically did not have trained personnel.

There was a limited system for tracking waste streams and no way to characterize wastes at the remote sites, making timely disposal extremely difficult. Wastes were indiscriminately placed in containers, mixing hazardous wastes, non-hazardous wastes, and used oil. Markings indicating contents, accumulation start dates, and sample numbers were quickly obliterated in the harsh Alaskan environment. Without documentation on contents, generator knowledge and prior drum sampling could not be used to identify the wastes. Some containers were sampled three or four times. Since site personnel were not trained in sampling techniques, every drum was sampled instead of taking composite samples. The drums were all stored outdoors, so samples could only be taken during the summer, or after moving the containers indoors and allowing them to thaw for several days. In an effort to be conservative, many non-hazardous wastes were incorrectly identified as hazardous.

The logistics of removing these wastes was tremendous. The three installations are accessible by air year round and by barge during the summer. There are no roads. Airlift was frequently not available, especially during Desert Shield and Desert Storm. Once airlift was obtained, coordination was required for storage space at the Elmendorf treatment, storage, and disposal facility (TSDF).

The problems with personnel turnover, training, poor waste tracking, sampling, transportation, and coordination with the TSDF resulted in more than 2,000 drums of unknown wastes at three installations stored in excess of 90 days.

Development of the HW/UO Database

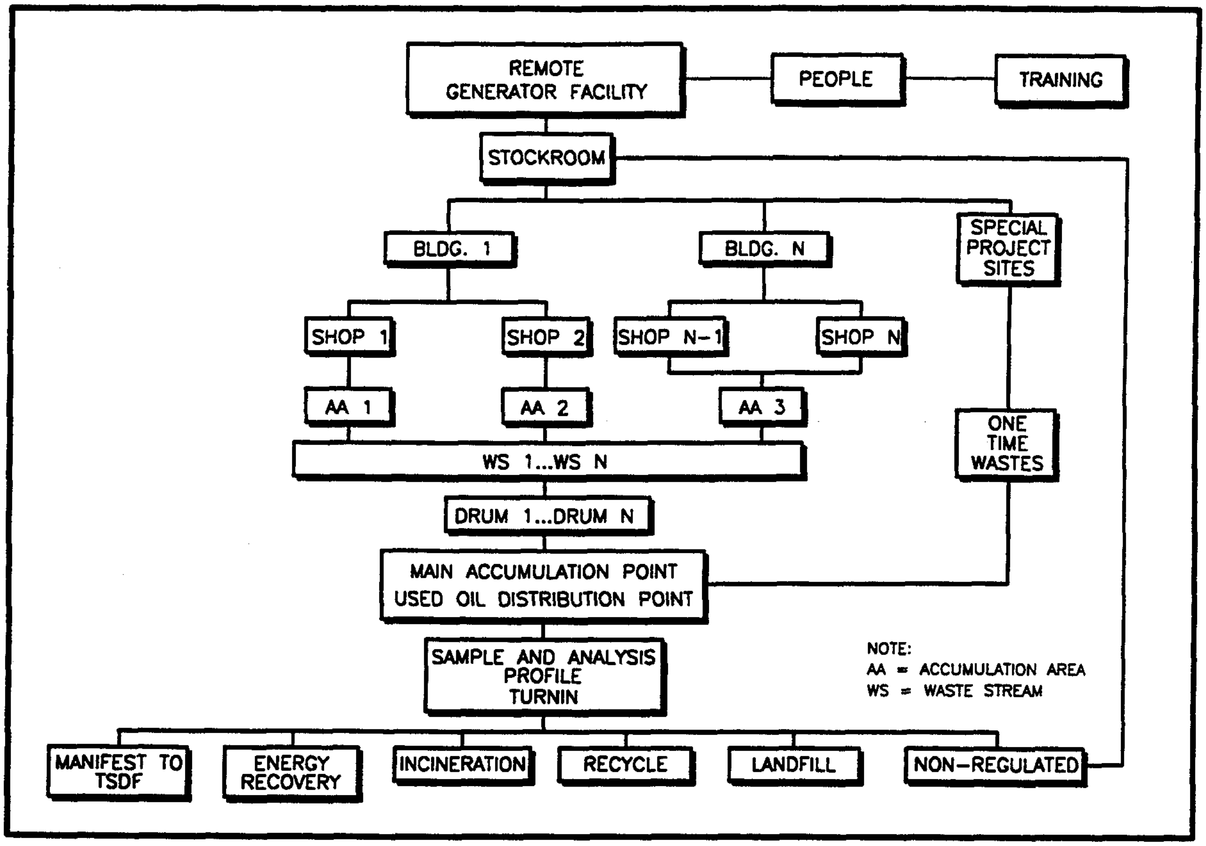
ENSR Consulting and Engineering (ENSR) and the 11th CEOS, which is responsible for environmental management at the remote sites, jointly developed a plan of action. Written documentation for HW and UO management, including procedures for accumulation, characterization, transportation, and disposal/recycling of HW and UO was to be prepared in accordance with Air Force, state, and federal regulations and needed to be available at every level of HW and UO management. In addition, a HW/UO database would supplement this document, and provide a tracking and administrative mechanism for ongoing HW, UO, and pollution prevention activities. The database was developed concurrently with the HW/UO Management Plan to ensure consistency of the model with reality. Development consisted of three phases: developing the conceptual model, applying the model to a relational database, and implementing and refining the model.

The goal of Phase I was to completely understand the existing HW and UO management system along with new requirements and regulations in order to develop a conceptual model. Hazardous waste and used oil data management involves manipulating interrelated information to generate documents to satisfy EPA, state, and Air Force requirements, and collecting information needed to minimize waste generation and costs, and maximize reuse and recycling. Phase I involved compilation of all available historical data including an inventory of existing waste streams; itemization of necessary tasks and reporting requirements; and definition of objects of interest and their relationships.

A conceptual model of HW and UO flow through the system is presented in Figure 1. The relationship between the point of entry of a hazardous material (the stockroom, or in some cases via a contractor), the point where a material is processed and a HW or UO generated (shop), and the point where HW/UO is accumulated (accumulation area) must be clearly understood. Recurrent waste streams versus one-time wastes must be identified. The waste streams of subcontractors and tenants must be located, identified, and channeled into the system. The people responsible for HW/UO management at each of these points must be identified, and the necessary training provided and tracked. Finally, the administrative and reporting requirements for management of the HW and UO streams must be clearly understood.

During Phase II, the relational database model was created using Paradox 4.0™ software. A relational database is a collection of data related to a particular topic or purpose that is organized and analyzed using a well developed relational model[1]. The relational model organizes information based on a mathematical theory and has an associated query language that provides access to the data and a method to report or sort consistent results. A data-centered relational database model focuses on the objects of interest rather than output reports or interface forms that are subject to frequent changes. The data-centered approach allows the user to query any combination of objects and their attributes to create necessary reports or forms. This is in contrast to an output or report-oriented approach, commonly used in spreadsheets, that focuses on the reports that need to be generated. This is inefficient and usually results in redundant and inconsistent information.

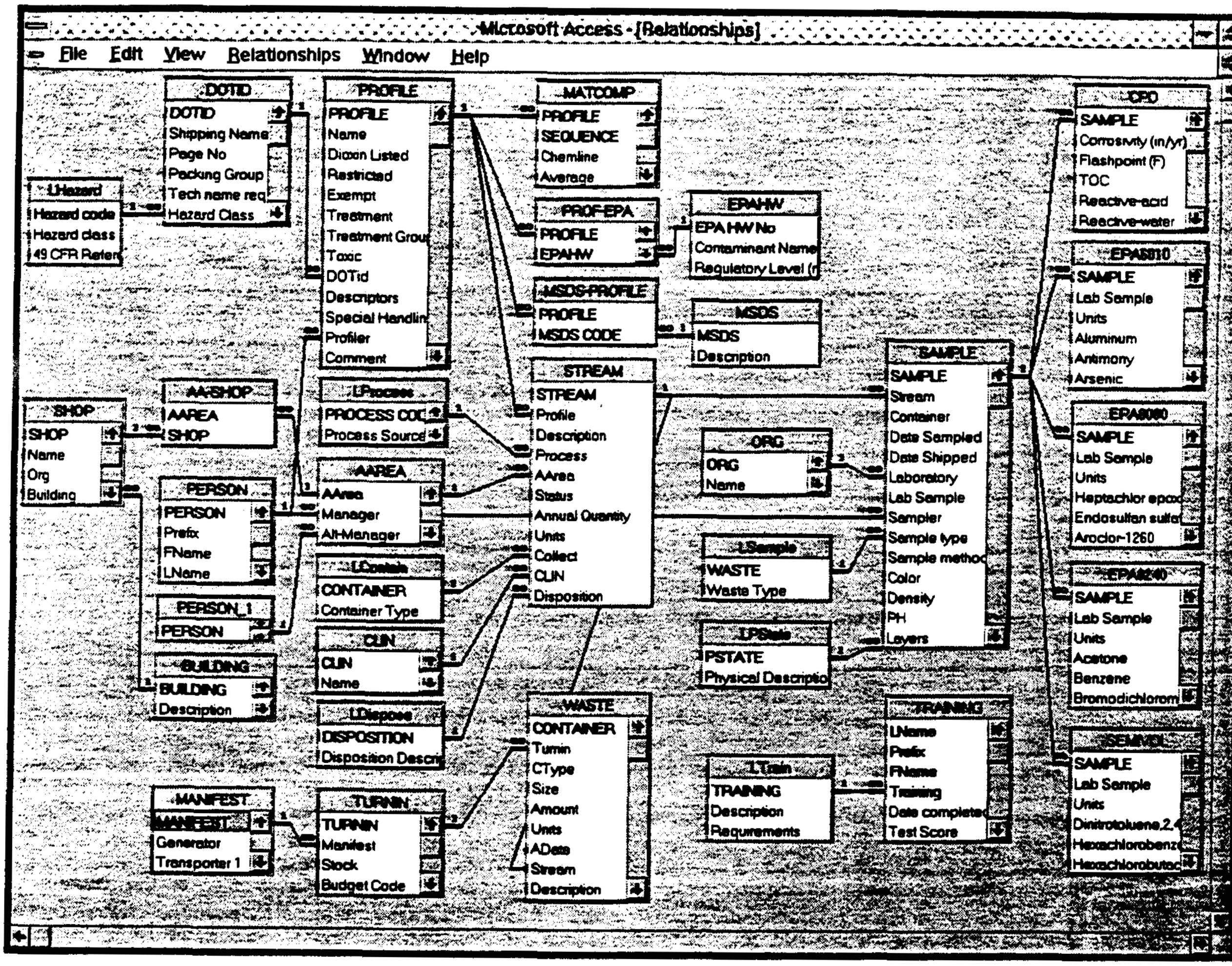
Figure 1. Hazardous Material and Hazardous Waste/Used Oil Flow Diagram



Another problem with the report-oriented approach is that requirements and requests for information keep changing. Using the data-centered approach, it is relatively easy to create new views or reports of existing data and to extend the model by adding new objects and attributes, as needed.

Figure 2 illustrates the relationship between the objects of interest in the HW/UO database. Six base tables relate people, organizations, and places: PERSON, ORG, BUILDING, SHOP, AAREA, and TRAINING. Three base tables describe or document containerized waste from accumulation to transport: WASTE, TURNIN, and MANIFEST. Three more base tables store information about the types of containerized waste: SAMPLE, STREAM, and PROFILE. All other tables serve to link information between two tables, or provide domains (explanations) for coded fields. An example of how information is stored in the database is as follows. A profile report describes a type of waste stream, providing necessary information for transportation and disposal. Profiles are stored in the PROFILE table. Analytical data used to characterize the waste stream are stored in the SAMPLE table and associated tables. A profile can be used to characterize more than one waste stream, if the characteristics and disposal requirements are the same. Likewise, a waste stream usually consists of more than one container of waste. In the database, waste stream information is stored in the STREAM table. Each container of waste is stored in the WASTE table (similar to a drum log). One or more representative containers of waste is sampled, and the resulting analytical data are stored in the SAMPLE table and linked to a waste stream in the STREAM table. The combined information is evaluated and ultimately used to complete the profile report, which can be submitted directly to the TSDF. An example profile generated by the HW/UO database is presented in Figure 3.

Figure 2. Relational Database Model for Hazardous Waste and Used Oil Management



Phase III consisted of applying the database to assist in HW/UO management at the three remote sites, and refining the structure, supplementary tables, and reports to address site-specific requirements. Due to the high turnover rate at the remote sites, central administration of the database remains at the 11th CEOS at Elmendorf Air Force Base, while site-specific information is collected and passed on to the central database.

Currently, the database is used for the following activities:

- **Generating profiles, land disposal restriction documentation, and turn-in documentation.** The database enables the users to create profiles, including land disposal restriction documentation, based on user knowledge, material safety data sheets, and sample analysis. Defense Reutilization and Marketing Office (DRMO)-required turn-in documents, including turn-in paperwork for hazardous materials being sent to DRMO for reutilization and resale, can also be generated from the database. Requested changes to database generated reports and data input screens are easily accommodated. Data from five different analytical laboratories can be recorded and tracked. With a baseline of existing waste streams, many streams can be characterized once and the profile re-used for subsequent containers of waste. This decreases sampling and analysis costs.

Figure 3. Profile Report Generated by HW/UO Database

HAZARDOUS WASTE PROFILE SHEET

PART I

A. GENERAL INFORMATION SAMPLE: FB5000DSL2 WASTE PROFILE NO. FB5000930002

1. GENERATOR NAME
3 CES/CEVCW

2. FACILITY ADDRESS
Bldg 22-009
Elmendorf AFB AK, 99506-5000

3. GENERATOR US EPA ID AK8570028649

4. GENERATOR STATE ID

6. TECHNICAL CONTACT
SSgt John Goelz

7. TITLE
Environmental Technician

PHONE
(907) 552-4542

B. 1. NAME OF WASTE Waste Oil

2. USEPA/STATE WASTE CODES D006,D007,D008,D018,D035

3. PROCESS GENERATING WASTE One-time Only

4. PROJECTED ANNUAL VOLUME/UNITS 5 gallons 5. MODE OF COLLECTION Metal drum

6. IS THIS WASTE A DIOXIN LISTED WASTE AS DEFINED IN 40 CFR 261.31? ☐ Yes ☒ No

7. IS THIS WASTE RESTRICTED FROM LAND DISPOSAL (40 CFR 268)? ☒ Yes ☐ No
HAS AN EXEMPTION BEEN GRANTED? ☐ Yes ☒ No
DOES THE WASTE MEET APPLICABLE TREATMENT STANDARDS? ☐ Yes ☒ No

PART II

1. MATERIAL CHARACTERIZATION
(OPTIONAL-NOT REQUIRED DATA)

COLOR Black

DENSITY ENERGY (BTU/lb)

TOTAL SOLIDS (ppm) ASH CONTENT(%)

LAYERING: ☐ MULTILAYER ☐ BILAYER ☒ SINGLE PHASE

4. MATERIAL COMPOSITION

Component	Average	Range
Oil	97	
Metals	1	
Benzene	1	
MEK	1	
TOTAL (%)	100	

2. RCRA CHARACTERISTICS

PHYSICAL STATE: ☐ SOLID ☐ GAS ☒ LIQUID ☐ OTHER ☐ SEMI-SOLID

TREATMENT GROUP: ☐ WASTEWATER ☒ NON-WASTEWATER

☐ IGNITABLE (<140% - D001)
FLASH POINT(F) ≥140
☐ HIGH TOC (>=10%)
☐ LOW TOC (<10%)

☐ REACTIVE (D003)
☐ WATER REACTIVE
☐ CYANIDE REACTIVE (>250)
☐ SULFIDE REACTIVE (>500)

☐ CORROSIVE (<2 or >12 - D002)
pH 10.19

5. SHIPPING INFORMATION

SHIPPING NAME Hazardous waste, liquid, n.o.s.

HAZARD CLASS 9 DOT UN or NA No. NA3082

DESCRIPTION Waste Oil Containing Metals, Benzene and MEK

METHOD OF SHIPMENT ☐ BULK ☐ DRUM ☐ OTHER

PACKING GROUP III

CERCLA REPORTABLE QUANTITY (RQ)

EMERGENCY RESPONSE GUIDE PAGE
DOT PUBLICATION 5800.4 PAGE NO. 31

SPECIAL HANDLING INFORMATION

3. CHEMICAL COMPOSITION (ppm or mg/l)

COPPER		PHENOLICS	
NICKEL		TOTAL HALOGENS	
ZINC		PCBs	
CHROMIUM	9.7		

NOTE: EXPLOSIVES, SHOCK SENSITIVE, PYROPHORIC, RADIOACTIVE, AND ETIOLOGICAL WASTE NORMALLY ARE NOT ACCEPTED BY THE DRMO.

6. GENERATOR CERTIFICATION

BASIS FOR INFORMATION

☐ CHEMICAL ANALYSIS (ATTACH TEST RESULTS)

☐ USER KNOWLEDGE (ATTACH SUPPORTING DOCUMENTS - *Explain how and why these documents comply with RCRA requirements)*

I, SSgt. John Goelz, HEREBY CERTIFY THAT ALL INFORMATION SUBMITTED IN THIS AND ALL ATTACHED DOCUMENTS IS TO THE BEST OF MY KNOWLEDGE AN ACCURATE REPRESENTATION OF THE WASTE TURNED IN TO THE DRMO. ALL KNOWN OR SUSPECTED HAZARDS HAVE BEEN DISCLOSED.

SIGNATURE OF GENERATOR'S REPRESENTATIVE DATE

DRMS Form 1930 Oct 90

SAMPLE FB5000DSL2 DATE SAMPLED: 6/3/93 WASTE PROFILE NO. FB5000930002 Page 2

TOXICITY CHARACTERISTIC LIST

EFFECTIVE 25 SEP 90 - LARGE QUANTITY GENERATORS
29 MAR 91 - SMALL QUANITITY GENERATORS

CONTAMINANT	EPA HW No.	Value (units)*	MCL** (mg/l)	CONTAMINANT	EPA HW No.	Value (units)*	MCL** (mg/l)
Arsenic	D004		5	Hexachlorobutadiene	D033		.5
Barium	D005		100	Hexachloroethane	D034		3
•Benzene	D018	63.0 mg/l	.5	•Lead	D008	53.5 mg/l	5
Cadmium	D006	3.58 mg/l	10	Lindane	D013		.4
Carbon tetrachloride	D019		.5	Mercury	D009		.2
Chlordane	D020		.03	Methoxychlor	D014		10
Chlorobenzene	D021		100	•Butanone,2-	D035	5600.0 mg/l	200
Chloroform	D022		6	Nitrobenzene	D036		2
•Chromium	D007	9.7 mg/l	5	Pentachlorophenol	D037		100
o-Cresol	D023		200	Pyridine	D038		5
m-Cresol	D024		200	Selenium	D010		1
p-Cresol	D025		200	Silver	D011		5
Cresol	D026		200	Tetrachloroethylene,1,1	D039		.7
2,4-D	D016		10	Toxaphene	D015		.5
Dichlorobenzene,1,4-	D027		7.5	Trichloroethene	D040		.5
Dichloroethane,1,2-	D028		.5	Trichlorophenol,2,4,5-	D041		400
Dichloroethene,1,1-	D029		.7	Trichlorophenol,2,4,6-	D042		2
Dinitrotoluene,2,4-	D030		.13	Silvex	D017		1
Endrin	D012		.02	Vinyl chloride	D043		.2
Heptachlor	D031		.00				
Hexachlorobenzene	D032		.13				

* If no data is entered, results were below minimum detection limits, or contaminant was not analyzed.
** MCL indicates maximum contamination level (Regulatory Limits).
• Indicates contaminant value exceeded MCL.

PART III

FOR DRMO USE ONLY

DRMO VERIFICATION

1. DATE VERIFIED ____________

2. RESULTS ☐ ATTACHED

pH ________ FLASH POINT ________ SPECIFIC GRAVITY ________ HALIDES (TOX) ________

REACTIVITY: WATER REACTIVITY ________ CYANIDES ________ SULFIDES ________

TCLP ____________

- **Tracking waste containers.** Containers of waste (including waste accumulation periods and location) are tracked in the WASTE table at each facility, minimizing NOVs related to exceeding the waste accumulation period. Environmental coordinators know where any container of waste is at any time.

- **Generating RCRA Biennial report.** The data used to create the RCRA Biennial report are easily accessible through the database, including waste codes and codes for processes generating wastes. Instead of manually going through the profiles and manifests to determine quantities from each process, a report of wastes for each process shipped during the calendar year can be generated from the database.

- **Oil/water separator and used oil tracking.** Previously, all disposal information was handwritten on profile forms and there was no method for tracking the disposition of used oil. Once a baseline for oil/water separator waste is established in the database, subsequent sampling can be used to determine whether the waste constituents have changed, enabling personnel to note if changes in practices may have occurred. Used oil is tracked like other waste streams and the required used oil specification sheets are generated by the database.

Continuing developments include changing the software platform to Microsoft Access™ 2.0 that operates in the Windows™ environment. This has led to several significant improvements. Windows™ provides a consistent, easy to use, graphical user interface (GUI). The conversion to Access™ facilitates enforcement of relational integrity and validation rules by incorporating them at the engine level. It is easier for the user to generate queries and the resulting reports to meet standard military form requirements. In line with a recent federal directive for consolidating software, Access™ supports structured query language (SQL) pass-through to any server that supports open database connectivity (ODBC) (i.e., Oracle, SYBASE). This allows the database to more easily connect to central support systems such as existing material procurement and facilities management systems.

Conclusions

In conclusion, a HW/UO database has been successfully applied to three Air Force installations in Alaska to assist in the challenging task of HW and UO management at remote facilities. The database, along with written documentation and training, has improved HW and UO management procedures by providing structure and consistency to the system. Specific non-compliance issues were immediately resolved: Within the first week of operation, 50 profiles were generated from the database from over 100 samples. This resulted in successful removal of excess drums from Galena Airport. A baseline for HW and UO has been developed and henceforth the database will track waste reduction efforts as required under federal pollution prevention requirements. Sampling, analysis, transportation, and disposal costs are reduced simply by streamlining waste sampling and characterization, and controlling waste accumulation at the source. At all sites, more used oil is being recycled instead of disposed as hazardous waste. Unlike report-centered databases, the HW/UO database will allow for expansion to accommodate new activities such as more comprehensive materials tracking, pollution prevention, oil/water separator management, and municipal waste management.

1. Codd, E.F. 1990. The Relational Model for Database Management. 2nd Ed. Addison-Wesley Publishing Co., Menlo Park, California.

SESSION VI

POLLUTION PREVENTION SUCCESS STORIES

Session Chairpersons:
Jo Walker, HQ SPACECOM/CEV
Captain Tim Green, HQ AFCEE/EP

HOME of the SICK, LAME, and LAZY....

SRA Keith S. Koskela
416 Logistics Group Environmental Flight
Griffiss AFB, Rome NY 13441
DSN:587-4479 COMM: (315) 330-4167

The Logistics Group Environmental Manager's handbook, from Maxwell AFB, stated that Logistics Group environmental management is typically a dumping ground for 'the Sick, Lame, and Lazy.' That statement might have been true five years ago but the Griffiss AFB Haz-Mat Cell has proven it very false. The Haz-Mat Team, through initiative, innovation, and hard work, has proven itself as a leader in the environmental awareness and operation of Griffiss AFB.

PROGRAM INCEPTION

In September 1992, the Headquarters Air Combat Command (HQ ACC) Environmental Compliance Assessment Management Program (ECAMP) team identified numerous problems in the management of 90-day hazardous waste accumulation points. The team then recommended the consolidation of these accumulation points. At that time, the 416th Logistics Group had eight separate accumulation points, overall the base had a total of twelve. In October 1992, the 416th Logistics Group Commander created a full time environmental manager position to improve and monitor the environmental compliance issues for the group. Several key issues were determined to be the root cause of the problems. The issues were identified through one-on-one communications between all parties involved in the process.

(1) Inadequate training at the accumulation points.
(2) Rapid personnel changes in management led to problems in training and documentation.
(3) Duplication of work was widespread. Every point had to maintain a separate set of inventory and inspection records. Civil Engineering's workload also increased trying to mange numerous programs.
(4) Too much work and not enough time to manage were the major factors. This was evident at hazardous waste accumulation points, Civil Engineering (CES), and at the Defense Reutilization and Marketing Office (DRMO).

The Haz-Mat Cell was established in September 1993 to support the maintenance areas of the Logistics Group (LG). The primary intent of the Haz-Mat Cell is to offer a truly "customer-oriented" program. The Cell offers a variety of unique customer service ideas to relieve the generating unit of time consuming work. The Cell works to meet the waste reduction goals set by HQ ACC and the State of New York while keeping Griffiss AFB in compliance with local, state, federal, and Air Force regulations. The Cell strives to initiate cost avoidance measures to reduce the overhead operating cost.

The Haz-Mat Cell is divided into six key departments: General Management, Waste Staff, Driver Section, Customer Service, Re-Issue Center and Inspections. The departments operate on a separate but cooperative basis to produce a cross-feed of information regarding all aspects of the Cell's day to day operations. Environmental Management is too diversified for one set of personnel to specialize in all areas. The separate departments combine their individual expertise to create a knowledgeable and professional staff achieving a combined result. During the 1994 Base Closure Environmental Assistance Team (BCEAT) inspection, the BCEAT Team recognized Griffiss AFB as the best they have inspected. The team contributed the success of the inspection to the management and leadership of the Haz-Mat Cell.

FUNDING AND MANNING

Funding opportunities for the Haz-Mat Cell are coordinated through HQ ACC and locally. In August 1993, a Simplified Acquisition for Base Engineering Requirements (SABER) contract was approved for $150,000 to up-grade the building to meet Occupational Safety and Health Administration (OSHA) and New York Department of Environmental Conservation (NYDEC) standards. Four transportable flammable storage shelters were relocated to the Haz-Mat Cell storage lot for expanded storage space. The Wing funded an additional $30,000 for spill response, personal protective and warehousing equipment. Excess computers were donated from other Logistics Group squadrons for use in the Haz-Mat Cell. Communications were installed for telephones, fax, and Standard Base Supply System (SBSS) data lines.

Personnel were recruited from throughout the Logistics Group to fill nine full time positions. All nine were selected from a large field of volunteers based on professional background, knowledge, and dedication. The Logistics Group Commander hand-picked the Haz-Mat Cells' Noncommissioned Officer In Charge (NCOIC). Two additional military members were selected after operations began to meet mission requirements. There are currently nine military and two civilian employees. Through this selective process the Hat-Mat Cell has the service of diversified and highly dedicated personnel.

FACILITIES

The Haz-Mat Cell currently utilizes an abandoned weapons storage facility. The building offers a tremendous amount of storage space with wide accessible entrances. These conditions make for easy transportation and manipulation of containerized waste. Contractors, working under the SABER contract, are upgrading the building to meet flammable and corrosive material storage standards.

The building contains four large storage bays and four securable vaults. Two large bays have been upgraded to meet flammable storage requirements. Corrosives are stored in another large bay equipped with a diked area, deluge shower, and emergency eye wash system. The fourth large bay is utilized for empty container storage. The four vaults are storage areas for nonflammable and non-corrosive waste. Portable shelving units, spill response equipment, and the necessary personal protective equipment are available in each area. A former missile maintenance area is converted to the Haz-Mat Re-Issue Center. Ten storage shelves and three fire-lockers are used to house and display available items. Four transportable storage facilities are located in a controlled access area for additional flammable storage. Office areas have been refurbished creating an ergonomically appealing work environment.

CUSTOMER SERVICE CENTER

When people envision a Customer Service Center it's usually of a department store not of a Hazardous Waste Storage Facility. Customer service is the driving force behind the success of the Haz-Mat Cell. The Customer Service Center is the central environmental information center for the entire base. The service representative is readily available to give guidance and answer technical questions regarding Ozone Depleting Compounds (ODCs), hazardous waste and material, EPA 17 chemicals and chemical alternatives. The service representative helps to resolve local problems within established Department of Defense disposal policies. A tracking system for hazardous material issues and requisitions is maintained in the Center to determine if Air Force environmental policies and goals are being met. The Customer Service Center guarantees customer satisfaction.

TRAINING AND AWARENESS

Through the distribution of environmental awareness literature, such as "Environmental Flashes" and a "Customer Services Guide Book," the customer service center is raising the environmental awareness of the entire base. Haz-Mat Cell management also directs a Pollution Prevention Working Group (P2) monthly to discuss, in open forum, environmental issues regarding EPA 17 chemicals, ODCs, hazardous waste and material and other environmentally significant issues.

The Customer Service Representative assists in the development and presentation of the Haz-Mat Cell training program. Resource Conservation and Recovery Act of 1971 (RCRA), OSHA, and Accumulation Point Management training are offered to all personnel who are required to be trained. The training and awareness programs help base personnel understand and cooperate with the Haz-Mat Cell.

Haz-Mat personnel are engaged in a continual training program to improve the quality of their performance. Cell personnel are trained in a variety of environmental specialties that best fit their current position. Training consists of On the Job Training (OJT) and off base certified training classes. Professional and required Air Force training is scheduled and completed in accordance with all Air Force regulations.

RE-ISSUE CENTER

Griffiss AFB is slated for realignment in September 1995. Due to this, the plans for a Pharmacy type Haz-Mart were abandoned. The concept for the Re-Issue Center was then adopted. All materials turned into the Haz-Mat Cell are inspected for serviceability and if deemed serviceable they are then given to the Re-Issue Center for reissue potential. Items in the Re-Issue Center are all excess items turned into the Haz-Mat Cell by shops that no longer have a use for the product. All reissuable items are available to any shop that is approved to utilize such items by Bio-Environmental Engineering (BEE) at no cost. This system ensures unused items are reissued before any new base supply stock is utilized. The only stipulation is the item is used completely or returned for reissue. The Re-Issue Center has reissued over 200 items for a cost avoidance savings of $12,336.46 for the period covering January to July 1994.

ACCUMULATION POINT MANAGEMENT

The Haz-Mat Cell is a 90-Day Hazardous Waste Accumulation Point. The Cell's original operational design was to serve as a consolidated accumulation point for LG maintenance areas replacing all former LG accumulation points. Today the Haz-Mat Cell is a centralized Wing accumulation point, working functionally for the Wing Environmental Leadership Council (EPC). The Cell's management works closely with every agency on base, Civil Engineering, DRMO, and BEE to find the best possible solution to the Wing's environmental issues.

The Haz-Mat Cell management has service contracts with known waste generators within the installation boundaries. The service contract is an agreement of terms set between the Haz-Mat Cell and the generating shop; it consists of a waste pick-up schedule, waste streams to be picked up, and both parties' responsibilities are covered in the agreement. All processing forms, tracking logs, and databases used in the Haz-Mat Cell are locally generated. The Haz-Mat Cell visitor badges are also locally generated. The badges are numbered to maintain an immediate count of all visitors in the accumulation point; emergency egress instructions are printed on the back.

At one time hazardous waste management only meant one thing, severe headaches. When the LG examined the current problems in waste management they came to the conclusion, that any type of waste facility had to be customer oriented. General management adopted this new approach to the operational functions of the Haz-Mat Cell. Management continuously strives to make this Cell even more user friendly. Now all the customer has to do if their shop is not on the daily pick-up route, is simply bring the waste to the Haz-Mat Cell and furnish the staff with information, (i.e. shop, phone number, name, and type of waste).

The Haz-Mat Cell provides technical, informational, and physical support to all satellite points. All hardware for satellite points, (i.e., drums, signs, grounds, and spill containment) is furnished by the Cell; this ensures uniformity and compliance at all of the satellite points on base.

Management tracks current success and problem areas with use of Quality Performance Measures (QPMs). The information contained in the QPMs is gathered from all operation areas by the inspection staff; management then uses this information to make any necessary modifications to improve quality and customer service.

SATELLITE POINTS

Currently there are fifty-nine daily satellite pick-up points on Griffiss AFB. Each Satellite Point is equipped with all necessary hardware, a drivers' inspection log and a driver sign-in log. The driver sign in log is used to keep a written record of activities at the Satellite Point. If the satellite point is on the Daily Pick-up List, the satellite manager has to maintain cleanliness of the satellite point, ensure all lids are secure, receive the proper training taught by Haz-Mat Cell personnel and maintain immediate supervision of personnel utilizing the site. The Haz-Mat Cell takes responsibility for controlling the quantity of waste at the site and maintaining the inspection log. The Satellite Point managers no longer have to undertake the administrative role. Managers are encouraged to reference the driver inspection log daily so as to correct any overlooked errors. The Haz-Mat Cell team feels this has greatly reduced the Satellite Point manager's workload and headaches.

DRIVER SECTION

The drivers daily actions at each satellite point are to enter the shop, sign the driver log for proof of visitation, perform daily inspections and annotate the findings in the inspection log, then remove the waste. The waste is transported to the Haz-Mat Cell for processing. The drivers are trained in Emergency Response, Hazardous Waste Operations and Emergency Response (HAZWOPER), and the proper transportation of hazardous waste. Because of this training, the drivers can handle any situation that might arise.

Four excess vehicles were acquired for use in the driver section. The truck most used in the section has a hydraulic lift-gate installed for heavier containers and easy unloading. All the trucks are equipped with a mounted two-way radio for direct communication with the Haz-Mat Cell. The drivers wear web belts containing one personal pager and a hand-held radio. Several precautionary measures are taken to help prevent any type of incident. The trucks carry one emergency spill kit, all necessary personal protective equipment, and tools for safe handling. The driver section has not had any incidents since operations began.

The drivers are ambassadors for the Haz-Mat Cell. Most Satellite Point managers rarely visit the Haz-Mat Cell but they do interact with the drivers every day. The drivers can give guidance and recommend action needed to improve the Satellite Point. This plays a large role in a positive customer service attitude toward the Haz-Mat Cell.

WASTE PROCESSING

Once the waste enters the accumulation point it is placed in the processing area where the waste staff proceeds with documenting, classifying and storing the item. The Haz-Mat Cell completes and processes all waste turn-in paper work for the Wing and assists with the off base locations; relieving satellite point managers of the extra workload returning them to mission duties. The Haz-Mat Cell limits the number of people involved in the 'paper-trail' to eliminate work duplication and inconsistency. Waste is tracked by using an in-processing form, which displays critical item information, such as generating unit, phone number, serviceability, and specific type of waste. Before the item is stored it is given a local tracking number and entered into the waste log along with the item information. The waste log information is then updated into a local database for easy reference and tracking.

After the waste is stored in the main Accumulation Point it is ready for bulking or turn-in. The Waste Staff condenses waste and reduces cost by bulking waste according to waste stream and compatibility. In order to limit the amount of waste stored in the Accumulation Point and reduce the risk of an item exceeding the 90 day time limit ontainers are turned in at DRMO when it is full. The Waste staff, to date, has received and processed over 47,000 lbs. of waste. The average amount of storage time in the Accumulation Point is 45 days.

TURN-IN PROCEDURES

Hazardous and non-regulated wastes are processed through the Waste Staff. After the Waste staff prepares the appropriate DRMO turn-in forms, the items are transported to DRMO by the Driver Section and one member of the Waste staff. The paper work is checked by a trained DRMO hazardous material specialist. When the paper work is accepted, the waste is off-loaded at the DRMO hazardous waste storage facility. The containers are inspected by DRMO for proper marking, cleanliness and serviceability.

After the turn-in, all logs are annotated to reflect that the waste was transferred to DRMO. All accompanying paper work is filed and recorded for future reference. The Waste staff works closely with DRMO to ensure waste is handled in accordance with all regulations.

INSPECTION

The Inspection staff utilizes the ACC Environmental Managers Inspection Checklist to performe weekly accumulation point self inspections and no-notice Wing inspections. All inspection discrepancies and corrective actions are annotated on AF Forms 2420. The AF Forms 2420 are copied and filed for future reference.

Discrepancies are separated into several areas. Areas include RCRA, housekeeping, inventory, container management, labeling and safety. Differentiating between types of discrepancies aids in training for problem areas.

Wing inspections are conducted to evaluate and determine reoccurring problems with the environmental management of the Wing. The inspector utilizes the same inspection criteria for Wing inspections as is used in accumulation point inspections The inspectors have greatly reduced the amount of discrepancies for the Wing.

RECYCLING CENTER

Griffiss AFB arguably has the best Haz-Mat Cell in the Air Force, but along with that it has a successful and profitable recycling center. The Recycling Center is in close proximity to the Haz-Mat Cell. Both buildings are centrally located and easily accessible. Recycling has exploded in popularity on the base. The Recycling Center is staffed by two full time employees and two detailed workers. The Center handles and processes everything from paper products to metals. Currently the Center is processing over ten tons of material weekly.

The Recycling Center works like the Haz-Mat Cell. Empty recycling baskets are given to shops; when the recycling baskets are filled, the shop delivers the baskets back to the Recycling Center. Every basket is separated by hand to ensure a pure material. After the materials are separated they are bailed and prepared for sale.

The Recycling Center has processed 767,313 lbs. of material for the period of January to July 1994. The cost avoidance for the processed material is $42,455.00. The approximate revenue generated is $15,161.62 for calendar year 1994.

SELF-INITIATED WASTE REDUCTION

The Haz-Mat Cell actively seeks improved techniques in waste reduction. The Waste staff has implemented several waste stream elimination practices. A device was designed and built to sever the aluminum and brass ends of incandescent light bulbs. The device, 'the Matusick Masher,' eliminated the incandescent waste stream and now the separate materials are recycled. The estimated cost avoidance for the year is $5000.00. A fluorescent light bulb crusher was purchased for $1,800 to condense the fluorescent bulb waste stream. The Waste staff designed a metal screen to separate the aluminum from the glass as it is crushed. The mercury vapor contained inside the bulb is filtered through the machine's filtering unit. The two separate materials, aluminum and glass, are now recycled. Fluorescent bulbs were the largest and most costly waste stream until the screen was used. The fluorescent light bulb waste stream is now reduced to just the used mercury filter from the bulb crushing machine. The estimated cost avoidance for the year is $18,000. The Matusick Masher and the screen were built from scrap materials; total cost of manufacturing was less than $100.00. Aerosol paint cans are now punctured then crushed in a hydraulic press. The Recycling Center accepts the crushed cans as recyclable aluminum. The Haz-Mat Cell produces approximately one thirty-gallon drum per week of crushed cans. Figures are not available for the cost avoidance of the recycled cans.

CLOSING

The Haz-Mat Cell staff are very proud of their achievements. We also invite all interested parties to visit the Haz-Mat Cell and witness the operation first hand. Cell personnel are always available to answer any questions regarding policies and operations. The team would also wish to express sincere a thank you to everyone who helped and participated in the creation and continued improvement of the Haz-Mat Cell. A special recognition is given to HQ ACC for their continual support of the program.

ENVIRONMENTAL APPROACH TO FIRING RANGE BACKSTOPS

Presented at the

Air Force Worldwide Pollution Prevention Conference and Exhibition
(29 Aug - 1 Sep 94)

by: Larry Webb, P.E., R.E.M.
Dyess Air Force Base

1. Background

The small arms range at Dyess AFB is relatively new and was designed utilizing current technology however, two major problems quickly developed. ***First***, the bullet impact berm which was constructed with a 45-degree frontal slope quickly eroded and sloughed off, permitting ricochets (primary and secondary) to more easily leave the range. Also, with the more flattened slope, ricochets can leave the range at less than 45-degrees from the horizontal and, as such, are considered unsafe. ***Second***, these ricochets have the potential for spreading toxic (lead) contamination downrange of the firing line near the Little Elm Creek which flows into Lake Fort Phantom. This lake is the primary source of drinking water for the City of Abilene, Texas. Figure 1 illustrates the design and existing configuration for the firing range at Dyess AFB.

2. Range Usage

This firing range is utilized primarily for weapons qualification/familarization training by organizational units at Dyess AFB. It is also used by various reserve units (490th Army Reserve, 111th Army Guard, Naval and Marine Reserves, etc.), as well as other Air Force Bases - Goodfellow AFB from San Angelo, Texas. Additionally, the range is open to the public for two periods each week. The primary military weapons being fired at the range include M-16 assault rifles, M-60 machine guns, and 9-mm pistols. Recreational firing by the public include most hunting calibers such as 22, 30-06, 7-mm, 30-30, etc. Utilizing the conservative estimating concept of 100 shooters per week firing 40 rounds each, ***in excess of one ton of lead per year can be accumulated at this firing range!***

3. Design Parameters

To rectify these problems, the Civil Engineer Squadron at Dyess AFB established design parameters and evaluated various options. ***First***, it was essential that the spread of lead contamination be discontinued as the toxicity effects of lead on humans (disorders of the brain, kidney dysfunction, anemia, infant mortality, etc.) are well known (Ref. 1). ***And***, Dyess AFB wanted to resolve Air Force Safety Criteria - criteria which states that a round leaving the firing range is inherently safe if it leaves at an angle of greater than 45-degrees from the horizontal. Such ricochets will quickly expend their energy and free fall to the ground (Ref. 2). To address/resolve such design parameters, some of the options considered are presented as follows:

(*paper.doc*-21Jul94)

- **Option 1**: Consideration was given to restoring the range to its original design conditions which would restore the 45-degree bullet impact berm and allow compliance with safety requirements regarding ricochets. This option was quickly rejected as it was only a temporary solution as the berm would begin to erode/slough immediately and the spread of lead contamination would continue. There was the additional concern of the spread of lead contamination during construction.

- **Option 2**: The addition of a bullet deflector to the top of the bullet impact berm to intercept/deflect ricochets was evaluated. Figure 2 illustrates this option. This option presents a viable solution to the safety issues; however, the spread of lead contamination would continue unabated. Accordingly, this option was also rejected.

- **Option 3**: The development of toxic-free ammunition has not progressed sufficiently to eliminate the current need for conventional lead collection measures (Ref. 3). Also, various premanufactured bullet traps were evaluated ("Snail" by Passive Bullet Traps, Inc, "Rubber Composite Bullet Trap" by Caswell International Corporation, and "Bullet Trap" by Action Target, etc). Each of these products was found to have merit; however, the adoption of a design concept utilizing a full firing range (width and height) bullet catch appears to be the only option capable of meeting the established design goals and allowing the full use of the existing range. Figure 3 illustrates the selected concept of a combination bullet catch/bullet trap.

4. Bullet Catch

The bullet catch would consist of a backstop steel plate with the following specifications:

- Minimum tensile strength = 190,000 pounds per square inch
- Brinell hardness of 400-440
- Minimum plate thickness = 3/8-inch
- Mounting angle = 45-degrees with the horizontal

Several manufacturers of steel plate were contacted regarding meeting these specifications. Lukens Hardwear and USS novAR Abrasion-Resistant Steel appear to make an economical product in plate steel which does comply with the specifications. It should be noted that the Brinell hardness of cast lead is 4.2; thus, the backstop plate will have a Brinell hardness number that is almost 100 times larger. This feature plus the following additional design concepts should provide an even greater life for the backstop plate:

- Utilize 1/2-inch thick plate
- Install the plate on a 40-degree angle with the horizontal for a more effective angle of deflection
- Place the center section of a steel plate behind each target centerline to minimize bullet impact to the plate joints which must be field welded with possible reductions in hardness and tensile strength

5. Bullet Trap

A bullet trap is selected that can be utilized either in the sand trap mode or in a combination sand/water trap configuration. The following concept from the subgrade up is selected:

- Subgrade soils prepared to receive premanufactured liners
- Double 40-mil high density polyethylene liners
- Non-silica type sand (6-inches)
- Water (6-inches)
- Freeboard (6-inches)

Deflected bullets will quickly expend their energy in the water and settle in - on top of the sand. Hence, the water will serve to trap and store the diverted bullets from the bullet catch in a submerged mode and will hold down lead dust. The normal drain/filtration system associated with a water trap is not considered necessary as Dyess AFB is located in a semi-arid area of West Texas with a net evaporation loss of approximately four-feet. In anticipation of a planned lead recovery phase, water addition to the bullet trap would be discontinued for a period of time to allow natural evaporation to occur. After sufficient evaporation has occurred, the sand could be easily sieved to recover/mine and ultimately dispose of the lead via recycling. After the lead is recovered, water would be added back to the bullet trap and range use could continue. The liners will insure that soluable lead is contained and prevented from downward migration.

6. Existing Lead Contamination

One legal theory holds that the deposition of lead and/or copper jacketing in earthen backstops on an active small arms range does not constitute disposal, rather the bullets are being used for their intended purpose, and are not considered solid waste. However, another legal theory asserts that the existing lead laden bullet impact berm ***becomes a regulated solid waste upon its abandonment*** or non-use following the construction of a bullet catch and bullet trap. Regardless of the correct legal theory, it was decided to identify the extents and types of lead contamination and then clean it up - in conjunction with the construction project for the bullet catch and trap.

Extensive testing of the soil downrange of the firing range was performed in February 1994. Figure 4 illustrates the results of this testing program. Surficial samples as well as samples with depth were taken to determine lead concentrations and leaching rates. The following results were considered illustrative of leaching rates:

Sample No.	Location	TCLP lead (ppm)
992	surface	6.8
993	3" below surface	less than 0.1
994	6" below surface	less than 0.1

This data confirms the known nature of the tight red-clay soils at Dyess AFB which will restrict and limit downward migration of leachate. Consequently, the removal of lead bullet fragments by sieve methods at the surficial level is expected to constitute adequate clean up.

However, cleanup of lead contamination in the face of the bullet impact berm will prove more complex. Significant deposits of lead were lodged in this slope face over a period of 6-years. Additionally, the sloughing/eroding of the slope face has shifted some of the lead contamination down the slope. Sampling/testing of soil samples in the bullet impact berm directly behind the targets established that 165-cubic yards of lead contaminated soil (TCLP lead greater than 5 ppm) will require resolution by treatment or disposal.

7. Treatment or Disposal?

Current disposal cost estimates for drummed hazardous waste runs approximately $3,000 per cubic yard of solid waste. The cost to gather and drum the material is an additional expense. Relating this cost to the 165-cubic yards of lead contaminated soil yields a disposal cost estimate of $495K. To develop cost alternatives, a search of the available literature was begun.

A process of sieving and stabilization of lead-contaminated soils has been successfuly performed at various locations. One successful full scale project was performed at the Mayport Naval Air Station (Ref. 4). This project utilized a pilot test program and tried various mixtures of portland cement, soil, water, and silicate. Eventually, 170 cubic yards of lead contaminated soil was treated for a total cost of $130K or $765 per cubic yard (Ref. 4). This cost also ***included the cost of the pilot test, mobilization, travel, excavation of the berm, replacement of treated soil on the berm, oversight, planning, and extensive sample analysis.*** The sieving/stabilization cost estimate of $765/CY at the Mayport Naval Air Station compares quite favorably with the estimated disposal cost of $3,000/CY. Even more favorable cost comparisons are obtained when adding the cost of gathering and drumming for the disposal method. Utilization of lessons learned at the Mayport Naval Air Station are expected to yield further significant cost reductions.

8. Treatment Process of Sieving/Stabilization

Some of the lessons learned at the Mayport Naval Air Station include:

- A 1/2-inch screen proved satisfactory in sieving out most of the bullets. Small screens continually clogged and a vibrating screen was suggested.
- Utilize concrete trucks as the mixing device
- The successful ratio included: 1)7.2 CY soil, 2)30 gal silicate, 3)4400 lb cement, 4)500 gal water, and 5)1 cup soap.

9. **Regulator Review**

The testing results, proposed bullet trap/catch, and proposed treatment scheme (Sieving/stabilization) were presented informally to the Regulators (Texas Natural Resource Conservation Commission) in June 1994. The presentation was favorably received.

10. **Conclusions**

The annual operating costs associated with lead recovery for this proposed range backstop design is considered as being only ***minimal*** when compared to such costs based on the current design (earthen backstop at 45-degree angle). This proposed range backstop design appears to ***completely resolve the known environmental issues***, and, it further provides the secondary benefit of ***resolving the safety issue of stopping ricochets!***

Currently, Dyess AFB is seeking funding to allow proceeding with the project.

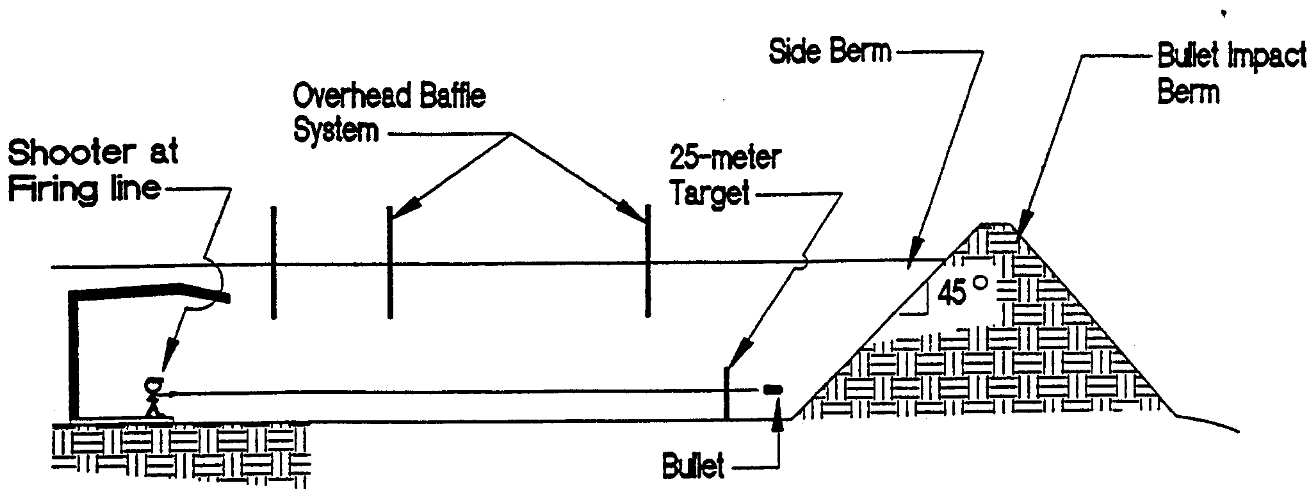
LIST OF REFERENCES

1. Environmental Effects of Small Arms Ranges, by Naval Civil Engineering Laboratory Port Hueneme California, October 1991, by J.C. Heath, L. Karr, V. Novstrup, and B. Nelson, NCEL and S.K. Ong, P. Aggarwal, J. Means, S. Pomeroy, and S. Clark of Battelle.

2. Combat Arms Training and Maintenance Program Training Management and Range Operations, AF Pamphlet 50-63, Volume 1, 26 February 1993.

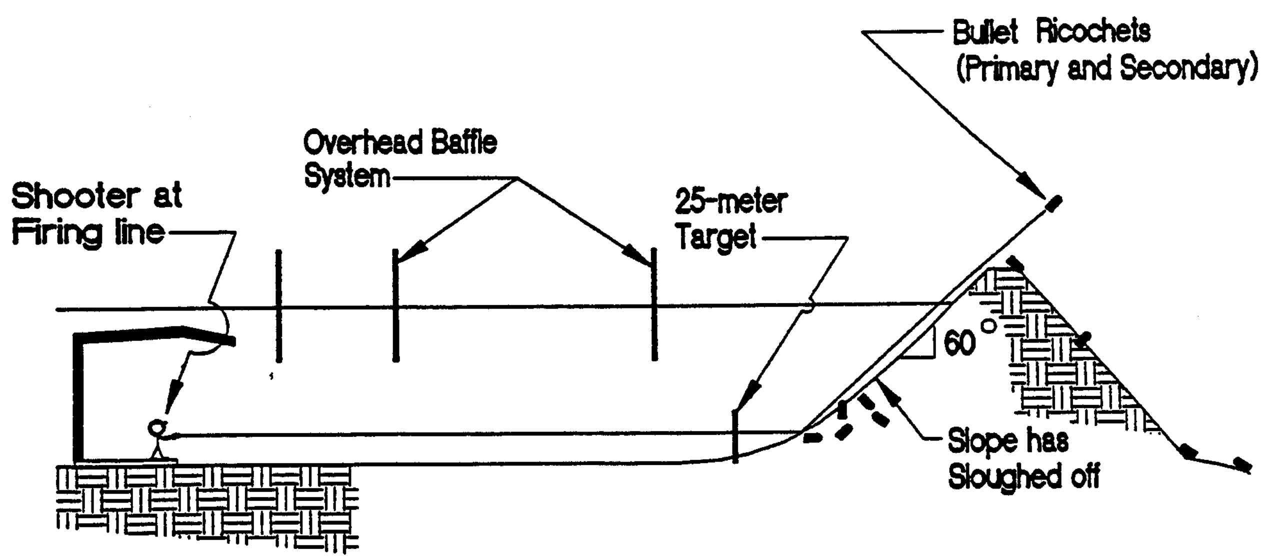
3. Development of Toxic Free Ammunition, by U.S. Army Armanent Research Development and Engineering Center, John Middleton - Project Engineer, 1993.

4. Field Demonstration of a Sieving and Stabilization Technology on Lead-Contaminated Soils at a Small Arms Range at Mayport Naval Air Station, by Battelle to the Naval Civil Engineering Laboratory in February 1991.



FIRING RANGE, AS DESIGNED (1988)

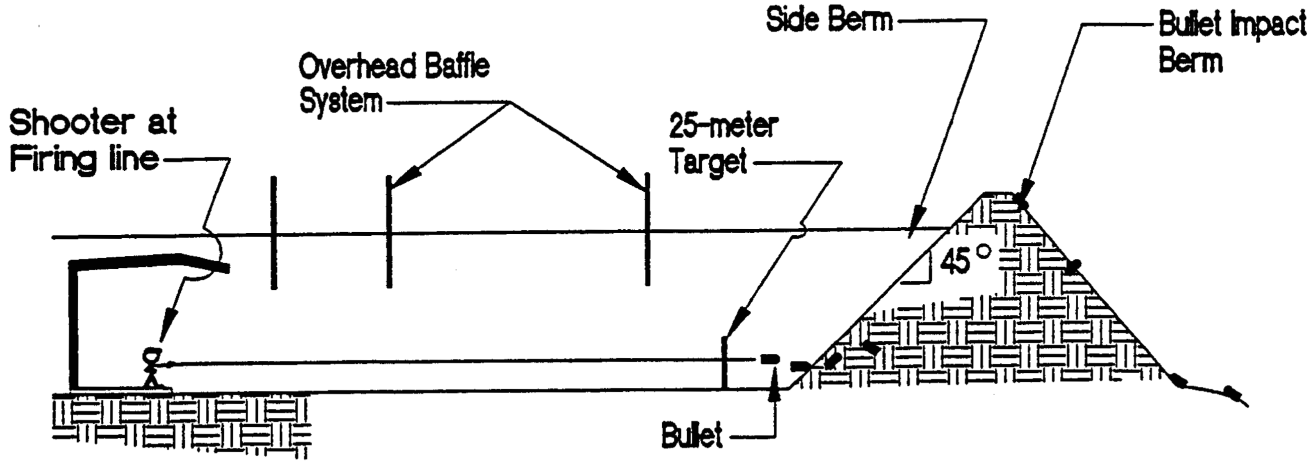
PROBLEMS: The 45-degree bullet impact berm began to slough off immediately.



FIRING RANGE, EXISTING (1994)

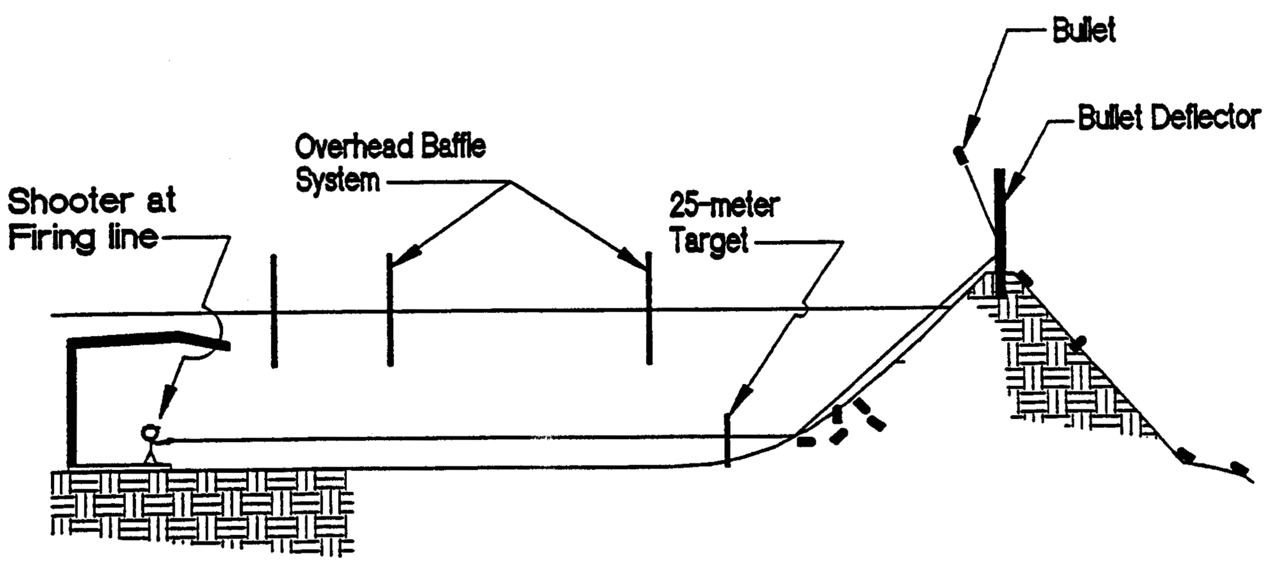
PROBLEMS: 1) Lead contamination is being spread extensively.
2) The slope is less than 45-degrees: unsafe ricochets.

Figure 1



OPTION NO. 1: Restore the 45-degree slope

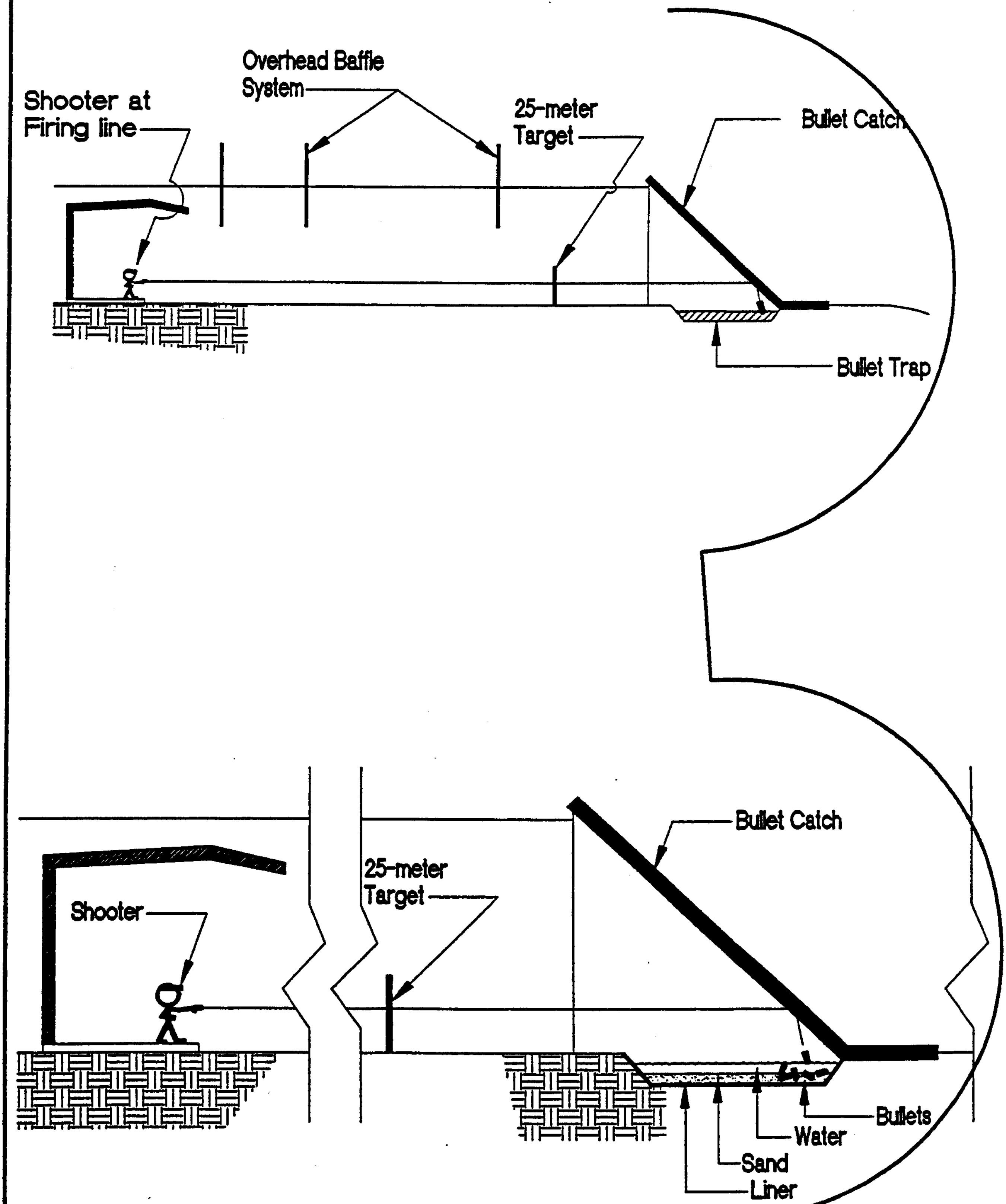
PROBLEMS: 1) 45-degree slope temporary - will begin to slough immediately.
2) The spread of lead contamination will continue
3) Construction will probably spread lead contamination
4) Annual restoration would be required



OPTION NO. 2: Install Bullet Deflectors

PROBLEMS: 1) Lead contamination continues.

Figure 2



OPTION NO. 3: Provide Steel Backstop

Figure 3

Sample No.	TCLP Pb (ppm)	Sample type/location
990	4.3	Surface, composite sample
991	less than 0.1	Surface, composite sample
992	6.8	Surface, individual grab sample
993	less than 0.1	3-inches down, individual grab sample
994	less than 0.1	6-inches down, individual grab sample
995	0.4	Surface, composite sample
996	42.7	Surface, individual grab sample
997	150	Surface, individual grab sample
998	14.6	Surface, individual grab sample
999	2.4	Surface, individual grab sample

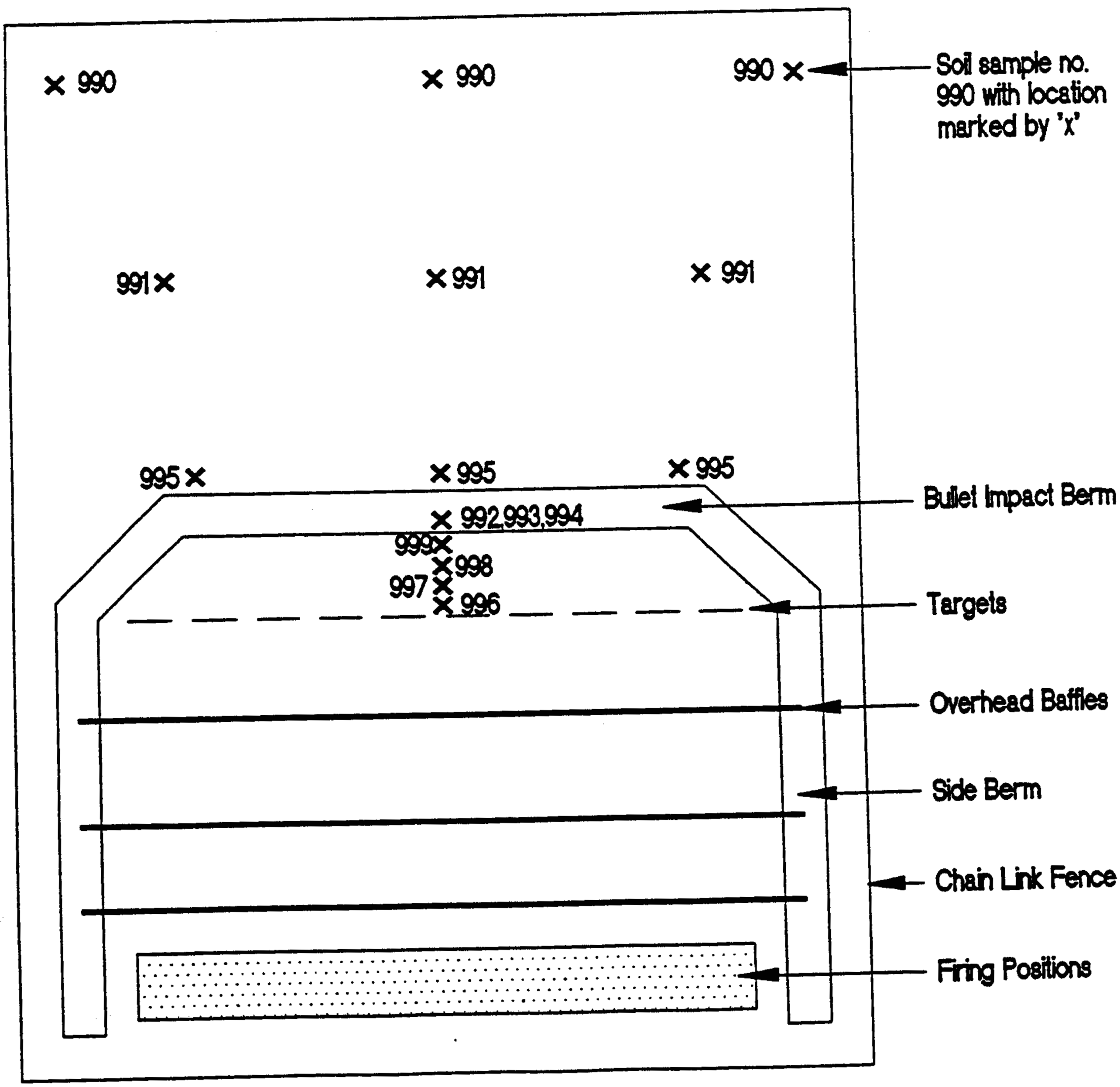


Figure 4

Navistar Success Story

Pollution Prevention Saves Money at Both Ends of the Pipe

by

John M. Mann, PE
Associate Partner
WOOLPERT
12700 Shelbyville Rd., #100
Louisville, KY 40243
(502) 244-4130

James A. Brandt
Construction Manager
NAVISTAR INTERNATIONAL
4949 Urbana Road
Springfield, OH 45501
(513) 390-4625

Overview

In order to maintain the pristine condition of the Mad River, one of Ohio's premier trout streams, Navistar International's Truck Assembly Plant, had to comply with stringent Ohio Environmental Protection Agency (OEPA) National Pollutant Discharge Elimination System (NPDES) requirements for heavy metals, oil and grease, BOD, TSS and NH_3N in their renewed permit.

To meet these new parameters, Navistar and Woolpert teamed together in a two staged approach. The first stage implemented pollution prevention opportunities to reduce and control the amount and strength of pollutants being directed to the wastewater treatment plant. The second stage maximized existing wastewater treatment capabilities while minimizing treatment plant capital, operation and maintenance costs.

Background

The Springfield Assembly Plant of Navistar International Transportation Corporation produces medium and heavy duty trucks. The plant has two final assembly lines, each a half-mile long and fed by miles of conveyor systems carrying components to employees stationed at points along the lines. A truck begins as two steel frame rails are placed on moving conveyors in the "frame room." After holes are pierced in the frames, steel cross members lock the rails squarely together; front and rear axles are then added. Several feet farther along the line the engine is dropped into place, chassis paint is applied, tires are mounted, fuel tanks and fuel lines are installed, and a cab is lowered into position through a second floor hatch.

On conventional models, a fiberglass hood is locked into place, radiator and hoses attached, seats installed, battery connected, horn tested, ignition key switched on, and a brand new International Truck drives off the end of the assembly line. Here, too, is the most modern paint facility in the world where International Trucks adopt their distinctive colors and paint patterns in hundreds of combinations.

As a result of the assembly process, three types of wastes are generated at the Navistar assembly plant. These wastes are classified as industrial, sanitary and E-Coat. Industrial and sanitary wastes are produced by the Finish Paint Facility and the Truck Assembly Plant. E-Coat waste is only produced by the Finish Paint Facility. An additional sanitary flow is produced by the Truck Sales and Processing Center. The facility provides its own on-site wastewater treatment for both its industrial, E-coat and sanitary flows. The .3 MGD wastewater treatment plant discharges into an unnamed tributary of Moore Run under the Ohio Environmental Protection Agency's National Pollutant Discharge Elimination System.

During the last NPDES permit renewal, Navistar was informed that their final discharge limits were to become more stringent (please see Exhibit 1) in order to better protect the cold water habitat of the Mad River, (into which Moore Run ultimately discharges) and to safeguard the groundwater recharge in the area.

To meet these new NPDES parameters, Navistar and Woolpert teamed together in a two staged approach. The first stage implemented pollution prevention procedures upstream of the wastewater treatment facilities and the second stage maximized the facilities wastewater treatment capabilities while minimizing capital, operation and maintenance costs.

Stage One

To develop successful first stage results, the team had to overcome worker insensitivity to pollution cause and effect and develop current accurate information on waste stream generators and waste stream characteristics. To overcome worker insensitivity, Navistar began an in-house educational program on pollution prevention. The program included the creation of pollution prevention teams, the development of pollution prevention fact books, and articles in the facilities newsletters. The information provided focused on identifying pollution causes, the costs involved in properly handling the pollution and how the individual worker's pollution prevention efforts can directly assist in controlling these costs and improving not only the environment, but the company's bottom line. As a result, Navistar was able to significantly reduce the amount of pollution generated at the facility, and in doing so, realized substantial cost savings.

For example, the implementation of a single base coat paint system has resulted in:

- 370 gallons per day less purge solvent usage
- 310 gallons per day less paint waste
- $2.7 million per year in cost savings.

Redesigned bottom feed paint urns which now allow all of the paint in the urn to be used, further reduces the quantity of paint wasted by 17,000 gallons per year, at a cost savings of $680,000 annually.

Another pollution prevention effort replaced the methylene chloride blend of solvents used to clean paint guns with a less toxic cleaner. The replacement solvent blend is not a listed hazardous waste and contains no chemicals listed by the EPA on the hazardous pollutants list. The result was a reduction of 49,000 lbs. annually in hazardous air pollutants and 97,000 lbs. per year of listed hazardous waste.

To further identify wastewater pollution prevention opportunities, Navistar interviewed and cataloged each plant operation and then, working with Woolpert, reviewed sewer segments to identify suspected cross connections and sources of infiltration. From this information pinpoint line repairs were made and cross connections eliminated. Strategic flow measurement and samplings of selected waste streams were then completed to determine wastewater treatment needs. The results of the investigation cut wastewater peak flows in half, and decreased loadings of BOD by 35% and TSS by 80%.

Effluent Characteristics		Discharge Limitations				Monitoring Requirements	
		Concentration Other Units (Specify)		Loading* kg/day			
Reporting Code/Units	Parameter	30 Day	Daily	30 Day	Daily	Measurement Frequency	Sample Type
00010 deg. C	Water Temperature ***	---	---	---	---	Daily	Daily Max.
00083 UNITS	Color, Severity **	---	---	---	---	Daily	Observation
00300 MG/L	Dissolved Oxygen	---	5.0 (min.)	---	---	1/Week	Grab
00310 MG/L	Biochemical Oxygen Demand (BOD)	12	18	14	21	1/Week	Grab
00530 MG/L	Residue, Total Nonfilterable	12	18	17	25	1/Week	Composite
00550 MG/L	Oil & Grease, Total	10	10	14	14	1/Week	Grab
00610 MG/L	Nitrogen (NH3)	---	---	---	---		
	(Summer)	2.5	3.75	3.5	5.63	1/Week	Grab
	(Winter)	---	10	---	14	1/Week	Grab
00665 MG/L	Phosphorus, Total (P)	---	---	---	---	1/Week	Composite
00719 MG/L	Cyanide, Free (1)	---	0.092	---	0.13	1/Week	Grab
01027 UG/L	Cadmium, Total (Cd)	30	49	0.042	0.069	1/Week	Composite
01032 UG/L	Chromium, Hexa-Valent (Cr + 6)	---	---	---	---	1/Week	Composite
01034 UG/L	Chromium, Total (Cr)	---	---	---	---	1/Week	Composite
01042 UG/L	Copper, Total (Cu)	---	---	---	---	1/Week	Composite
01051 UG/L	Lead, Total (Pb)	---	---	---	---	1/Week	Composite
01067 UG/L	Nickel, Total (Ni)	200	2262	0.28	3.16	1/Week	Composite
01077 UG/L	Silver, Total (Ag)	---	---	---	---	1/Week	Composite
01092 UG/L	Zinc, Total (Zn)	---	370	---	0.518	1/Week	Composite
01330 UNITS	Odor, Severity **	---	---	---	---	Daily	Oberservation
01350 UNITS	Turbidity, Severity **	---	---	---	---	Daily	Oberservation
22456 UG/L	PAHs (2)	0.82	---	0.0011	---	1/Month	Grab
31616 #/100M	Fecal Coliform (Summer Only)	1000	2000	---	---	1/Week	Grab
31648 #/100M	E. coli (Summer Only)	---	---	---	---	1/Week	Grab
50050 MGD	Flow Rate	---	---	---	---	Daily	24 Hr. Total
50060 MG/L	Chlorine, Total Residual	---	0.019	---	---	1/Week	Grab
61425 TUa	Acute Toxicity, Ceriodaphnia	1.6	---	---	---	1/Month	See Part II, Item J
61426 TUc	Chronic Toxicity, Ceriodaphnia	5.9	---	---	---	1/Quarter	See Part II, Item J
61427 TUa	Acute Toxicity, Pimephales promelas	1.6	---	---	---	1/Month	See Part II, Item J
61428 TUc	Chronic Toxicity, Pimephales promelas	5.9	---	---	---	1/Quarter	See Part II, Item J

Exhibit 1

Stage Two

Using the information gained from the first stage investigation, the second stage investigation looked for ways to most cost effectively treat the wastewater flows. The resulting treatment scheme consolidated some industrial streams reducing the amount of tankage and chemicals needed to treat them, and also simplified treatment operations. Additional modifications improved heavy metals capture, and oil and grease removal enough to eliminate the need for a separate OEPA individual sampling station, saving approximately $10,000 per year. In addition, these modifications virtually eliminated the need for two stage filtering which was previously one of the most expensive and time consuming steps in the treatment process. Expanded treatment capacity, simplified operations and reduced facility size allowed a doubling of treatment capabilities within the same footprint as the old treatment facility.

Results

As of this writing, the treatment plant improvements have been completed and are operational. Savings in capital expenditures exceeded $500,000 on a $3M budget. Operation and maintenance costs are currently being compiled, and are expected to be 20-30% below past expenditures. The enhanced treatment capabilities continue to spawn pollution prevention opportunities as Navistar has switched to water based paints reducing hazardous air pollution emissions by 70%, and saving Navistar $1.3 million per year. This would not have been possible without the ability of the new treatment plant to more efficiently handle the increased organic waste from the plant.

In conclusion, a team approach to pollution prevention which educates workers and looks at "both ends of the pipe" can result in significant capital and savings as well as daily operational savings while being good to the environment.

A CRITICAL ANALYSIS OF 1,1,1-TRICHLOROETHANE REDUCTION FOLLOWING POLLUTION PREVENTION INITIATIVES AT HILL AIR FORCE BASE (OGDEN, UT)

Dale A. Rice, P.E.
Engineering-Science, Inc.
10521 Rosehaven St.
Fairfax, VA 22020

E. Allan Dalpias and Craig Pessetto
OO-ALC/EMP
7274 Wardleigh Rd.
Hill AFB, UT 84056

ABSTRACT

With the passage of the Pollution Prevention Act of 1990 which established a national policy to prevent or reduce pollution at its source, many federal facilities have taken the initiative to complete pollution prevention (P2) opportunity assessments. These assessments are typically aimed at identifying viable options, such as chemical substitutions or other modifications, to specific processes that use hazardous materials. The results of the opportunity assessment process can be very beneficial in leading to significant reductions in hazardous material usage; however, many federal facilities are tracking only the facility-wide reduction of a particular chemical or group of chemicals. Often, these overall reductions are not correlated with the specific contributions of individual process modifications. This trend can be attributed to a number of factors including the absence of process-specific chemical usage baselines or a failure to measure chemical reductions at the process level.

A process baseline and opportunity assessment was completed at Hill Air Force Base in 1993. The project included an estimate of the 1991-1992 usage rates of Ozone Depleting Chemicals (ODCs) and the EPA 17 Industrial Toxics as determined for each process using these chemicals. Since the time of the study, Hill reduced its 1,1,1-trichloroethane usage by 85% during 1993. This paper documents how these reductions were made at the process level and, in particular, how the opportunity assessment recommendations were implemented to determine the assessment's degree of effectiveness.

INTRODUCTION

Hill Air Force Base (AFB) is home to the Ogden Air Logistics Center and has several major missions including depot-level maintenance of various aircraft and the Peace Keeper and Minuteman missile systems. Hill AFB is also a world-wide center for landing gear repair. The base, located near Ogden, Utah, employs approximately 16,000 civilian and military personnel and includes four major maintenance directorates: Aircraft Directorate (LA), Commodities Directorate (LI), Intercontinental Ballistic Missile Directorate (LM), and Technical and Industrial Support Directorate (TI). In addition several independent tenant organizations are operated at Hill AFB.

A hazardous waste minimization program was initiated at Hill AFB in 1985 and was expanded into a pollution prevention (P2) program following the Pollution Prevention Act of 1990. Historic funding for P2 programs at Hill AFB is as follows:

1990 (and earlier)	-	\$0.5 Million
1991	-	\$1.0 Million
1992	-	\$0.8 Million
1993	-	\$8.2 Million (Including \$2.5 Million for AFMC)
1994	-	\$7.9 Million

The P2 program has been accelerated by several regulatory initiatives including the following:

- Ozone Depleting Chemicals (ODCs) production ban (and 1/7/93 USAF ban)
- EPA 17 Industrial Project Chemicals reduction program
- Executive Order 12856 (including 50% reduction in Toxic Release Inventory Chemicals by 1999)
- Clean Air Act Amendments of 1990

The Hill AFB program included the completion of a base-wide opportunity assessment in 1993. The assessment was focused on the industrial operations with special attention given to establishing baselines at the process level for ODCs and the EPA 17 Industrial Project Toxic Chemicals for a 12 month period in 1992-1993. One of the results of the process assessment was the identification of more than 100 potential alternatives aimed at reducing the usage of the EPA 17 and ODCs. Based on an accounting of the base-wide chemical procurement in 1993, the following reductions have been achieved at Hill:

ODCs	-	89%
EPA 17	-	69%

In particular, the usage of 1,1,1-trichloroethane (TCA) was reduced by approximately 85% in 1993. A review of the various processes that historically used TCA (an ODC and an EPA 17 chemical) was conducted to document the reduction while addressing the following questions:

1. Which of the P2 alternatives from the opportunity assessment were actually implemented?
2. What are the reasons other alternatives were not implemented?
3. What lessons can be learned from the Hill AFB P2 experience?

REVIEW OF P2 PROGRAM IMPLEMENTATION FOR TCA PROCESSES

The primary uses of TCA at Hill AFB are in vapor degreasing operations, solvent stripping, and hand-wipe degreasing. The 1991-1992 annual usage rates are estimated as shown in Table 1. Vapor degreasers (13 in operation in 1991-1992) accounted for about 85% of the TCA usage in the baseline year. The Commodities Directorate used nearly 80% of this volume.

Table 1 - Estimated 1991-1992 1,1,1-Trichloroethane Annual Usage Rates at Hill AFB

Annual Usage Rate By Directorate (Pounds x 1,000)

Process Type	LA	LI	LM	TI	Others
Vapor Degreasing	8	180	0.6	0	8
Hand Wiping	4	0.3	0.2	0	0
Solvent Stripping	24	0	0	0	0
Miscellaneous Use	5	1	0	0	0.4
Total (to nearest 1,000 lb)	41	181	1	0	8

Based on the opportunity assessment, which included the ranking of the potential alternatives, several short-term and long-term options were identified to address the reduction of TCA (Tables 2 and 3, respectively).

Table 2 - Short-Term P2 Options Addressing TCA Reductions at Hill AFB

Applicable Process	Option Description
DSH	Train operators in optimizing use of solvents.
DSV	Train operators in efficient use of vapor degreasers.
DSV	Improve solvent storage and degreaser locations, where applicable.
DSV	Monitor solvent baths for impurities.
DSH	Implement solvent application with plunger cans to control amount of solvent dispensed.
DSH	Use cleaners in tanks instead of at work stations, where applicable.
DSV	Install in-line filters in vapor degreasers to purify and recycle solvent.
DSH	Segregate hazardous rags from nonhazardous rags and dispose accordingly.

DSH - Solvent handwiping
DSV - Vapor degreasing

Table 3 - Long-Term P2 Options Addressing TCA Reductions at Hill AFB

Applicable Process	Option Description
DSV	Substitute hazardous solvents with aqueous cleaners.
DSV	Substitute hazardous solvents with low-VOC, less- or non-hazardous solvents.
DSH	Substitute hazardous solvents with low-VOC cleaners.
BON/ETC	Substitute hazardous solvents with aqueous cleaners.
ERC	Substitute hazardous solvents with low-VOC, less- or non-hazardous solvents.
PRC	Substitute hazardous solvents with low-VOC, less- or non-hazardous solvents.

DSH Solvent Handwiping
DSV Vapor Degreasing
BON/ETC Bonding/Etching
PRC Chemical Stripping

Although the short-term options would have resulted in modest reductions of TCA and had favorable payback periods (typically less than one year), they were never implemented following the assessment study. Instead, several of the long term options have been implemented since 1993 and appear to account for the bulk of the TCA reduction. Most of the short-term options (Table 2) would help reduce but would not eliminate the use of TCA. The LI and LA directorates have each been able to shut down vapor degreasers and degrease aircraft parts with aqueous cleaners such as Duraclean 282 (Grace Chemical) which is used effectively in a "jet" or high-pressure washer. The LM directorate will eliminate a vapor degreaser in 1994. Also, at least one handwiping operation in LM, which formerly used TCA, has now been modified to use methyl lactate. In another case, the 388th Fighter Wing has completed process modifications for the corrosion and the non-destructive inspection shops to eliminate TCA usage. A total of about 15 projects has been implemented at Hill AFB, and each project can be linked to a reduction in TCA as shown in Table 4. Most of these projects were identified in the process opportunity assessment. Several projects conducted in LI required a change in technical orders.

Table 4 - Summary of P2 Options Implemented (or Planned for 1994) at Hill AFB Resulting in Reduction of 1,1,1-Trichloroethane

Directorate/ Tenant	Project Description	Estimated % Reduction TCA	Project Cost ($1,000)
LM	Installed four jet washers/aqueous cleaning	100	250
LM	Replaced TCA with methyl lactate for handwiping Minuteman motors	100	NA
LM	Replaced TCA with nonclorinated solvents in Corrosion Shop	100	NA
388th FW	Installed jet washer/aqueous cleaning	100	25
388th FW	Replaced penetrant containing TCA (NDI)	100	NA
LI	Installed seven jet washers/aqueous cleaning	100	351
LI	Installed manual parts washer	100	7
LI/LA	Installed deionized water treatment system (reduces load on aqueous cleaning system)	*	181
LI	Installed part washer	25	14
LI	Replaced TCA with nonchlorinated hydro-carbon blend for handwiping	100	NA
LA	Replaced TCA with aqueous cleaner for spot degreasing	100	NA
LA	Replaced TCA with alkaline cleaner in bonding process	100	NA
LA	Installed "ultralight" vapor degreaser; replaced TCA with perchloroethylene	100	260
LA	Installed jet washers/aqueous cleaning	100	150
Basewide	Conducted study for developing protocol to test new cleaners	*	46

* Project supports processes reducing TCA usage.

CONCLUSIONS

Hill AFB has taken the initiative since 1985 to minimize the use of hazardous materials while performing its required mission. These efforts have been greatly accelerated in the last two years by regulatory (and Air Force driven) imperatives. In particular, with the ban of ODC production, Hill AFB has decreased the use of such solvents as TCA while not abandoning the functions in which these chemicals were used. Basewide TCA reductions were not accomplished as a result of reduced production requirements but through process modifications such as substituting aqueous cleaners. These changes were completed by recognizing the inevitable (e.g., decreasing availability of traditional solvents), using substitute materials to accomplish the mission, and planning and budgeting requisite equipment changes.

The Digital Imaging System

1Lt Bradley E. Anderson
633 SUPS/CCQ (USAF)
Unit 14006
APO AP 96543-4006
(671) 366-3213 FAX 366-4206

TSgt William H. Tyler
633 CS/SCTV (USAF)
Unit 14009
APO AP 96543-4009
(671) 366-2130 FAX 366-3446

There is now an electronic darkroom replacement for chemical based processing of color and black and white photography. This technology enables photo labs to work without hazardous chemical effluents such as developer and fixer while simultaneously doing away with wash water needs and silver reclamation. The old chemical processing is replaced by digital recording and printing which produces full color images or quality black and white prints. Time savings are also realized as images can be altered to remove small blemishes. The images are immediately available for either hard copy viewing or electronic presentation via computer based presentation programs such as Aldus Persuasion and Microsoft Powerpoint. This technology is available for photographic images, text, and graphics. Digital imaging allows for immediate updating of all briefing materials and presentations to present real time information. Andersen AFB and other PACAF bases are working to get this system in place, and believe other bases would also benefit greatly from this system.

IMPLEMENTATION

The Electronic Imaging Center (EIC) concept (see attachment) was field tested in 1991 and validated a 25 percent manpower savings when electronic imaging systems are integrated into Base Visual Information Service Center (BVISC) operations. This system has been implemented for use throughout the Air Force as put forth in the May 1992 Electronic Imaging Center Implementation Plan from the Electronic Imaging Support Branch, Air Force Media Center, Norton AFB. The EIC system has changed since original implementation and will continue to change rapidly with new technology, so specific hardware and software referenced are subject to change. Most bases are already using computerized graphic imaging systems (GIS), but desktop color imaging technology has changed dramatically since many of these systems were fielded. Approximately two thirds of the GIS systems in use today are incapable of keeping pace with customer imaging demands into the mid-1990s.

SYSTEM CONFIGURATION

The EIC system configuration is organized into four major categories: Electronic Still Photography, Graphic Imaging Systems (GIS), Local Area

Networking (LAN), and Electronic Presentation Systems (EPS). The Electronic Darkroom portion of the EIC configuration (see attachment) consists of a desktop computer configured to handle a host of peripheral devices, including input, edit, and output functions for digital printing as well as electronic image transmission. The EIC provides powerful and easy-to-use productivity tools that help you communicate better and faster. This system provides interoperability with customer desktop computers as well as DOD command centers, the Joint Combat Camera Center, and the Still Media Records Center.

SYSTEM CAPABILITIES

The desktop color imaging system translates photography, graphics, text, video, and sound to a common language. The Digital Camera System (DCS) is capable of recording up to 50 color digital images on a reusable hard dive at 1.5 Megapixels, or about 1,500 lines or resolution.

The old method for producing a black and white photograph is to take the photograph on black and white photographic film, process this film using B&W developer, use stop bath to halt the processing, then use B&W fixer to make the image permanent, and finally a wash cycle is needed to eliminate all residual chemistry. The negative is printed using an enlarger and processed on photographic paper using developer, fixer, and wash water. Every one of these steps produce effluent that contains harmful metallic silver by-products. The average production time from exposure to print is approximately one hour for the first photo. Forty minutes is needed for processing the film and twenty minutes for exposing and processing the print.

In the digital process, a special digital camera produces an image saved within the camera. This image is downloaded to your computer where it can be manipulated to enhance contrast, brightness, lighting, clarity, and any number of other photographic controls that are very time consuming in film based printing. Once this has been accomplished, the image is output through a digital printer. This process has no chemistry in any step and generates absolutely no hazardous materials. The average production time from exposure to print is approximately fifteen minutes for the first photo with five to eight minutes for image manipulation and seven minutes for printing the image. Impurities can be erased from the image prior to printing, thereby reducing reshoots. Another advantage is the capability to use the laptop computer in the field with the digital camera to preview images prior to leaving the scene, ensuring that the photos are adequate.

If speed of the imaging process is a major concern to you, as in newspaper publishing or real time briefings, digital imaging is the only way to go. You can take an image in the field and, using a notebook computer and a portable satellite transmitter, produce the image anywhere in the world in a matter of minutes. This image can be made available to any organization tied into your computer system.

Images can be maintained virtually forever on computer based media without the archival life expectancies of film based images.

SYSTEM COMPONENTS/COSTS

The quality of the image produced is directly related to the type of equipment used in the process. The main components of the electronic darkroom system are the desktop computer, laptop (portable) computer, film scanner, digital camera, and color dye sublimation printer. This entire package can cost anywhere from 50,000 to 250,000 dollars. Andersen AFB uses the Kodak DCS 200 camera that utilizes an unaltered Nikon 8008 camera body in conjunction with the Kodak digital camera back. The price for this camera is about 7,000 to 10,000 dollars. The Macintosh Quadra 800 computer is used with 24 Mb of RAM and a 230 Mb hard drive at a cost of about 4,400 dollars. Applicable software includes Adobe Photoshop image manipulation software (895 dollars) and Microsoft Powerpoint presentation software (299 dollars). The Kodak XL 7720 dye sublimation printer works well at a price of 18,500 dollars. This printer requires a regular supply of cartridges which cost about 200 dollars each and can produce about 100 7.5"x10" size photographs. Savings can be obtained by consolidating smaller photos to fill the 7.5"x10" print.

The printer is the single biggest factor when considering cost. The Kodak XL 7720 is a top of the line, photographic quality, dye sublimation printer. The resulting print will be comparable to any professional photographic image from your photo lab. Dye sublimation printers are ideally suited for users who produce photographic images. They produce an image that looks like a photograph, without the pixelization seen in magazine photographs. The heating element uses the sublimation process of vaporizing dyes directly onto the paper. Wax transfer printers are best suited for printing overhead transparencies and color charts because they have a tendency to show color step graduations in large, solid color areas. Ink jet printers on the other hand print by spraying bursts of different colored inks from nozzles in the print head. This medium is best suited to applications where cost, not quality, is the guiding principle. These inks impregnate the paper and bleed to some extent. Print quality is also governed by the quality of paper and ink in use. Dye sublimation printers average 15,000 to 20,000 dollars. Thermal wax transfer printers average 3,000 to 5,000 dollars. The lowest cost color printers are the ink jet printers at an average of 300 to 600 dollars. The deciding factor in purchasing lower cost printers is the quality of the output required for your customer's needs and the size of your budget.

This equipment is becoming the Air Force standard, however it is not the only solution. Any piece can be substituted with lower price equipment or different alternatives. The Kodak camera is only one of the digital cameras available, and there are alternatives if your production requirements don't need digital imaging.

Electronic still video cameras, such as the Canon RC-570 and RC-360, are viable alternatives. The image quality from these cameras is comparable to the output of your television monitor. They are capable of providing images that can be displayed through your computer presentation system at about ten percent of the cost for the DCS 200. IBM compatible computers can also be substituted for the Macintosh with the same production results, although the windows compatible software may be slightly more cumbersome until you get to know the shortcuts. Photo manipulation software is available for under 200 dollars and while this software does not include all the capabilities of a program like Photoshop, it will have most of the basic capabilities. The same is true for presentation software like Microsoft Powerpoint.

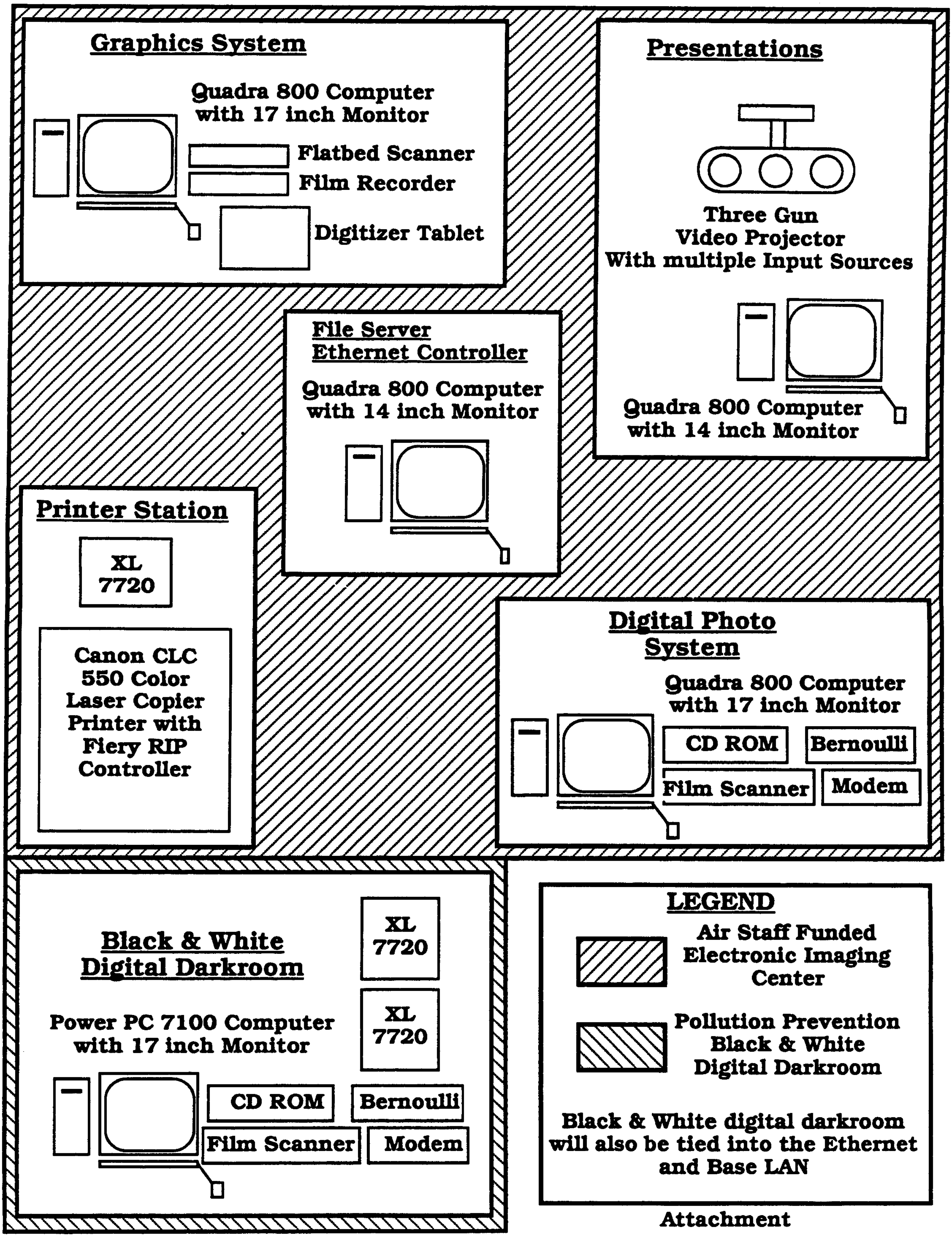
REALIZED SAVINGS

The elimination of all effluents in photographic printing provides a great savings in any setting. Andersen AFB has a relatively small production facility, but in an average year will use over 550 gallons of B&W developer, over 480 gallons of B&W fixer, 234 thousand gallons of wash water, and over 480 gallons of liquid hazardous waste requiring silver recovery. Approximately 40 pounds of solid hazardous waste will also be produced. The digital process eliminates these wastes immediately and completely, saving approximately 20,000 dollars a year.

CONCLUSION

The electronic imaging system will save you money by eliminating all chemical needs and wastes, while substantially reducing the production time of needed photographs or presentations. This system enables the user to produce, store, manipulate, and transmit information in ways not possible before. Each organization can tailor a system to their needs and to fit varied budgets. The technology is constantly evolving and products are continually improved, so stay vigilant, but don't miss out on this opportunity.

Electronic Imaging Center and Black & White Digital Darkroom



Attachment

SESSION VII

POLLUTION PREVENTION MANAGEMENT

Session Chairpersons:

Lt Col Alec Earle, HQ USAF/CEV

Lt Col Pat Fink, HQ AFCEE/EP

Mountain Home AFB Baseline Survey and Opportunity Assessment: A Case Study

Bruce C. Goddard, P.E., Principal
Brian Soucy, P.E., Principal
Law Environmental, Inc.
114 TownPark Drive
Kennesaw, Georgia 30144
(404) 421-7020

OBJECTIVES AND GOALS

On 24 September 1992, Law Environmental, Inc. (LAW) was awarded a delivery order under an Air Force Center for Environmental Excellence (AFCEE) contract to provide Pollution Prevention Technical Support for Headquarters (HQ) Air Combat Command (ACC).

Under the delivery order which included 23 ACC bases, LAW performed baseline waste generation surveys to inventory the quantities used in 1992 of environmentally hazardous materials including ozone depleting chemicals (ODCs), the United States Environmental Protection Agency's (USEPA) 17 Industrial Toxic Project (ITP) chemicals, hazardous waste (HW) and municipal solid waste (MSW). In addition, an air emissions inventory of criteria air pollutants was conducted and oil/water separators were surveyed. The baseline data was input into a database program, HAZMIN, provided by ACC and modified by LAW. Opportunity assessments and recycling economic analysis/feasibility studies for MSW were conducted for these materials to help the bases evaluate methods that could be implemented to achieve the following Air Force (AF) established reduction goals for these materials:

Date	Goal
31 Dec 93	Reduce MSW disposal by 10 percent from 1992 baseline
31 Dec 95	Reduce MSW disposal by 30 percent from 1992 baseline
31 Dec 97	Reduce MSW disposal by 50 percent from 1992 baseline
31 Dec 95	Reduce HW disposal by 25 percent from 1992 baseline
31 Dec 99	Reduce HW disposal by 50 percent from 1992 baseline
31 Dec 95	Reduce ODC releases by 50 percent from 1992 baseline
31 Dec 97	Eliminate the purchase of ODCs
31 Dec 95	Reduce the use of the USEPA's 17 ITP chemicals by 50 percent from 1992 baseline
31 Dec 99	Reduce volatile air emissions by 50 percent from 1992 baseline

In addition, the following restrictions were included in an Action Memorandum dated 7 January 1993 for ODCs:

Date	Action
1 Jan 93	No purchase of virgin ODC
1 June 93	No purchase of virgin halon
1 June 93	No purchase of vehicles that contain ODCs
1 April 94	No purchase of solvents containing ODCs

This paper presents the results of the baseline data gathering, waste characterization study, opportunity assessments, and recycling economic analysis/feasibility study for Mountain Home AFB, Idaho.

METHODOLOGIES

The composition and quantities of MSW generated and disposed from Military Family Housing (MFH) and base activities is not well documented at most bases. Most bases keep fairly accurate records of materials recycled through the Defense Reutilization and Marketing Office (DRMO) and Morale, Welfare and Recreation (MWR). Therefore, a modification to the delivery order was executed to perform a MSW waste characterization study at five of the bases including Mountain Home. This study enabled LAW to perform opportunity assessments (OAs) for specific MSW materials.

Data from the individual shops on chemical usage was not readily available. Data on chemical usage in the shops were obtained from interviews with shop personnel. Other sources of data included supply organizations, Civil Engineering/Environmental Flight hazardous waste logs, and the base Bioenvironmental Engineer.

RESULTS

Baseline

Baseline data gathering site visits were conducted at Mountain Home AFB from 22-26 February 1993 and 19-23 July 1993. During the visits, interviews with shop personnel were conducted and records reviewed to determine the quantities of materials that were used in 1992. In addition, oil/water separator drawings were reviewed and separators inspected to determine which buildings they served and their general condition.

During 1992, Mountain Home emitted, disposed, or recycled the following quantities of materials:

Material	Quantities
Criteria Air Pollutants	943.4 tons emitted
Hazardous Waste	20.4 tons disposed
ODCs	13.6 tons emitted
VOCs	215.5 tons emitted
USEPA's 17 ITP Chemicals	192.3 tons emitted (not including emissions from fuel evaporation or combustion sources)
MSW	3,596.4 tons disposed and 358.6 tons recycled

Waste Characterization Study

The waste characterization study for Mountain Home AFB was conducted the week of 4 Oct to 8 Oct 1993. The study involved separating and categorizing waste from MFH, temporary lodging and military dorms, industrial/commercial facilities (both military and tenant), dining facilities, and office facilities. The following quantities disposed are the results of the study:

Material	Quantity Disposed/pounds	%
Computer paper	2,070.0	1.3
Office paper	2,114.1	1.4
Cardboard	27,734.1	18.0
Newspaper	8,616.0	5.6
Magazines	1,891.1	1.2
Mixed paper	30,734.6	20.0
Food waste	15,946.1	10.4
Glass containers	9,574.5	6.2
Aluminum cans	1,970.3	1.3
Bi-metal/tin cans	1,464.1	1.0
Plastic PET containers (#1)	666.6	0.4
Plastic HDPE containers (#2)	1,607.4	1.0
Ferrous metal	1,796.0	1.2
Aluminum metal	1,437.8	0.9
Copper	65.0	<0.1
Wood	2,065.5	1.3
Batteries	252.6	0.2
Yard Waste	11,293.7	7.3
Other misc. waste[1]	32,409.8	21.1
TOTALS	153,709.3	99.8[2]

1-Other misc. waste includes diapers, other glass, textiles, rubber, other plastic materials, and dirt.
2-Numbers do not add to 100% due to rounding

Opportunity Assessments

Hazardous Waste

Tank Cleaning

Tank cleaning resulted in the largest single hazardous waste disposed in 1992. A 70 percent reduction in tank sludge disposal could be realized by the installation and operation of mixers in the three 120 foot diameter POL tanks.

HAZMART

Expired shelf-life material disposal amounted to approximately 8,063 pounds in 1992. By the institution of a HAZMART program, it is estimated that the quantities disposed could be reduced by 50 percent.

Paint Waste

Paint waste disposal amounted to approximately 3,554 pounds in 1992. It is estimated that reduced painting operations due to relocation of painting to off-base facilities, distilling waste paint solvent for reuse, and switching to water based paints and stains in Civil Engineering (CE) could reduce waste paint disposal by 80 percent.

Abrasive Media Blasting

Abrasive media blasting waste, primarily plastic media blasting (PMB) materials, amounted to approximately 2,125 pounds in 1992. It is estimated that by leasing the PMB materials from a company which uses the waste material to manufacture other products such as bathroom fixtures could reduce this waste by 100 percent.

Rags Contaminated With Alodine and Stripper

Alodine contaminated rags (chromic acid) amounted to approximately 2,000 pounds disposed in 1992. A possible substitute for this material might be an acidic iron phosphate solution. Further tests on this substitute would be required to check the suitability of the iron phosphate material as an aluminum conversion material substitute and to check that it meets appropriate MIL specification requirements.

Contaminated Jet-Fuel

JP-4 jet fuel contaminated with water amounted to approximately 1,700 pounds or 250 gallons disposed in 1992. The off-spec fuel could be blended with in-spec fuel and used to power non-critical AGE equipment or sold to a fuel blender and used as fuel in cement kilns or other fuel burning operations. It is estimated that the quantities to be disposed could be reduced by 80 percent.

<u>Ozone Depleting Chemicals (ODCs)</u>

R-22 - Basewide Refrigeration Equipment

The most widely used ODC at Mountain Home in 1992 was R-22 (HCFC-22, chlorodifluoromethane) followed by R-12 (CFC-12, dichlorodifluroromethane). Approximately 21,983 pounds of R-22 and 3,515 pounds of R-12 were released in 1992. R-22 is a Class II HCFC with an ozone depleting potential of 0.05, and R-12 is a Class I CFC with an ozone depleting potential of 1.0. Approximately 96 percent of the R-22 refrigerant is used in chiller and refrigeration equipment and 80 percent of the R-12 is used in water chiller and refrigerant equipment for automobiles.

R-12 - Basewide Chiller Refrigeration Equipment

R-134a is currently being used in new refrigerant units and has no legislative phaseout requirement. The ozone depleting factor for R-134a is zero. Retrofitting existing R-22 units to use R-134a is not a feasible option due the degree of modifications required. Therefore, replacing older R-22 units as they wear out with new R-134a units and instituting an effective refrigerant management program that includes periodically checking and repairing leaking units could eventually reduce the releases by nearly 100 percent.

R-12 - Refrigerant in Vehicles

Retrofitting vehicle R-12 air conditioning systems to use R-134a costs approximately $700 per vehicle which is approximately one-half the cost a new R-134a system. Since Mountain Home is in an area that generally does not have hot and humid summers, disconnecting and removing leaking and unrepairable air conditioners is feasible. These actions could reduce the releases by nearly 100 percent.

1,1,1 Trichlorethane - NDI Usage

Approximately 1,184 pounds of 1,1,1 trichlorethane (TCA) were released in 1992. The majority of these releases were from the NDI shop. NDI has substituted a non-ODC product manufactured by MagnaFlux. The remaining TCA emissions were mainly from products which had TCA as an ingredient. Also, Safety-Kleen 105 parts washers used chemicals which contain 0.5 percent TCA. Safety-Kleen has several non-ODC substitutes available for their parts washers and information on other chemical substitutes can be obtained from the PRO-ACT Air Force Environmental Information Clearinghouse (phone 800-233-4356).

Halon 1211 - Fire Extinguishers

Halon 1211 releases in 1992 amounted to approximately 446 pounds. Halon 1211 has an ozone depleting potential (ODP) of 3.0 an currently has no universal replacement. Some of the releases can be attributed to hand-held fire extinguishers. Two options for replacing hand-held extinguishers are the use of CEA-614 and CO_2 extinguishers. It is recommended that the USAF Halon 1211 Fire Fighting Agent Replacement Program be contacted prior to substituting extinguisher media.

Volatile Organic Compounds (VOCs)

Switching From JP-4 to JP-8

Approximately 282,000 pounds of VOC emissions from fuel evaporation were estimated in 1992. By switching from JP-4 to JP-8, the following emissions and reductions could realized:

Source	Emissions with JP-4 (tons/yr)	Emissions with JP-8 (tons/yr)	Reductions (tons/yr)
Fugitive Emissions	74.8	23.5	51.3
Jet Fuel Dispensing	40.3	8.7	31.6
Jet Fuel Unloading	11.0	0.1	10.9
Jet Fuel USTs	14.9	0.3	14.6
TOTALS	141.0	32.6	108.4

Fugitive Emissions

After switching to JP-8, fugitive emissions are estimated to account for approximately 46,000 pounds in 1992. These emissions occur from evaporation through mechanical fittings such as valves, flanges, and pump seals. By instituting a leak detection and repair (LDAR) program, fugitive emissions could be reduced an additional 35 percent.

Surface Coatings

Surface coatings contributed approximately 22,900 pounds in VOC emissions in 1992. Of this quantity, approximately 11,400 pounds have been reduced by the relocation of painting operations to off-base. An additional 4,940 pounds could be reduced by using a low VOC, high solids polyurethane aircraft paint, assuming an average usage of 30 percent low VOC paint by aircraft corrosion control. In addition, assuming a 90 percent reduction in usage of solvent-based paint by CE, a further reduction of 3,200 pounds could be realized.

Parts Cleaning (Degreasing)

Assuming 75 percent of the solvent degreasing units could be replaced with aqueous parts washers, the VOC emissions could be reduced by approximately 1,040 pounds.

Alternative Fuel Powered Vehicles

A combination of duel-fueled compressed natural gas (CNG) and electric vehicles could be utilized by the base. By using CNG, VOC emissions could be reduced by 1,400 pounds. The cost for converting an existing gasoline-fueled vehicle to CNG is approximately $2,500. The cost for an electric golf cart is approximately $3,100.

<u>USEPA 17 ITP Chemicals</u>

Methyl Ethyl Ketone

Approximately 10,100 pounds of methyl ethyl keytone (MEK) were used in 1992. With the reduced painting due to the relocation of painting operations to off-base facilities, it is estimated that MEK usage has been reduced by approximately 7,500 pounds. Substitutes for MEK as a solvent wipe might include N-methyl pyrrolidine, isopropyl alcohol (IPA), acetone and mixtures of IPA.

Toluene

Approximately 5,100 pounds of toluene were used basewide in 1992. It is estimated that toluene usage has been reduced by approximately 3,800 pounds with the relocation of painting operations to off-base facilities.

Methylene Chloride (Dichloromethane)

Approximately 1,250 pounds of methylene chloride were used in 1992. This quantity has been reduced by approximately 475 pounds with the relocation of painting operations to off-base facilities. In addition, NDI will reduce usage of methylene chloride by approximately 470 pounds with the substitution of the non-ODC product manufactured by MagnaFlux discussed in Section 3.3.2.4.

1,1,1-Trichloroethane

Approximately 1,450 pounds of 1,1,1-trichloroethane (TCA) were used in 1992. As discussed in Section 3.3.2.4, NDI will reduce the usage of TCA by approximately 845 pounds with the substitution of the TCA-free product manufactured by MagnaFlux.

Recycling Economic Analysis/Feasibility Study For Solid Waste

Curbside Collection of Recyclables

Presently, there is no program for the collection of recyclables from MFH at Mountain Home. With the institution of a curbside collection program and assuming a 25 percent recovery rate for recyclable material, approximately 214,500 pounds of material could be diverted from the on-base landfill. This is a reduction of approximately 3.0 percent from the 1992 baseline quantities at a cost of $0.59 per pound of reduction.

Base Composting Program

Presently, the Grounds Superintendent operates a mulching program for yard waste material generated from base grounds maintenance. With the institution of a base wide program to include MFH and the golf course and a recovery rate of approximately 50 percent, approximately 294,000 pounds of yard waste could be diverted from the landfill. This is a reduction of approximately 4.1 percent at a cost of $0.20 per pound of reduction.

Base Collection of Old Corrugated Cardboard (OCC)

Presently, there is no organized collection of OCC from base facilities. Morale, Welfare and Recreation (MWR) operates a recycling center where materials can be dropped off including OCC. This opportunity assumes that an organized collection program including pick-up would occur for the Dining Hall, Class VI Store, Burger King, NCO Club, and Officer's Club. The Commissary and BX presently share a baler and Supply also has their own baler. The OCC generated form these facilities are presently brought to the recycling centered and marketed by MWR. With an assumed recovery rate of 50 percent, an additional 99,100 pounds of OCC could be diverted from the landfill. This is a reduction of approximately 1.4 percent at a cost of $0.36 per pound of reduction.

Office Paper Collection Program

Presently, there is no organized program for the collection and marketing of computer print out (CPO) and high grade office (HGO) paper. With the institution of an office paper collection program from the five largest generators and an assumed recovery rate of 50 percent, approximately 36,900 pounds of office paper could be diverted from the landfill. This is a reduction of approximately 0.5 percent at a cost of $0.13 per pound of reduction.

Charge MFH Residents for MSW Collection

Presently, MFH residents are not charged for the collection MSW. By charging by the bag or container with free collection of recyclables, residents would have an incentive to recycle more materials. For this reason, the assumed recovery rate was assumed to be 50 percent and approximately 428,850 pounds could be diverted from the landfill. This is a reduction of approximately 6 percent and would produce a revenue of $0.10 per pound of reduction.

Charging Shops for MSW collection

Presently, shops are not charged for the collection of MSW. By charging shops for MSW collection based on the size of their container and the number of pickups or pulls per week, shops would also have an incentive to recycle more materials. With an assumed recovery rate of 50 percent for recyclable materials, approximately 941,000 pounds could be diverted from the landfill. This is a reduction of approximately 12.9 percent at a cost of $0.09 per pound of reduction.

Basewide Education Program

The proposed education program would target three areas: MFH residents, schools, and remaining base generating activities. Each MFH resident would be given pamphlets describing the base programs and ways to reduce and reuse solid waste. The school program includes presentations three times per school year on the three "Rs" of solid waste: reduce, reuse, and recycle. The base program would include information on the operated programs for office paper, OCC and composting. Approximately 145,000 pounds of solid waste could be diverted from the landfill. This is a reduction of approximately 2 percent at a cost of $0.02 per pound of reduction.

Crushed Glass For Firebreak Line

Mountain Home has a firebreak line encircling the firing range that is approximately 120 feet wide by 40 miles long. This opportunity explored using crushed glass as a fill material for this line. With an assumed recovery rate of 25 percent, approximately 100,000 pounds of glass could be diverted from the landfill. Additional glass from off-base could also be used as fill material. This is a reduction of approximately 1.4 percent at a cost of $0.40 per pound of reduction.

Reusable Coffee Filters

Presently, each shop and office brews their own coffee using disposal coffee filters. By using reusable filters and disposing the coffee grounds in the base composting program, approximately 22,000 pounds of filters and grounds could be diverted from the landfill. This is a reduction of approximately 0.3 percent at a cost of $0.20 per pound of reduction. At an initial cost of $3.98, the payback period for one reusable filter is approximately 1.5 months.

Expand Food Waste Pickup by Local Pig/Hog Farmer

The base presently has a local pig/hog farmer that picks up waste vegetative material from the commissary on a weekly basis. This opportunity explored expanding the program to include the NCO Club and the Dining Hall. With an assumed recovery rate of 25 percent from these two facilities, approximately 23,300 pounds of food waste could be diverted from the landfill. This is a reduction of approximately 0.3 percent at a cost of $0.02 per pound of reduction.

Expanded Recycling Program

Opportunity evaluations for the base composting program and charging the MFH residents and shops for MSW collection assumed a recovery rate of 50 percent for a limited number of materials. This opportunity evaluates recovery rates for materials of 25, 50, and 75 percent and adding OCC, ferrous metal, and wood from MFH and magazines and mixed paper from both MFH and base collection programs. By charging both residents and base shops, the programs provided a net revenue income. The following are the quantities that could be diverted from disposal and their associated revenues:

Recovery Rate	Quantity Diverted	Revenues per Pound reduction
25%	1,189,340 pounds	$0.008
50%	2,378,680 pounds	$0.007
75%	3,568,010 pounds	$0.0004

CONCLUSIONS

By continued application of existing initiatives undertaken by Mountain Home AFB such as the antifreeze recycler by Power Production, the establishment of a recycling building at the RRRP recycling center, and the application of new initiatives as outlined in this report, the reduction goals as established by the Air Force can be met. However, there are costs or "changes in ways business is conducted" that are associated with each initiative that needs to be considered before implementation is undertaken.

PREPARING FOR THE EPA'S FEDERAL FACILITIES MULTIMEDIA ENFORCEMENT/COMPLIANCE INITIATIVE INSPECTIONS; AND THE ASSOCIATED POLLUTION PREVENTION OPPORTUNITY

MAJOR STEVEN E. HOARN
HEADQUARTERS AIR COMBAT COMMAND
ENVIRONMENTAL PROGRAMS DIVISION
CHIEF OF POLLUTION PREVENTION

INTRODUCTION

The EPA has been inspecting federal facilities with multimedia inspection teams since the early 70's, so the inception of the Federal Facilities Multimedia Enforcement/Compliance Initiative, officially kicked off by the EPA in February of 1993, was not an earth shaking event. Indeed, although the agency had been chomping at the bit to get the Initiative going for several months before, there was little fanfare for the start of the effort either in the EPA's Office of Federal Facilities Enforcement in Washington DC or the various offices where the program is executed in the ten EPA Regions. The EPA program managers, for the initiative, all admit that the Federal Facilities Multimedia Enforcement/Compliance Initiative is nothing more than new packaging of an old idea. Few of these EPA managers hide the fact that the new administrator's emphasis on the environment, and especially pollution prevention, has been an accelerant to the Multimedia Enforcement/Compliance Initiative process.

Through July of 1994, the first 18 months of the Initiative, the EPA has conducted 61 multimedia inspections of federal facilities under the auspices of the Enforcement/ Compliance Initiative. This is not to say there have not been other regional multimedia inspections of federal facilities. There have been some other inspections driven primarily by state environmental agency concerns involving between three and five media that have not been captured by the EPA and made part of the Initiative. For the most part, the Regions are attempting to structure their inspection efforts in such a way to be credited as part of the Initiative and in some cases this determination has been made after the fact of the inspection.

Needless to say, the threat is real and the potential for open enforcement actions is there. However, in addition to the enforcement threat, there is some potential for promoting, if not partnering, with the EPA in the area of pollution prevention on a non-enforcement level. Therefore, it is important to concerned environmental leaders that they understand the policy and practices of the EPA's Federal Facilities Multimedia Enforcement/Compliance Initiative and have a game plan to prepare their installations for coming inspections.

GOALS OF THE INITIATIVE

One goal of EPA's Federal Facilities Multimedia Enforcement/Compliance Initiative is to assure environmental compliance and reduce environmental risk for federal facilities. Specifically examining compliance with the Resource Conservation and Recovery Act (RCRA), the Clean Water Act (CWA), the Clean Air Act (CAA), the Toxic Substance Control Act (TSCA), the Emergency Planning and Community Right-to-Know Act (EPCRA), and to a lesser extent and as applicable, the Safe Drinking Water Act (SDWA), and the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), all under the umbrella of the Federal Facilities Compliance Act (FFCA). In addition to the compliance goal of the Initiative, driven by executive orders, the EPA hopes to promote pollution prevention efforts by federal facilities and to make the best use of limited environmental oversight resources by using efficient and hopefully well coordinated multimedia teams comprised of both state and federal enforcement authorities.

Finally, a goal of Initiative that is only now emerging in a handful of the EPA Regions is the promotion of "environmental equity" an attempt to address acute concerns for minority and low income communities impacted by environmental noncompliance.

SCOPE OF THE INITIATIVE

The scope of the EPA's Federal Facilities Multimedia Enforcement/Compliance Initiative has been significantly expanded since its inception. The initial plan was to complete forty multimedia inspections of federal facilities throughout all ten EPA Regions over a two year period (two inspections per Region per year). At present, EPA Initiative program managers in Washington are anticipating completing inspections at between 80 to 90 inspections by the summer of 1995. Although the original claims of EPA called for the reporting of results and measures of success throughout the two years of the Initiative through a series of press releases, the regular release of information and certainly press releases have been confined to one or two Regions with no indications of any measures of success. It is important to emphasize, however, that although the Initiative may end after 24 to 28 months with a comprehensive report which details all findings and the trends in environmental compliance at federal facilities, it will not mark the end of federal facility multimedia inspections. It is fair to say that all major federal facilities will eventually see a multimedia inspection team at its gates. In addition, the EPA's commitment to pollution prevention and its pursuing of opportunities and partnerships with federal facilities managers is only now reaching its full stride.

FACILITY TARGETING CRITERIA FOR THE INITIATIVE

Although the list of targeted federal facilities is a closely guarded "inspection sensitive" document that the EPA is not likely to share with federal agencies any time soon, they are more open with us regarding their targeting criteria. Unfortunately, and not unprecedented, each of the EPA Region's targeting criteria are not cast in stone and varies among the Regions and in some cases, due to state regulatory involvements within the Regions themselves. While each Region's current thinking on facility targeting is contained in Table 1, in general, risk ranking, either as developed by the EPA National Enforcement Investigation Center (NEIC) in Denver or one of several Regional or state methods, is the largest component in the targeting formula, 25 to 70% of the EPA's targeting formula. Compliance history is the second most significant component of the targeting formula, 25-40%. Other national, regional, or state program priorities such as the Chesapeake Bay Initiative, if applicable, can be anywhere from 10 to 30% of the targeting consideration. Pollution prevention opportunities are also part of the published targeting criteria formula according to Headquarters EPA guidance; however, only a few Regions have factored in pollution prevention into their targeting formula. Finally, but considered by only a few of the EPA Regions in their targeting formula are environmental equity factors.

THE INITIATIVE PROCESS

For those experienced with working with the various EPA Regions, it will come as no surprise to hear that each Region executes the Federal Facilities Multimedia Enforcement/Compliance Initiative differently. Again, the concept of EPA lead multimedia inspections of federal facilities is nothing new. Indeed, the EPA Initiative shares some of the goals of the Air Force's Environmental Compliance Assessment and Management Program (ECAMP) and their processes are somewhat similar as well. Both the EPA Initiative and the Air Force's ECAMP draw on teams of multimedia experts to assess environmental compliance as well as pollution prevention opportunities at a particular facility. Team size, performance period and the inbrief, data gathering, data summary, and outbrief process are not unusual for either the EPA or Air Force teams. As the Air Force will often bring in environmental media experts from other bases, the EPA will often call in state inspectors. In some cases, such as EPA Region 9, the EPA has partnered with the state and heavily supports the resources needed by the state to support the Initiative's inspections. In other cases, as in the case of Texas and Oklahoma, the states resist working with the federal inspectors and prefer to work multimedia inspections by themselves. While the Air Force relies on their ECAMP manual as an assessment checklist, the EPA uses its National Enforcement Investigations Center (NEIC) Multi-Media Investigation manual as a guide for determining compliance with non-Regional or non-state specific laws and regulations. Of course, the Air Force's ECAMP is an assessment and the EPA Initiative is an inspection tool. While the Air Force works hard to foster a "we're one of you and are here to help" attitude, the EPA makes it clear their job is to enforce the law and that they carry a stick. Indeed, as a result of President Bush's signing of the Federal Facilities Compliance Act into law on 6 October 1992, the once sovereign immunity of federal facilities, particularly with respect to hazardous waste, where provisions for fines are clear in the law, the EPA's enforcement stick has cost the Air Force over $150,000 in settlements to over $300,000 in fines in only a six month period following the President's signing of the Act. The EPA is also not shy about pursuing fines with federal agencies in other media besides hazardous waste and are confident they will soon clear the way for fines in these other areas. As a result of the EPA's role as enforcers, the EPA does not provide a great amount of detail in its outbriefs or provide federal facility environmental managers a final or even draft report to work from to improve its programs. Indeed, until the EPA's lawyers have completed their reviews, a process that has taken as long as two years, little if any feedback can be found. Details as to the process and where the EPA's teams have gone are included in Table 1.

PREPARING FOR THE INITIATIVE'S INSPECTIONS

Now that we understand better the goals of the EPA Federal Facilities Multimedia Enforcement/Compliance Initiative and have a sense of the scope and targeting criteria used as well as the process they follow, it is important to specifically outline some steps that can be taken to prepare for the Initiatives' inspections.

First of all, we should remember the words of the Chief of Staff, United States Air Force, General Merrill A. McPeak; "We're not doing this just because the law requires it--we're doing it because it's the right thing to do." Of course, what General McPeak was referring to in "doing this" was environmental stewardship and compliance. It should be understood that federal facility leaders and managers should not be driven by the EPA's Initiative into a reactionary mode of doing the minimum to "game" the multimedia inspection teams of the EPA. Indeed, the "right thing to do" is to make environmental compliance and pollution prevention part of our way of life and way of doing business and this is indeed the way we operate in the United States Air Force.

Of course, our number one environmental management tool in the Air Force continues to be the Environmental Compliance Assessment and Management Program (ECAMP). The results of this ongoing effort, both via internal and external teams, adjusted slightly to assure we are correlating our findings with the latest open enforcement actions from our servicing environmental regulatory agencies, help prepare us for the day these regulators show up at the gate. In preparing for the EPA's multimedia inspectors, it is critical we concentrate our energies on areas where we have received enforcement actions and areas or environmental media where we know the multimedia teams are looking in our Regions. That means we start by looking at hazardous waste management, air, water, toxic substances, and pesticides and narrow our focus further by looking at the results of multimedia inspections elsewhere in our EPA Region. Closing out findings cannot be the driver, but focusing on enforcement action vulnerable findings, addressing root causes, and pursuing the resources to affect permanent fixes must be the goal.

In addition to ECAMP, the number one management tool, there are other tools available to help us prepare federal facility leadership for an EPA multimedia inspection. The EPA's National Enforcement Investigations Center in Denver has produced a Multimedia Investigations Manual that many of the EPA Regions refer to in preparing for and executing a Multimedia Enforcement/Compliance Initiative inspection. This manual details the multimedia inspection planning process, field inspection strategies, and specific media investigation procedures. It even discusses laboratory and documentation methods and contains copies of many of the forms the EPA teams may be using in an actual inspection. In addition, Because several state environmental regulatory agencies play a major role in the EPA's multimedia inspection effort, it is not surprising that many states have developed their own inspection manuals and guides. Many of these types of manuals are available via Air Force Regional Compliance Offices (RCOs) or are available for the asking directly from the States. Federal facility environmental managers should pursue these documents and add them to their technical libraries and consider incorporating them into their internal ECAMP efforts at the earliest opportunity.

In August of 1993, the Headquarters EPA published guidance to its Regional Compliance Program directors in the form of a National Multimedia Screening Inspection Checklist. All of the EPA Regions had a hand in building these checklists and only a few had their own checklists in place prior to August. These checklists give excellent insight into what the multimedia inspection teams are looking at. Federal facility environmental managers have already started to see these checklists and additional questions in reference to state regulatory concerns. This does not necessarily mean these facilities are targeted for an EPA Multimedia Enforcement/Compliance Initiative inspection soon, but it does indicate these facilities are on their mailing list and are being considered in accordance with their targeting criteria.

Another tool out there to help prepare federal facilities for EPA multimedia inspections is a product of the Air Force Center for Environmental Excellence's (AFCEE) Region Compliance Offices. In AFCEE's pamphlet, Managing Compliance Inspections... Pocket Guide to Handling Visits by Regulators, the nuts and bolts of handling the day-to-day activities associated with being on the receiving end of an inspection are detailed. Pre-inspection activities, ideas to better handle site entry and how to take advantage of inbriefs and prepare the documentation the inspectors will ask to see are all discussed.

It may be obvious, but one lesson we have learned from the AF Inspector General (IG) process is that one of the best ways to prepare for an inspection at our base is to observe an inspection, or at the, least talk with our counterparts at our neighboring bases. In the case of EPA multimedia inspections, it is important we keep in touch with the environmental leadership at other federal facilities in the same EPA Region. To this end, Table 1 provides the names of most of the facilities visited to date as part of the EPA's Federal Facilities Multimedia

Enforcement/Compliance Initiative. To date, we have not been doing a great job cross feeding lessons learned from regulatory inspections and need to do better but for now, not unlike our AF IG process, we must fight for this feedback.

If we are to be successful in seeking feedback regarding the EPA's multimedia inspections from our counterparts at neighboring installations, we must also remember to be forthright with this process by providing feedback once our installation is inspected. If we do not make an effort in this regard, how can we expect quality feedback when it again becomes time for our installation to be visited by the EPA? To this end, we should prepare for each inspection by identifying the appropriate escorts for the visiting EPA team. Ideally, we should have a primary and an alternate escort identified by name for each of the visiting regulators. These escorts become our first line in the feedback effort and should be prepared to take written notes, audio tape recordings, photographs, and video recordings on occasion.

For the ambitious environmental manager who wants to take a proactive effort in preparing for the EPA's multimedia inspection teams, we can expand upon the inbriefing normally given by the installation's environmental leadership to visiting ECAMP auditors, by providing the regulators with a positive and well orchestrated inbrief which stress the progress being made, good management practices, and pollution prevention achievements. The old saying that first impressions are the most important certainly apply here, and we want to take advantage of having the regulator's team all together in one room to make them aware of any environmental program success stories, especially any pollution prevention successes or even planned initiatives, we may have. Following this inbrief, we should be prepared to have a room or area set aside with pertinent environmental plans, reports, and other records. In many cases, the team will identify what documentation they want to review during their inspection in their inbriefing. Having all the documents required by the regulators together is a proactive effort that sends the signal that our programs are well managed and we are not holding anything back from them. As a reminder, however, it is the EPA's policy not to request copies of internal or external environmental audits, so we should not provide or be asked to provide ECAMP reports or related information to visiting inspectors.

Since a part of most EPA multimedia inspection teams is a pollution prevention cadre, it is important we are prepared to show this group our pollution prevention program to include the installation pollution prevention plan, baseline survey and opportunity assessment. The biggest opportunity here however may be in demonstrating various pollution prevention processes that are in place or that are readily implemented and to solicit their support if not approval. Although not widely advertised, even within the EPA, the Federal Facility Multimedia Enforcement/Compliance Initiative Program has a considerable annual appropriation that can be used by other federal agencies to fund pollution prevention projects related to the Initiative's inspections. Therefore, it is essential that we have pollution prevention projects "on the shelf" to propose to the EPA as an investment opportunity. Also, in the event the EPA is considering or proposing a penalty for our installation, as a result of regulatory non-compliance, such a pollution prevention project could be used as a substitute for a monetary fine.

If you can't get a copy of the upcoming inspection schedule of your local EPA Region or do not have a clairvoyant in your base's Environmental Flight, you may want to do some research on the federal facilities in your EPA Region and by applying the Table 1 targeting criteria information, try to figure your own base's vulnerability to an EPA multimedia inspection. Although the EPA Regions' targeting criteria, with the exception of a few Regions, is not an exact science and there are no guarantees that a state regulatory agency driven influence can enter into the targeting decision making at a moment's notice, there are obvious advantages of knowing approximately when an EPA multimedia inspection team may come to visit.

CONCLUSION

The EPA Federal Facilities Multimedia Enforcement/Compliance Initiative may be nothing new, but when added to the already full plate in front of base Environmental Flights, it becomes one of the many challenges that demand our full attention. Given the dynamic nature of environmental legislation and regulation as well as the seemingly growing staffing of State and Federal EPA enforcement offices, we must do our homework like we have never done it before. This includes posturing for the pollution prevention opportunities inherent with this program. Again, not so as to game the regulators and their inspections but because environmental compliance is the "right thing to do."

REFERENCES

1. "Federal Facilities Multimedia Enforcement/Compliance Initiative", U.S. EPA Pamphlet OE-2261, Office of Federal Facilities Enforcement, Feb 93.
2. "FY93 Multimedia Strategy and Guidance", Texas Water Commission, Oct 92.
3. Herman, Steven A., "Final Enforcement Guidance on Implementation of the Federal Facilities Compliance Act", U.S. EPA, Jul 93.
4. "Managing Compliance Inspections", Air Force Center for Environmental Excellence, Regional Compliance Offices, 93.
5. McPeak, General Merrill A., "Air Force Environmental Doctrine", Headquarters U.S. Air Force, Apr 92.
6. "Multimedia Investigation Manual," U.S. EPA, Mar 92.
7. Tobin, Lt Col Richard W. II, "Region VI Multimedia Inspection Program", Air Force Legal Services Agency, Nov 93.
8. Wiley, William B., "The Federal Manager's Guide to Liability", FPMI Communications Inc., 92.

TABLE 1

EPA REGION PRACTICES WITH RESPECT TO
FEDERAL FACILITY MULTIMEDIA ENFORCEMENT/COMPLIANCE INITIATIVE INSPECTIONS

REGION	POINT OF CONTACT	TEAM SIZE	INSPECTION NOTICE	PERIOD	INSPECTIONS FY 93	FY94 GOAL	TARGETING CRITERIA	INSPECTIONS TO DATE
1	Ann Fenn (617)565-3927	14-16	1 wk	1 wk	5	4-5	NEIC Risk Ranking (40%) Compliance History (30%) Env. Equity (20%) Regional Concerns (10%)	8; 6 DoD: 3 USN, 1 USA and 2 USAF (Westover AFB, Burlington ANGB)
2	Bob Hargrove (212) 264-1892	10-14	2 wks	1 wk	4	2-4	NEIC Risk Ranking (40%) Compliance History (30%) Regional Concerns (30%)	7; 6 DoD: 2 USN, 3 USA and 1 USAF (Plattsburg AFB)
3	Larry Teller (215)597-1269	15	4 dys	1 wk	4	5-6	Regional Risk Ranking (50%) Compliance History (35%) Regional Concerns (10%) Environmental Equity (5%)	5; 4 DoD: 3 USA and 1 USAF (Dover AFB)
4	Arthur Linton (404)347-3776	6-20	4 dys	1 wk	6	10-12	Regional Risk Ranking (50%) Regional Concerns (30%) Compliance History (20%)	14; 12 DoD: 2 USN, 4 USA, and 6 USAF (AF Plant 6 and S-J, MacDill, Pope, Keesler, Tyndall AFBs)
5	Lee Regner (312)353-6478	15-20	1 wk	1 wk	2	2-3	NEIC Risk Ranking (45%) Compliance History (25%) Regional Concerns (25%) Pollution Prevention Op (5%)	3; 2 DoD: 1 USA and 1 USAF (WPAFB)

TABLE 1 (CON'T)
EPA REGION PRACTICES WITH RESPECT TO
FEDERAL FACILITY MULTIMEDIA ENFORCEMENT/COMPLIANCE INITIATIVE INSPECTIONS

REGION	POINT OF CONTACT	TEAM SIZE	INSPECTION NOTICE	PERIOD	INSPECTIONS FY 93	FY94 GOAL	TARGETING CRITERIA	INSPECTIONS TO DATE
6	Jim Highland (214)655-7452	8-18	3 dys	1-2 wks	3	20	Compliance History (40%) Regional Concerns (30%) Reg VI Risk Ranking (25%) Env. Equity (5%)	20; 16 DoD: 5 USA and 11 USAF (AF Plant 3 and 4; Kelly, Bergstrom, Little Rock, Cannon, Barksdale, Holloman, Tinker, Kirtland, and Vance AFBs)
7	Craig Burnstein (913)551-7688	10-12	0-1 dy	1 wk	2	3	Compliance History (40%) NEIC Risk Ranking (30%) Regional Concerns (20%) Pollution Prevention Op (5%) Env. Equity (5%)	4; 1 DoD: 1 USA
8	Elmer Chenault (303)294-1982	6-7	3-5 dys	1 wk	3	2	Updated NEIC Risk Ranking (40%) Compliance History (30%) Regional Concerns (30%)	3; 3 DoD: 3 USAF (Grand Forks, FE Warren and Hill AFBs)
9	Sara Segal (415)744-1570	8-10	Varies	1 wk	2	2-3	NEIC Risk Ranking (40%) Compliance History (30%) Regional Concerns (30%)	3; 3 DoD: 1 USN 2 USA and no USAF
10	Barbara Lither (206)553-1191	11-13	0 dys	1 wk	2	2-4	Reg. X Risk Ranking (70%) Environmental Equity (20%) Regional Concerns (10%)	4; 4 DoD: 1 USN 2 USA and 1 USAF (Eielson AFB)

AIR FORCE POLLUTION PREVENTION RESEARCH AND DEVELOPMENT PROGRAM

Point of Contact:
Lt Col Gil Montoya
WL/MLSE Building 652
2179 Twelfth Street Suite 1
Wright-Patterson AFB, OH 45433-7718
(513) 255-3953

The Air Force Pollution Prevention R&D Program is managed through the Materials Directorate of Wright Laboratory and is a coordinated effort between the Air Force "super" laboratories, the Air Force Office of Scientific Research, industry, and academia. The mission of the US Air Force is to control air and space to defend the United States. The mission of the laboratories is to provide the superior technology with which to control air and space. Technology preeminence has always been the trademark of the US military, fight the battle and win the war with fewer but superior weapons. Organizationally, the laboratories are under the command authority of the AFMC and product center commanders, with technical direction coming from the Technical Executive Officer, AFMC/ST. For organizational purposes, each product center has a laboratory assigned; Space and Missile Center(SMC), Phillips Laboratory(PL), Electronic Systems Center(ESC), Rome Laboratory(RL), Aeronautical Systems Center(ASC), Wright Laboratory(WL), and Human Systems Center(HSC), Armstrong Laboratory(AL). Armstrong Laboratory is the lead Air Force Laboratory for Environment and primarily works compliance, conservation, and remediation. Under the overall Armstrong environmental umbrella, Wright Laboratory is the Air Force lead for Pollution Prevention.

Pollution Prevention means "source reduction," as defined under the Pollution Prevention Act of 1990 and other practices that reduce or eliminate the creation of pollutants through increased efficiency in the use of raw materials including energy, water, and other resources or materials substitution. National policy places highest priority on pollution prevention and the eventual decision to use substitute materials depends upon environmental safety. Present laws and regulations are greatly impacting our Air Force customers and pollution prevention R&D will play a vital role to ensure long-term Air Force mission accomplishment.

The Wright Laboratory role is to coordinate the efforts of the R&D facilities to ensure the highest priority Air Force needs are met, eliminate duplication of effort, and ensure the appropriate technology is developed and transitioned to the customer. Coordinating the R&D efforts requires interfaces with the Army, Navy, DOE, and EPA. This coordination takes place primarily through the Tri-Service Environmental Quality Strategic Plan, Project Reliance, the Strategic Environmental Research and Development Plan (SERDP), the National Defense Center for Environmental Excellence (NDCEE), and the DOD Deputy Director for Research and Engineering (DDR&E). Internal Air Force coordination requires interfacing with higher headquarters, primarily Air Force Materiel Command (AFMC) and Air Force (AF) Civil Engineers (CE), AFMC Science and Technology (ST), AFMC Logistics (LG), AFMC Plans and Programs (XP), and AFMC Requirements (XR). At the AFMC level, each of these organizations is responsible for meeting at least one of the Air Force Pollution Prevention Objectives.

The Air Force Pollution Prevention Policy Objectives are: 1. Reduce use of HAZMATs in acquisition of new weapons systems (AFMC/XR); 2. Reduce use of HAZMATs in existing systems (AFMC/LG); 3. Reduce HAZMATs usage and waste generation at installations and government owned and contractor operated (GOCO) facilities (AFMC/CE); 4. Acquire and transition state of the art technology (AFMC/ST); 5. Identify technology shortfalls, develop, and transition new technology (AFMC/ST); 6. Establish an Air Force investment strategy (AFMC/CE). AFMC established the Technology Master Process (TMP) as a systematic process to work towards meeting these objectives.

The Technology Master Process (TMP) provides top level guidance from needs identification to technology transition. The TMP defines the roles and responsibilities of the participants, i.e. HSC/XRE is responsible to gather and prioritize the needs, the laboratories to develop the technology to meet the needs, and the Aeronautical Systems Center(ASC) Technology Transition Office (TTO) to transfer the technology to the user.

This paper focuses only on objective five, the role of the laboratories to develop the technology. The R&D community process begins with a prioritized list of technical needs (TNs) provided to the laboratories through HSC/XRE. The TNs are divided by the laboratories into the technology areas: batteries; cleaning; coating; coating removal; composites manufacturing; deicing; electronics fabrication; fire suppression; fuels, lubricants, and fluids; munitions; plating; surface preparation; testing and qualifications; and other pollution prevention R&D support. The next step is to determine if technology exists to address the specific TN. If technology exists, the TN is assigned to the Technology Transition Office to work the need. If technology is not available to meet the need, a determination is required if it is appropriate to develop the technology. If it is appropriate to develop the technology, the need is assigned to the laboratory best capable of developing the required technology. Each laboratory is then responsible for coordinating with the TN submitter to develop a mutually defined project to meet the user need. This mutually defined project will be described in an Integrated Data Sheet and road map to be included in the Air Force Environmental Quality Research, Development and Acquisition Strategic Plan. Once in the Strategic Plan, the potential project will be prioritized by the Environmental Safety and Occupational Health (ESOH) Technical Planning Integrated Product Team (TPIPT).

This presentation will overview the R&D in selected technology areas to meet high priority customer needs. Projects are categorized into four areas: Ozone Depleting Compound (ODC) Elimination, HAZMAT Materials and Substitution, HAZMAT Waste Reduction, and Volatile Organic Compound(VOC) Elimination. Each category of projects has specific goals. The ODC Elimination goal was to eliminate the purchases of ODCs by 1 Apr 94. The HAZMAT Materials and Process Replacement goal is to reduce purchase of EPA 17 materials from 1992 baseline 50% by the end of 1996. The HAZMAT Waste Reduction goal is 25% by the end of 1996, and 50% by the end of 1999. VOC elimination goals are included in the HAZMAT Materials and Substitution and HAZMAT Waste Reduction. Each category consists of a portfolio of projects which meet high priority customer TNs and contributes to meeting specific goals.

ODC Elimination on-going programs include: On-Board Halon Replacement, Aerosol Fire Suppression Technology, Advanced Streaming Agent , Lube-Free Compressor, Advanced Supercritical Carbon Dioxide Cleaner, CFC-Free Oxygen Cleaning System, and Low Nitrous Oxides Turbine Engine Emissions. ODCs have been banned from production by the Montreal Protocol and Air Force ODC policy, effective 1 Jan 93, directs the removal and banking (stock piling) of halon from non-mission critical applications as well as prohibiting the purchase of newly produced halon as of 1 Jun 93. Mission critical applications are allowed to use recycled halon and implement alternatives once they are available. Air Force mission critical halon applications are defined as halons used on board aircraft which are required to meet flight safety, flight survivability, or flight certification requirements.

On-Board Halon replacement program is a joint service and Federal Aviation Administration (FAA) research program to evaluate available alternative chemical agents for non-occupied, in flight fire/explosion suppression application. The program is on schedule to select the most suitable available chemical by FY95 and deliver design application information to aircraft engineering organizations by FY96. This Advanced Technology Demonstration program has an approved technology transition plan which involves representatives from single managers, major commands, Army and Navy aviation programs as well as FAA technical representatives. Existing aircraft systems use the halon bank until a product is delivered. Wright Laboratory is also addressing alternative fire suppression technologies such as false alarm proof fire detectors and solid propellant gas generators.

The Aerosol Fire Suppression Technology project is to investigate the capabilities of a totally new class of fire suppressants known as aerosols that have emerged in the international literature, and to evaluate and test these aerosols on a laboratory scale that simulates operational conditions to suppress fires in enclosed space. On a weight basis the aerosols are 5-6 times more powerful than Halon 1301. The successful development of aerosol technology and its delivery systems will provide the DOD with a broad range of fire suppression agents that are not only state-of-the-art in fire extinguishing capability, but are also environmentally safe. Aerosol systems will be able to protect all types of facilities, storage areas, fuel storage tanks, and possibly have aircraft fire suppression roles.

The Advanced Streaming Agent project objective is to develop a "drop-in" clean, environmentally safe streaming fire suppressant to replace Halon 1211 used in flight line and aircraft portable fire extinguishers. The candidate compounds will be examined for their global environmental impact to ensure those filtered through to advanced testing have low/zero ozone depleting potential and global warming potential. The major uncertainties at present are their toxicity and manufacturability. The successful completion of this research effort will provide the Air Force and other DOD components with a replacement for Halon 1211, a heavy ozone depleter. Due to the widespread use of Halon 1211 fire extinguishers in the civilian community, the agent developed in this research effort will have dual applicability.

The goal of the Lube-Free Compressor project is to conduct a field demonstration a high efficiency lubrication free compressor that allows the use of various environmentally safe alternate refrigerants in both aircraft and ground equipment applications. The use of chlorinated-fluoro-carbons (CFCs) and even hydro-chlorinated-fluoro-carbons (HCFCs) will be outlawed by 1995 by the EPA's Clean Air Act. The development of a lubrication-free magnetic bearing compressor, when coupled with an alternate working fluid, enables the continued use of centrifugal compressor technology. The use of this technology also allows for the possible retrofit of current systems, at considerable cost savings. Only the compressor and working fluid are changed. Application of the technology is not only environment enhancing, but also provides immense energy efficiency and energy cost benefits.

The Advanced Supercritical Carbon Dioxide Cleaner project will design and build a prototype supercritical fluid cleaner with an internal chamber sized to accommodate both avionics and mechanical components. The prototype cleaner shall work on the same principal as the old solvent degreasers and requires no expensive pumps and valves to circulate the fluid. The principal fluid to be evaluated will be carbon dioxide and may include a variety of non-ioinc and anionic surfactants which are non toxic and more potent than ordinary co-solvents. The program shall test the prototype to evaluate the ability to clean the desired components and allow for recommendations to improve the system.

The objective of the CFC-Free Oxygen Cleaning System project is to optimize the atomic oxygen reaction with hydrocarbons and many other non silicon dioxide materials to develop an environmentally benign cleaning system to replace existing systems which use chlorinate fluorocarbons and other hazardous materials. Optimize the process to be reliable, reproducible, and meet cleanliness standards.

The objective of the Low Nitrous Oxides Turbine Engine Emissions project is to establish the mixing and combustion technology for controlling the emissions of pollutant species, especially oxides of nitrogen (NOx), from advanced high performance military gas turbine engines. The program will leverage the resources of an integrated in-house/contractual research program involving General Electric, Pratt & Whitney, the University of California, and an Air Force Office of Scientific Research (AFOSR) in-house research team.

HAZMAT Materials Replacements on-going projects include; Non-Chemical Metal Surface Preparation, Solid State Metal Cleaning, Accelerated Test Methods/Cleanliness Standards, Laser Based Cleaning/Surface Preparation, Environmentally Compatible Aircraft/Runway Deicers, and Non-toxic Fuel Icing Inhibitors.

Non-Chemical Metal Surface Preparation is to develop surface preparations for aluminum and titanium alloys that eliminate or minimize use of hazardous materials such as hexavalent chromium, strong oxidizing acids or concentrated bases, or generation of large amounts of contaminated waste water. State-of-the-art surface treatments for aluminum and titanium alloys generate large amounts of waste water within the process and/or incident to waste treatment. The objective is to identify, develop, and optimize non-wet chemistry approaches for the formation of stable morphologies on the surface of aluminum, titanium, and copper materials that will allow performance of high quality coating or adhesive bonding. Breakthrough technologies to prepare metal surfaces in various stages of manufacturing and remanufacturing will be of enormous benefit to aerospace and other industries in the US and worldwide. The total cost avoidance will be dependent upon the specific applications and the technologies developed.

Solid State Metal Cleaning is to develop innovative metal cleaning processes that do not require the use of water or volatile organic compounds (VOCs). State-of-the-art cleaning processes now involve the use of PD 680 type solvents, chlorinated solvents, or water-based cleaning systems to remove oil, waxes and particulates from the surface component surfaces. The two technical objectives to be achieved by this project are (1) to develop and transition to a using customer a cleaning process for large and small aircraft components that do not require the use of water or VOCs, and (2) to develop a process that will allow components to proceed directly to the next step in the process for surface without the need for subsequent treatments involving water or organic solvents.

The Accelerated Test Methods/Cleanliness Standards project goal is to develop low risk, fast track methodologies and techniques for military qualification of new or modified environmentally benign materials. There is a need to develop accelerated and less costly means for qualification testing of alternate, substitute and emerging new materials and processes to rapidly introduce environmentally acceptable materials into the military inventory and force structure. The efficiencies and economies will result from elimination of unnecessary or redundant tests and earlier implementation of clean technology.

The Laser Based Cleaning/Surface Preparation project approach is to design, fabricate, test, evaluate and demonstrate a state-of-the-art automated, controllable laser cleaning and coating removal facility. The facility will be designed for carbon dioxide and eximer laser cleaning and coating removal operations. System operation will be fully robotized and computer controlled with on-line instrumentation for component positioning and measuring and controlling laser inputs to the part surfaces. Benefits include the complete elimination of the use of toxics and hazardous waste generation in logistics center maintenance and remanufacturing operations relying on the new technology. The process is expected to be highly cost effective considering that all costs for hazardous materials management and management of solid, liquid, and vapor waste streams will be eliminated.

For Environmentally Compatible Aircraft/Runway Deicers, the technology being developed under this project, production of potassium acetate from waste gas, is projected to reduce the cost of potassium acetate runway deicers by 30-50%. Unless environmentally compatible deicers are developed, expensive runoff control/treatment facilities may be required to meet regulatory requirements. Continuous production of potassium acetate and calcium-magnesium acetate from waste gas will be demonstrated in a continuous bench scale system and the process will be optimized. Production of potassium acetate from waste gas has the potential to save the Air Force between $300,000 to $500,000 per year.

The Non-toxic Fuel Icing Inhibitors project objective of this program is to develop a non-toxic, environmentally safe fuel system icing inhibitor to replace the currently approved icing inhibitors. This new additive will eliminate hazardous waste, eliminate a toxic hazard for field personnel, and ensure environmental compliance for the Air Force and DOD. Ethylene glycol monomethyl ether and diethylene glycol monomethyl ether are the currently approved fuel system icing inhibitors. Glycol ethers have been targeted in the 1990 Clean Air Act Amendment and their use may be severely regulated in the future. Additionally, the inhibitors and water separate from the fuel, settle to the bottom of the storage fuel tanks and must be disposed of as hazardous waste. This disposal costs the government millions of dollars each year. Molecular modeling and chemical graph theory will be used to predict the effectiveness and toxicity of potential inhibitor candidates. The Naval Air Warfare Center will perform bench scale testing on all potential technologies to determine effectiveness. Results of these efforts will be shared with researchers working to develop wing deicing compounds and runway deicing agents to determine commonalty.

HAZMAT Waste Stream Reduction on-going projects include; Low Maintenance Nickel-Cadmium, Nickel Metal Hydride Battery, Non-lead Base Sealants, Electromagnetic Powder Spray, Laser Torch Metal Deposition, and Large Aircraft Robotics Paint Stripping(LARPS), and one just completed project, Light Curing Fuel Tank Repair Sealant.

The Low Maintenance Nickel-Cadmium or 20 year Maintenance Free (Ni-Cd) Aircraft Battery (MFAB) objective is to couple an MFAB with an integrated charger/diagnostics unit to extend battery lifetime to 20 years. Accomplishing a 20 year life eliminates frequent and costly maintenance of vented nickel-cadmium batteries and will significantly reduce the amount of cadmium, an EPA identified highly toxic substance, to be handled and disposed of after a battery has failed.

The Nickel Metal Hydride Battery project goal is to eliminate the use of cadmium metal, an EPA identified highly toxic substance, in rechargeable nickel-cadmium (Ni-Cd) batteries. A new battery system, Nickel-Metal Hydride (Ni-HMx), completely eliminates the use of cadmium and has performance capabilities beyond that of Ni-Cd or lead-acid (Pb-acid) batteries. Inherent to the Ni-MHx system is the elimination of maintenance. It is a sealed system which eliminates the need to check or adjust electrolyte as is required for vented Ni-Cd or Pb-acid batteries. Elimination of flight line maintenance of vented Ni-Cd batteries is estimated to save the Air Force alone approximately one billion dollars over the next twenty years. Preliminary Ni-MHx data show that battery weight can be reduced to half of Ni-Cd or Pb-acid without sacrifice in performance.

The objectives of the Light Curing Fuel Tank Repair Sealant were to develop a fuel tank repair sealant that has a long work life and application properties similar to conventional polysulfide sealants, yet cures rapidly to form a tough, fuel resistance elastomer when exposed to ultraviolet light. A single-component sealant material which meets these requirements has been successfully developed from acrylated sulfur-containing oligomers combined with a proprietary photoinitiator sensitive to light in the 365 to 410 nm waveband. The uncured sealant, in either liquid or thickened "flowable putty" form, can be applied by brush, spatula, or extrusion gun and cures in 10 minutes or less when exposed to the portable UVA light source. The physical properties of the cured sealant, measured using the test methods of MIL-S_8802, exhibit excellent strength, fuel resistance, and adhesion to a wide variety of substrates including cured polysulfide.

The objective of the Non-lead Base Sealants project is to develop a non-hazardous material substitute for electrical grade polysulfide (MIL-S-8516F) which is used extensively throughout the DOD as a fuel-resistant sealant for electrical components in aircraft and by DOE as a sealant to protect warhead arming, fusing, and firing sections, which operate at medium to high voltages. This project is a continuation of a DOE funded seed project and will continue to technology transfer to both aerospace and DOE integrated suppliers, contractors, and repair depots.

For Electromagnetic Powder Spray, the goal is to develop environmentally benign materials and processes to deposit or remove chromium, nickel, copper on metal parts. The availability of usable non-electroplate deposition/removal processes to the aerospace industry will free Air Force and industry users from the burdens of using a technology dependent on chromates and cyanides. The total cost avoidance will be dependent upon the specific applications and the technologies developed.

The objective of the Laser Torch Metal Deposition project is to eliminate the need for solution based electroplating of chrome and nickel by the development of a solid state deposition process based on laser energy. New and more stringent EPA requirements under the Clean Water Act and Air Force policy guidance make it clear industrial processes are required which do not depend on toxic water soluble forms of these heavy metals. This program will support technology developments made by industry in the laser shock wave deposition of thin metallic films onto various substrates. The processes to be developed will not depend upon the use of water, VOCs, ODCs, or water soluble forms of the deposited metal. The technology development will be done in conjunction with the participating customer, OC-ALC, and the technology will be scaled up and demonstrated at the center.

Large Aircraft Robotics Paint Stripping(LARPS). Currently the Air Logistics Centers (ALCs) remove organic coatings from large aircraft with methylene chloride based chemical stripping compounds. Methylene chloride and other hazardous chemicals will be banned by the EPA, Air Force, or federal law by the year 1997. This initiative provides an enhanced, fully automated LARPS system providing an environmentally safe (94% reduction in hazardous waste) paint stripping system which will eliminate personnel exposure to a hazardous working environment. This project eliminates significant quantities of hazardous waste, reduces ALC personnel exposure to hazardous waste environment, and provides high estimated cost savings of $4.6M/yr at Oklahoma City ALC.

The Volatile Organic Compound (VOC) Elimination on-going project is Powder Base Prime/Topcoat Development.

The Powder Base Prime/Topcoat Development objective is to develop technologies that do not require spray application or the use of toxics such as VOCs or isocyanides. Selected technologies will be developed, optimized, reduced to practice, qualified, and implemented for use on Air Force weapon systems. This program will develop alternatives to solvent based coating systems for large aircraft parts. Considerations in identifying an acceptable technology will include: maintenance or improvement of substrate integrity, effects of part geometry, process quality assurance, and curing specifications. Candidate technologies, including both government and industry initiatives, will be identified and assessed.

The extent to which each project contributes to meeting the specific goals is being determined through studies of the waste streams at the Air Logistics Centers. However, as an example, it is estimated that using the LARPS will virtually eliminate the usage of methylene chloride at the Oklahoma City Air Logistic Center and reduce the ALC's HAZMAT waste stream by over 90%.

Some of the Pollution Prevention R&D technical accomplishments are provided. Non-chromate aluminum deoxidizer developed and specification issued in 1990. Non-ODC/NON-HAZMAT dye penetrant qualified and approved and specification issued in 1994. Chromate/HAZMAT-Free Surface Preparation for aluminum, transitioned to Warner-Robins Air Logistics Center and used to repair C-141 weep hole cracking. Chromate-free Sealant developed and specification issued in 1993.

INFORMATION SOURCES

Strategic Environmental Research and Development Program (SERDP)
Strategic Investment Plan, Fiscal Year 1993, September 1993
DOD and DOE Proposals for Fiscal Year 1994

USAF Environmental Quality Research, Development and Acquisition Strategic Plan, 27 May 1994

Technology Investment Plans (TIPs)
Control of Pollutant Emissions in High Heat Release Combustors, TIP NO. F&L-03
Development of a Non-toxic Environmentally Sate Fuel System Icing Inhibitor, TIP NO. F&L-07
Laser Shock Wave Deposition of Metallic Chrome and Nickel, TIP NO. ML-94-3.13
Powder Base Priming and Coating, TIP NO. ML-94-3.16

Phase II Final Report, Light Curing Fuel Tank Repair Sealant, 1 April 1994

SESSION VIII

EPA 17/EPA POLLUTION PREVENTION INITIATIVES

Session Chairpersons:

James Edward, EPA

Colonel Sam Garcia, HQ AFCEE/ER

Incorporating Pollution Prevention into Multi-Media Inspections and Enforcement

Prepared by:

Reggie Cheatham, Environmental Engineer
U.S. Environmental Protection Agency
Office of Enforcement & Compliance Assurance
Federal Facilities Enforcement Office

Introduction:

Federal facilities are a highly visible sector of the regulated community. Although improving, Federal facility compliance rates in all media have been traditionally lower than those of the private sector. Based on the need to address the environmental problems in the Federal sector, the Enforcement Management Council (EMC) identified the Federal Facilities Multi-Media Enforcement Initiative (FMECI) for FY 93/94.

Many Federal agencies currently use a multi-media approach in their internal auditing and compliance evaluations. Multi-media enforcement provides an opportunity for a holistic evaluation of a facility by identifying threats to the environment where pollutants cross through various media. Also, multi-media activities provide for a more in depth opportunity for identifying pollution prevention projects that can be implemented as Beneficial Environmental Projects at the facility or throughout similar Government Branches, Agencies, Departments, and even the private sector. The pollution prevention projects are designed to resolve identified violations or improve environmental areas of concern.

Federal agencies are benefitting from the FMECI in that EPA is clearly defining their environmental compliance status and the risks the facility poses to human health and the environment. The FMECI provides greater efficiencies for installations by eliminating the resource burden of numerous single media inspections and serves as an excellent training ground through enhanced EPA technical assistance to Federal agency environmental staffs.

The goal of the FMECI has been to improve Federal agency compliance and reduce environmental risks from Federal facilities through increased use of multi-media inspections; efficient utilization of all available enforcement authorities; and enhanced use of innovative pollution prevention (P2) approaches to solving compliance problems.

Purpose:

The purpose of this paper is to present the FY 93 results from the FMECI and to discuss the activities associated with the first utilization of EPA's pollution prevention technical assistance provided by EPA's Office of Research & Development/Risk Reduction Engineering Laboratory (ORD/RREL).

FY93 Results from the FMECI:

In FY93, EPA and participating states conducted 41 multi-media investigations. These investigations produced 57 enforcement actions by EPA and participating states. The following is a list of the type and number of enforcement actions taken as part of the FMECI:

Warning Letters:	17
Field Citations:	01
NON/NOVs:	28
Orders:	05 (4 w/penalties)

These enforcement actions were for violations under RCRA, CWA, CAA, TSCA, SPCC, UST, EPCRA, SWDA and FIFRA. Many of these violations can potentially incorporate pollution prevention approaches to return to or go beyond compliance. In FY94, EPA and participating states are continuing to conduct multi-media inspections. Currently, it appears EPA and the states will complete 25 to 30 multi-media investigations in FY94. Many EPA regions and states are currently planning their FY95 Federal facility multi-media activities.

Pollution Prevention in Multi-Media Inpsections & Enforcement:

A new perspective of utilizing pollution prevention in Federal Sector enforcement is emerging via the FMECI. Pollution prevention was used as a targeting criteria for the selection of Federal facilities as candidates for multi-media inspections under the FMECI. Pollution prevention profiles were developed for each Federal facility utilizing EPA data bases. Generally, the data bases utilized were for air emissions, water discharges, and hazardous waste management.

The pollution prevention profile process began with the Regions providing headquarters (OFFE) with a list of candidate Federal facilities that potentially would receive multi-media inspections as part of the FMECI. OFFE used a "hybrid" approach to prepare pollution prevention opportunity profiles. The "hybrid" approach involves concurrent analysis of two sources:

1) Facility Mission Analysis: identifies those generic P2 opportunities which generally would be associated with the operations that support the mission.

2) EPA Data Base Analysis: using data from the Biennial Reporting System (BRS), the Permit Compliance System (PCS), and the Aerometric Information Retrieval System (AIRS), OFFE searched each system for wastes streams and discharges that show the potential for P2.

The data was evaluated and compared to the Facility Mission Analysis to identify major P2 opportunities that could be associated with identified violations (eg. areas subject to regulation/evaluation).

The pollution prevention profiles were given to inspection teams and the Office Regional Counsel to assist in the identification of potential pollution prevention opportunities at each selected facility. If violations are identified, the FMECI promotes the maximum use of negotiated pollution prevention settlements to address compliance problems. The Federal budgeting process supports implementation of pollution prevention projects to address areas of non-compliance.

As mentioned earlier, EPA's Office of Research & Development/Risk Reduction Engineering Laboratory (ORD/RREL) is available to EPA Regions and states to provide technical pollution prevention opportunity assessment assistance, including innovative technology demonstration projects. This non-enforcement technical assistance in the pollution prevention arena is designed to assist in the identification of prevention oriented solutions to compliance problems identified during the FMECI.

The first pollution prevention technical assistance was provided at Eielson AFB, Alaska. After the conclusion of the multi-media investigation, EPA Region 10 requested ORD/RREL technical assistance to work with Eielson AFB in the identification of potential pollution prevention opportunities that would fix several compliance concerns.

ORD/RREL is currently working with base environmental personnel at Eielson AFB to fully identify base-line pollution prevention opportunities and programmatic shortfalls which could assist the base environmental personnel in achieving full compliance and realizing the true pollution prevention potential throughout facility operations. One major area of focus is within the Structural Maintenance Facility (SMF).

The SMF is currently utilizing plastic media blasting techniques to depaint small parts. They also hand sand whole aircraft, which usually requires three days of processing per unit. From the pollution prevention opportunity profile (See Attached), the data (1989 most recent available) indicates that five waste streams totaling 54.19 tons were associated with painting/corrosion control activities. According to the facility, the plastic media blasting and sanding techniques were implemented as waste minimization projects. These techniques, however, have several shortfalls that can be overcome by exploring other techniques.

Early analysis by ORD/RREL appears to indicate that bicarbonate stripping techniques may be more user friendly for operators and could eliminate the one use plastic media currently used for depainting small parts. The impacts of bicarbonate baths are still being evaluated for effectiveness and potential water pollution concerns. Another technology is being considered to replace the hand sanding stripping operations. The Air Force is currently testing and utilizing carbon dioxide (CO_2) stripping in aircraft corrosion control activities. The technology is being evaluated for logistical concerns before proceeding with possible implementation.

These two prevention approaches provide Eielson AFB with an opportunity to address their identified compliance problems with hazardous waste management by changing the processes that are generating the waste. The two source reduction techniques mentioned may not create a zero discharge/generation scenario, but they can provide process operators with an opportunity for better waste generation control. This is based on the capacity of the technologies identified, but has not been field demonstrated at Eielson AFB.

Closing:

Overall, each Federal facility with environmental compliance concerns has the opportunity to pursue prevention oriented approaches to compliance. The value of the approaches in many cases can be both a monetary and environmental savings for the facility. The FMECI will continue to emphasize pollution prevention solutions to compliance deficiencies. The FMECI has provided EPA with a mechanism to further evaluate compliance and reduce risks posed by non-compliant Federal facilities. It is continuing to demonstrate the resource efficiencies and environmental benefits of multi-media enforcement, and will assist the Agency in refining the multi-media enforcement process. The FMECI has increased the level of environmental awareness of installation employees at all levels, and will help improve Federal facilities compliance by providing a holistic view of compliance problems and creative opportunities to protect human health and the environment.

GUIDE TO POLLUTION PREVENTION OPPORTUNITIES
AT
EIELSON AFB

As part of the Federal Facilities Multimedia Enforcement Compliance Initiative (FMECI), the EPA Office of Federal Facilities Enforcement (OFFE) is providing this guidance package to assist enforcement personnel in identifying and documenting pollution prevention (P2) opportunities that can be incorporated into settlement agreements with the federal facility identified above. This package consist of two parts: a Federal Facility Pollution Prevention Field Reporting Form (Attachment A), and a Pollution Prevention Opportunities Profile (Attachment B). Both parts are prepared specifically for use at the federal facility identified above.

PART I. FEDERAL FACILITY FIELD REPORTING FORM

The field reporting form presented in Attachment A provides a mission statement for the facility, which can be used by inspectors to predict the types of processes and wastes that may be present at the facility. In addition, the form provides a consistent format for inspectors to record information on pollution prevention activities and opportunities at the facility. Parts I through IV of the form are provided by OFFE and include the name of the facility, and its address and identification number, as well as a mission statement for the facility. Parts V through VIII are to be completed by the inspector and maintained as part of the inspection record.

Part V.A is to be used by the inspector to record information about wastes that may present opportunities for pollution prevention. Part V.B. allows inspectors to record the types of pollution prevention opportunities that they know or suspect are relevant to each waste identified in Part V.A. Inspectors may use the Pollution Prevention Opportunities Profile (Attachment B) as an aid in completing Part V of the field reporting form.

Part VI of the field reporting form allows the inspector to record detailed information about ongoing pollution prevention activities at the subject facility. That information may be used by EPA to propose the wider application of certain pollution prevention techniques that already have been implemented at the facility.

Part VII of the field reporting form allows inspectors to record violations associated with those waste generation activities that have pollution prevention potential as determined pursuant to Part V of the field reporting form. These types of violations may allow the EPA to introduce pollution prevention requirements into settlement agreements.

Part VIII of the field reporting form allows inspectors extra space to nominate one or more pollution prevention opportunities at the subject facility that are most likely to be incorporated into a settlement agreement.

PART II. FEDERAL FACILITY POLLUTION PREVENTION OPPORTUNITY PROFILE

OFFE investigated a number of EPA information sources to identify potential pollution prevention opportunities at Eielson AFB (EAFB). Those sources and the types of data they provided are listed below:

- RCRA 3016 data base: EAFB was not found on this data base.

- Aerometric Information Retrieval System (AIRS) data base: Annual quantities of federally regulated air pollutants.

- Permit Compliance System (PCS) data base: EAFB was not found on this data base.

- RCRA Biennial Reporting System (BRS) data base: Annual quantities of RCRA hazardous waste.

- Toxic Release Inventory System (TRIS) data base: EAFB was not found on this data base.

Data from the sources listed above were used to prepare the profile for EAFB which is presented in Attachment B. This profile does not represent all wastes that may have pollution prevention potential at EAFB. Further, this profile may include wastes that have little or no potential for pollution prevention. The profile was prepared to provide the inspectors with an initial list of wastes that appear to present the best opportunities for pollution prevention. This list is based on data from the sources listed above and the information provided in the facility's mission statement. The inspector is encouraged to investigate these potential pollution prevention opportunities during the upcoming inspection. If the opportunities identified in the profile are confirmed during the inspection, the inspector should obtain as much additional information as possible on such opportunities and record all such findings in Parts V through VIII of the field reporting form (Attachment A).

ATTACHMENT A

FEDERAL FACILITY
POLLUTION PREVENTION SUMMARY

I. Facility Name: Eielson AFB

II. Facility Address: Fairbanks (City), Alaska (State)

III. EPA ID No.: AK1570028646

IV. Mission Description: The major units at Eielson AFB include the 343rd Wing, 3636 Combat Crew Training Wing (Detachment 1) (Arctic Survival School), and the 168th Air Refueling Group (Air National Guard). Eielson AFB is located 25 miles south of Fairbanks, Alaska on Richardson Highway. The population at Eielson AFB includes 3,500 active duty personnel, 5,500 family members, 600 Guard, and 957 civilians.

V. Wastes with P2 potential (observed):

A. Waste description (Include waste sources[1], chemical compositions, physical properties, and quantities)

B. P2 opportunities (see Attachment B)

[1] Waste source descriptions should include the location of the waste-generating activity (for example, building number), and the process that generates the wastes (for example, degreasing of aircraft motor parts).

VI. Current Pollution Prevention Activities:

A. Waste Description (Sources[1] and Quantities)

B. P2 Initiative Description

VII. Violations affecting Waste Sources[1] with P2 Potential (see Part V of this form):

A. Waste Source

B. Violation

C. Status of Violation

VIII. Recommendations for Modifications to Current Programs:

[1] Waste source descriptions should include the location of the waste generating activity (e.g. building number), and the process that generates the wastes (e.g. degreasing of aircraft motor parts).

ATTACHMENT B: FEDERAL FACILITY

POLLUTION PREVENTION (P2) OPPORTUNITIES PROFILE FOR EIELSON AFB

Waste Description[1]	EPA 33/50 Program Target[2] (Y/N/I)	Annual Waste Quantity (Year)	Assumptions on Waste Origin and/or Composition[3]	Potential Pollution Prevention Opportunities	Data Source[4]
Ignitable nonhalogenated cleaning solvents, including methanol and propanol (D001, D006, D007, D008, and D009)	I	In 1989, there were approximately two waste streams, accounting for 1.43 tons of these wastes.	Cleaning of aircraft	• Establish solvent standardization and waste segregation programs • Prevent solvents from entering wastewater stream • Minimize solvent use • Reduce number of different solvents to enhance recycling opportunities • Extend solvent life through filtering and settling • Initiate on-site or off-site solvent recovery through distillation • Eliminate all nonessential degreasing operations • Investigate recovery options, such as burning in on-site boilers • Prevent dragout of solvents from degreasing baths • Investigate replacement of solvent degreasers with acids, caustics, hot water, biodegradable detergents, or mechanical degreasing methods • Determine whether spent solvents can be reused directly in other operations at the facility • Investigate with suppliers methods to prevent need for degreasing parts	BRS
Halogenated solvents from cleaning and halogenated solvents mixed with petroleum and others (F001 and F002)	I	In 1989, there were approximately two waste streams, accounting for 4.36 tons of these wastes.	Cleaning of engines	• See opportunities listed above for ignitable nonhalogenated solvents	BRS
Paint thinner, ignitable solvents, and other paint-related waste (D001, D005, D006, D007, D008, D009, F003, and F005)	I	In 1989, there were approximately five waste streams, accounting for 54.19 tons of these wastes.	Degreasing, paint stripping, and other painting operations	• Dewater water based paint waste through evaporation • Extend life of thinners through settling or filtering • Establish rigid inventory controls to reduce use of thinner • Replace oil-based paint with water-based paint • Remove solids by settling or filtering and reuse paint thinner • Adjust paint application method to minimize excess paint (especially spray operations) • Mix paints according to needs • Contact waste exchanges to reduce inventories of unused paint • Reduce or eliminate the use of spray paint cans • Investigate mechanical cladding options instead of paint	BRS

ATTACHMENT B: FEDERAL FACILITY

POLLUTION PREVENTION (P2) OPPORTUNITIES PROFILE FOR EIELSON AFB (continued)

Waste Description[1]	EPA 33/50 Program Target[2] (Y/N/I)	Annual Waste Quantity (Year)	Assumptions on Waste Origin and/or Composition[3]	Potential Pollution Prevention Opportunities	Data Source[4]
Spent nickel-cadmium, lithium, and mercury batteries (D002, D003, D006, and D009)	Y	In 1989, there were approximately three waste streams, accounting for 0.57 ton of these wastes.	Spent batteries	• Send spent batteries to off-site recyclers • Improve maintenance procedures to reduce rate of battery replacement • Recycle mercury	BRS
Contaminated oil (D006, D007, D008, F002, F003, and F005)	Y	In 1989, there were approximately two waste streams, accounting for 62.63 tons of these wastes.	Used oil from oil changes, and oil water mixture from oil water separator	• Use higher-quality oil to reduce the frequency of oil changes • Investigate heat recovery options such as burning in on-site boilers • Investigate off-site recycling at refineries or fuel blending facilities • Improve oil management procedures to prevent contamination with halogenated and nonhalogenated solvents and metals	BRS
Corrosive wastes (D002)	I	In 1989, there were approximately three waste streams, accounting for 0.72 ton of this waste.	Unknown	• Improve inventory controls and waste documentation procedures	BRS
Discarded off-specification materials (D001, D002, D006, D007, D008, D009, F002, F003, F005, and U151)	Y	In 1989, there were approximately 18 waste streams, accounting for 82.82 tons of these wastes.	Materials with contamination and materials that have exceeded their shelf life	• Improve inventory controls to reduce disposal of unused materials • Encourage suppliers to accept unused materials before their shelf life expires • Contact local waste exchanges • Improve operating procedure to present the prediction of off-specification material	BRS
Spilled materials, residues from spills, materials used in spill response (D001, D002, D007, D008, and D009)	N	In 1989, there were approximately six waste streams, accounting for 11.77 tons of these wastes.	Residues from cleanup of spills	• Revise inspection and maintenance procedures • Improve storage and stacking procedures • Improve waste or product transfer operations • Install overflow alarms and/or automatic shutoffs • Install secondary containment	BRS

ATTACHMENT B: FEDERAL FACILITY

POLLUTION PREVENTION (P2) OPPORTUNITIES PROFILE FOR EIELSON AFB
(continued)

Waste Description[1]	EPA 33/50 Program Target[2] (Y/N/I)	Annual Waste Quantity (Year)	Assumptions on Waste Origin and/or Composition[3]	Potential Pollution Prevention Opportunities	Data Source[4]
Volatile organic compounds from a boiler	I	In 1991, there was one waste stream, accounting for 75 tons of this waste.	Losses from volatile emissions	• Investigate current efficiency of the boiler to reduce volatile emissions	AIRS

[1] Waste descriptions are derived from the data sources provided in the last column of this matrix. RCRA hazardous wastes in reported quantities below 500 lb (0.25 tons) per year are not included in the matrix. No limits were placed on waste generation quantities for non-hazardous wastes.

[2] A voluntary national program to reduce releases of pollutants and off-site transfers of 17 toxic chemicals by 33 percent by the end of 1992 and by 50 percent by the end of 1995. Y = yes; N = No; I = insufficient data. (The 17 chemicals include benzene; cadmium and cadmium compounds; carbon tetrachloride; chloroform; chromium and chromium compounds, cyanide and cyanide compounds; lead and lead compounds; mercury and mercury compounds; methylene chloride; methyl ethyl ketone; methyl isobutyl ketone; nickel and nickel compounds; tetrachloroethylene; toluene; 1,1,1-trichloroethane; trichloroethylene; and xylenes.)

[3] Assumptions based on professional judgment.

[4] BRS = RCRA Biennial Reporting System; AIRS = Aerometric Information Retrieval System; PCS = Permit Compliance System; and TRIS = Toxic Release Inventory System.

MINIMIZATION OF EPA-17 HAZARDOUS CHEMICALS IN THE PLATING SHOP AT TINKER AFB

OKLAHOMA CITY AIR LOGISTICS CENTER

by

Glenn Graham	Mike Patry	Patti Shreve
OC-ALC/LPPNP	OC-ALC/LPPNP	OC-ALC/EMV
3001 Staff Dr, Suite 2A87	3001 Staff Dr, Suite 2A87	7701 2nd Street, Suite 220
Tinker AFB OK 73145-3034	Tinker AFB OK 73145-3034	Tinker AFB OK 73145-9100
(405) 736-5185	(405) 736-5185	(405) 736-7698
DSN 336-5185	DSN 336-5185	DSN 336-7698

Abstract: The electroplating shop in the Oklahoma City Air Logistics Center uses a variety of hazardous materials to restore worn dimensions and provide corrosion protection to engine and aircraft parts. In the past many coatings were specified automatically for certain applications.

Today, the environmental impact is also taken into account. We consider source reduction preferable to recovery or treatment. The specific requirements for each application are identified and alternative processes or substitute products chosen to meet those needs. Secondarily, recovery and treatment techniques are employed. Policy has been to implement established technology before research and development work is undertaken.

The following is a list of the hazardous materials that have been targeted for source reduction/elimination: (1) Cadmium, (2) Chromium, (3) Cyanide, (4) Perchloroethylene, (5) Nickel, (6) Toluene

This paper will address each of these hazardous materials delineating the reasons for their use as well as the work currently underway to reduce or eliminate them. Potential problem areas will also be identified in order to help focus future R & D efforts.

Many of the hazardous chemicals have already been reduced or eliminated. Cadmium plating has been virtually eliminated by product substitution of zinc-nickel alloys. Chromium plating has been reduced by several process stripper solutions. High pressure water jet systems are currently being investigated to replace the perchloroethylene vapor degreasers. A plasma spray process has replaced some of the nickel plating applications. Even though nickel is on the base's hazardous chemical list, plans call for its use as a substitute for cadmium and chromium until a less hazardous chemical and/or process is found. OC-ALC plans to steadily move down its targeted list until none of these chemicals are used.

INTRODUCTION

The Oklahoma City Air Logistics Center (OC-ALC) is responsible for the repair or overhaul of many of the Air Force's aircraft and weapons systems. The Propulsion Directorate at the Oklahoma City ALC operates one of the largest surface finishing facilities in the United States. The electroplating shop uses a variety of hazardous materials to restore worn dimensions and provide corrosion protection to engine and aircraft parts. Over the past several years, many changes have occurred that impact its operation: (1)Air emission stahdards have tightened. (2)Allowable exposure limits have decreased. (3)Water quality standards have increased. (4)Solution and sludge disposal costs have skyrocketed. (5)And hazardous waste disposal sites have closed. All these changes point to only tougher restrictions in the future. In order to meet these tougher restrictions, Tinker AFB must reduce or eliminate the toxic materials.

At the OC-ALC, the Process Engineering Group in the Propulsion Directorate has been working in partnership with the Environmental Management Pollution Prevention Group. The process group has identified and implemented projects that target hazardous waste minimization. The environmental group has supplied funds and support to manage these important projects. Together this team has been effective in reducing hazardous materials.

The first step toward developing a hazardous waste minimization program was to identify the hazardous chemicals. By examining the EPA's top 17 toxic chemicals, the following prioritized "hit" list: was developed:

(1) Cadmium
(2) Chromium
(3) Cyanide
(4) Perchloroethylene
(5) Nickel
(6) Toluene

Next an overall plan was defined. The base is working toward meeting its hazardous waste minimization goals using the following approaches: (A) Source Reduction, (B) Recycle, (C) Material Recovery, (D) Process Control, and (E) Waste Treatment.

Source reduction or elimination of the chemical is considered preferable to all other approaches as it is the only long-term solution to the hazardous waste problem. First, waste streams that contain toxic chemicals are identified. Secondly, the specific requirements for each application that uses the toxic chemicals is charted. Next, a listing of alternative process are identified and evaluated to meet those needs. Finally, the best alternative is implemented. The following guidelines are used when planning Tinker AFB's source reduction strategy:

(1) Source reduction is preferable to recovery or treatment.
(2) More than one alternative process could be required.
(3) Implement established technology where possible.
(4) Substitutes must meet or exceed all functional requirements.
(5) Improve production efficiency.

(6) Maximize process flexibility.
(7) Conserve production floor space.

Because source reduction is not always possible, other methods have also been used. Recycling decreases the quantity of toxic chemicals both disposed and purchased. Bath purification and rejuvenation and closed loop material recovery are examples of recycling. Process control measures include conductivity-controlled rinses, computerized chemical tracking, dedicated solution-maintenance crews and chemists, and training. The plating shop wastewater pretreatment system is an example of waste treatment.

Pat decisions have been questioned and re-evaluated. Many coatings were specified almost automatically for certain applications simply because that is the way it was always done. The specific requirements such as hardness, degree of corrosion protection, wear resistance, etc., must first be identified. Then new processes can be implemented which produce coatings that meet those requirements. A prime example of this philosophy at work is the case of chromium. In the past, chromium was always selected as a build-up material of choice for any high wear, high temperature application. OC-ALC is now looking at plating nickel alloys as an alternative.

In some cases, OC-ALC has substituted a less hazardous toxic chemical in place of a more hazardous toxic chemical. For example, nickel is being used in place of cadmium and chromium for some applications. Current strategy is to incorporate new, less hazardous processes and chemicals into our shop as they become approved. In this way, the team plans to steadily move down on our toxic enemies 'hit' list.

Waste minimization is a continuous process. Using the above guidelines as a directive, great strides have been made in eliminating or reducing hazardous chemicals by attacking each chemical one-by-one. The on-going refurbishment of OC-ALC's plating shop is proof of such accomplishments. As a result of some of these process substitutions, the total number of plating tanks will be significantly reduced. Planning is underway for reducing from two to one chrome plating line. Likewise, the nickel plating lines have been reduced from four to one and one-half. The cadmium and nickel-cadmium line has been eliminated. These reductions will significantly reduce the total cost of the refurbishment. This reduction can be accomplished with no loss of production capability, efficiency, part quality, or surge capacity.

CADMIUM

Cadmium is the most toxic metal used in the plating shop and was, therefore, number one on our hit list. It is used to provide sacrificial corrosion protection to steel and high strength steel. Since cadmium is less noble than steel, the cadmium layer corrodes first, protecting the underlying part. Cadmium is a very soft coating and is also limited to low temperature applications. Nickel-cadmium is used where increased erosion resistance and higher temperature limits are required. Cadmium tank electroplating was eliminated at Tinker in 1991. Successful substitution of several processes for cadmium and nickel-cadmium electroplating has been achieved.

CADMIUM BRUSH PLATING

Presently, OC-ALC brush plates low hydrogen embrittlement (LHE) cadmium on aircraft parts such as engine supports. Although this process still uses cadmium, it does have the advantage of using very small quantities of solution (less than 5 gallons). Other corrosion resistant coatings such as zinc-nickel can also be applied with brush plating. The Navy has approved the use of LHE zinc-nickel brush plating and we have been granted limited approval also.

ION VAPOR DEPOSITION OF ALUMINUM (IVDAI)

Ion Vapor Deposition of Aluminum (IVDAI) process is already in widespread use in both civilian and military shops to replace Cadmium and Nickel-Cadmium plating. IVDAI is performed in a vacuum. Aluminum wire is fed into a chamber and vaporized. The positively charged aluminum vapor is attracted to the negatively charged parts thus depositing a very uniform coating of aluminum. IVDAI coated parts show superior sacrificial corrosion protection with no hydrogen embrittlement. These parts also have a higher maximum service temperature over cadmium (925 degrees F vs. 450 degrees F). They are good electrical conductors and are compatible with aircraft fuels.

One of the concerns with IVDAI coated parts are with threaded components. Because Aluminum has a higher coefficient of friction than cadmium; a higher torque must be applied to achieve the same axial loading. Testing has shown that using an IVDAI-coated bolt with a Cd-plated nut requires 12% more torque than that required for Cd-plated nuts and bolts. Application of dry film lubricants further reduces this difference to only 8%. Most of our threaded components are approved for either Cd or Ni-Cd and the torque values with IVDAI fall between these. Torque is not critical for compressor tie rods since these parts are tightened to a specified stretch.

Another concern is with internal surface coverage of IVDAI coated parts. Although not strictly limited to line-of-sight applications, IVDAI is unable to coat the inside of a bore to a depth greater than half its diameter. This problem can be addressed by using paint coatings, zinc alloy or electroless nickel plating to coat ID's and recessed areas.

Finally, IVDAI (pure aluminum) and cadmium are relatively soft coatings and are not typically used where erosion is a concern. Nickel-cadmium (Ni-Cd) is much more erosion-resistant. Tests have shown that IVDAI wears about four times faster than Ni-Cd. However, in many applications, the IVDAI coating may be applied thicker, thus minimizing the difference. Testing of alloys of aluminum has not significantly improved hardness or erosion resistance.

ZINC ALLOY PLATING

Zinc alloy plating baths are known to produce coatings with up to 3 times the corrosion resistance of cadmium. The automotive industry uses zinc alloys extensively. Tinker AFB has been using the nickel-zinc alloy AMS 2417 as an authorized replacement for cadmium plating since February 1992. Corrosion tests confirm that the nickel-zinc alloy with 10-12% nickel is superior to cadmium, nickel-cadmium, and IVDAI coatings in salt fog spray corrosion resistance. Tinker AFB also has an on-going research project with a contractor both to validate this practice and to see if nickel-zinc use could be expanded to cover some of the former nickel-cadmium coated high strength steel parts. Results are pending.

HIGH PHOSPHOROUS ELECTROLESS NICKEL (EN) PLATING

High phosphorous (10.5 - 12 %) EN plating produces a very uniform coating with almost no porosity. Although it does not provide sacrificial corrosion protection like cadmium or zinc alloys, it does produce a tough barrier that protects the underlying surface. It also has excellent wear/erosion resistance.

The main area of concern with EN is the relatively short bath life. The baths only produce acceptable coatings for about 4 to 5 nickel metal turnovers. The short bath life is due primarily to the buildup of orthophosphite in the solution which causes rough plating and pitting and crosses over from a compressively to a tensilely stressed deposit. Tinker AFB has had a research project with a contractor to investigate the rejuvenation of EN baths. The Stapleton-Enfinity Process has been identified and the prototype equipment is currently awaiting installation. The technology consists of treating a slip stream with a calcium salt to precipitate the orthophosphite, filtering, then sending the filtrate back to the bath.

High Phosphorous (10.5 - 12 %) EN coatings are now specified by the Original Equipment Manufacturer (OEM) of aerospace equipment such as Pratt & Whitney for corrosion and erosion protection. Since IVDAI does not provide uniform coating of complex geometry's and deep narrow inner diameters, EN plating is being used to meet the corrosion requirements for these parts. The other requirement of erosion resistance provided by nickel-cadmium plating can easily be met by EN plating. Corrosion tests at OC-ALC's Material Management Laboratory have shown chromate treated EN plating to be superior to cadmium plating, nickel-cadmium plating, IVDAI coating, and slightly better than regular EN plating. This test data has further expanded the use of EN plating as a Cd and Ni-Cd plating substitute.

CADMIUM STRIP REJUVENATION (CLOSED LOOP - RECYCLE)

Even though cadmium plating is no longer used by the Air Force, the overhaul of previously processed parts includes the removal of old cadmium coatings. This stripping process generates a concentrated bath and large volumes of rinse water. The concentrated stripping bath has to be periodically hauled off-site for disposal. Rinse water has to be treated on site resulting in a cadmium-containing wastewater treatment sludge. By close looping the operation, OC-ALC is recovering the cadmium as a metal that can be sold to refiners. The technology was installed in May 1994 and consists of cadmium removal from strip solutions by ion exchange followed by electrowinning of the ion exchange regenerate solution to recover cadmium metal. This rejuvenation system is currently being optimized.

CHROMIUM

Chromium plating has survived as a common coating since its beginning in the early 20's due to its exceptional hardness (68 Rc) and high temperature resistance (1700 F).

It is used extensively despite its poor plating efficiency, undesirable build-up on high current density areas, and slow deposition rate.

OC-ALC is actively pursuing a multiple approach to the elimination of chromium plating even though the newly refurbished chrome plating line includes a chrome recovery system that consists of a climbing film evaporator and an ion exchange column. This system takes water from the rinse tanks and the scrubbers, concentrates it, removes the impurities and puts it back into the plating tanks (i.e. recycle - closed loop). The recovery system not only reduces the amount of chromic trioxide purchased each year but also reduces the chromium that must be removed by the wastewater pretreatment system.

Due to substitutions already in place, the plating shop is currently operating the chrome line at 50% of the capacity used in 1988 a further reduction is hoped for. To do so will require a part-by-part re-evaluation of what coating properties are really needed.

BRUSH PLATING SUBSTITUTION

Brush plating has been used for many years to apply industrial coatings. Brush plating is already approved to apply nickel coatings on some gas turbine engine parts. OC-ALC had anticipated using semi-automated brush plating equipment to apply nickel and nickel alloy (such as nickel tungsten) coatings as a substitute for chrome plating. Unfortunately, initial contractor tests designed to evaluate the suitability of commercially available brush plated coatings as substitutes were unsuccessful.

HIGH VELOCITY OXY-FUEL FLAME SPRAY (HVOF) SUBSTITUTION

HVOF is the newest generation high energy thermal spraying process. The high impact speed produces very dense, hard coatings. It is already approved for the application of wear/erosion resistant coatings and thermal barriers on exhaust nozzles, combustion chambers and compressor blades. The HVOF process has many advantages including: fast coating times, good coating flexibility, smaller quantities of waste, and the overspray can be captured in a wet or dry booth.

One drawback to the HVOF process is its restriction to line-of-sight applications. Special nozzles are available that allow coating IDs as small as four inches, but the use of these nozzles creates turbulence which results in lower-density coatings. Since the majority of the depot's chrome plating workload involves OD's, This is not seen this as a serious impediment. A current research project with a contractor to identify and test HVOF spray powders as potential substitutes is ongoing.

NICKEL ALLOY PLATING SUBSTITUTION

The depot is currently substituting high phosphorous EN (nickel alloy) for chromium on gears and gear shafts. Lower phosphorous EN deposits, with hardness values similar to chromium may be used for additional chrome substitution. OC-AIC has an on-going project with a contractor to test potential nickel alloy alternatives to chrome plating. This effort has identified two different technologies for possible substitution {AMPLATE (Ni, W, B), and Takada (Ni-W, Si-C)}; the Takada process is recommended as the most likely. This process produces a coating with good anti-galling effects and improved fatigue debit characteristics over chromium. Also, the process deposits thick coatings (>15 mils) at relatively fast rates. The drawbacks of this process are its relatively low hardness and poor wear resistance; it might, however, be possible to improve these characteristics through optimization. Another drawback is its short bath life. This problem is already being addressed by another project as described earlier.

CYANIDE

The use of cyanide in the plating shop has been cut over 95% since 1989 by the introduction of non-cyanide alkaline cleaners and nickel stripper solutions. Non-cyanide cleaners and nickel strippers that are being now used cannot be treated in the depot's waste treatment system. The ozone oxidation process that is used to destroy cyanide has no effect on these solutions so they have to be drummed and hauled off for disposal. Alternative ways are being looked at to extend the life of these solutions. The plating shop is currently awaiting installation of a microfiltration system to rejuvenate these caustic solutions in the chemical cleaning shop. Once this process is installed and proven, a similar filtration process will be looked at for the plating shop's alkaline cleaners. The stripping solutions cannot be handled by filtration so replacement stripping processes with a high-pressure water jet system are being investigated.

The remaining cyanide is used in silver plating, silver stripping, and cadmium stripping solutions. Non-cyanide silver plating solutions are commercially available, but they have not yet been approved by the engine manufacturers. A prototyping of one of the silver plating solutions in the Tinker AFB plating shop is underway. Additionally there are plans to prototype a non-cyanide silver stripping solution that will allow for recovery of the silver metal. If not successful, a closed looping of the silver plating and stripping operation will be implemented.

PERCHLOROETHYLENE

The plating shop operates two state-of-the-art perchloroethylene vapor degreasers complete with extended, refrigerated freeboards, integrated solvent stills, low-velocity exhaust hoods and a carbon recovery system. These degreasers are used to remove masking wax after nickel and chrome plating. Planning is underway on replacing these degreasers with one pressure spray washer (i.e. an industrial dishwasher that uses a biodegradable soap). Preliminary vender tests showed satisfactory wax removal capability. The equipment has been purchased and will be installed in September 1994. At that time, testing will be done and when proven, the perchloroethylene will be eliminated.

NICKEL

Nickel is number five on Tinker AFB's 'hit' list. As earlier stated, a plan to use nickel and nickel alloys in place of cadmium and chromium for some applications is under study. The plating shop currently uses nickel-zinc as a replacement for cadmium and have a current research project to investigate the possibility of using nickel alloys to replace some of the chromium plating.

Most of the major engine cases (including diffusers and intermediates) have been switched from nickel plating to twin-wire plasma spray. This substitution is a perfect example of the importance of questioning past practices and implementing new processes when the coating fits the requirement. Although the two coatings are not the same, the plasma coating met all performance requirements for the application. The result of this effort was a 50 per cent reduction in nickel plating waste and a significant decrease in production time.

TOLUENE

Toluene is used as a solvent for the organisol maskant used in electroless nickel (EN) plating. Investigations are currently underway for alternative water-based maskants.

CASE STUDY—ALTERNATIVES TO THE USE OF CHROMIUM IN PLATING AND CONVERSION COATING AT McCLELLAN AIR FORCE BASE, CALIFORNIA

Mr. Elwin Jang, McClellan Air Force Base Sacramento Air Logistics Center/TIELE
Mr. Barry Meyers, The MITRE Corporation
Mr. Steve Lynn, The MITRE Corporation
4920 46th Street
McClellan Air Force Base, California 95652-1346

INTRODUCTION

The Sacramento Air Logistics Center at McClellan Air Force Base (AFB) refurbishes a variety of airframes and components on aircrafts including the A-10, F-15, F-16, F-111, KC-135, etc. Periodically, the airframes and components must be stripped of coatings (organic or metallic), inspected for base metal integrity, and recoated to restore the parts to original specifications.

During airframe refurbishment, aluminum structural components are stripped of paint and are remanufactured. The chromate conversion coating that was originally applied to the parts as a paint base must be reapplied. This coating is typically applied by spray, bucket and mop, or an immersion process on individual components. Coated parts are required by specification to meet the paint adhesion and corrosion resistance requirement of MIL-C-5541.

Similarly, chrome-plated components must meet or exceed the hardness, porosity, and corrosion resistance requirements of Federal Specification QQ-C-320. Additionally, when chromium is applied to hydraulics, landing gear, rotating shafts, gears, and surfaces that are subjected to sliding or rolling wear, the coating must be abrasion-resistant, low-friction, and resistant to galling. The hydraulic component assemblies must also meet the piston rod and seal wear tests conducted per MIL-C-5503. The plating is applied generally to 10–30 mils thickness to allow for dimensional restoration and grinding tolerance limits.

Working closely with McClellan AFB, The MITRE Corporation applied a systems engineering approach to evaluate the alternative technologies. Potential replacements were evaluated by direct comparison to the chromium-based technologies. This comparison was made based on the specifications, functional performance, system life cycle, mass balance, energy balance, labor balance, facilities compatibility, process line compatibility, and cost-benefit analysis.

APPROACH

The systems engineering approach used for evaluating the alternatives evaluation under this contract (contract number F04699-91-D-0065), closely followed *"The EPA Manual for Waste Minimization Opportunity Assessments,"* EPA/600/2-83-025, April 1988. Source reduction was the sole priority over all other pollution prevention approaches. Extensive research was conducted on the material properties, process operations, equipment specifications, emissions control technologies, and waste treatment/disposal for chrome and each alternative through physical testing, literature review, and industry exchange. The physical performance of the alternatives is the principal factor for determining the technologies' acceptance.

Several production parameters were set as constants prior to the investigation because they affect the outcome of the feasibility analysis. The production rate in square feet per day at a given thickness can affect the utilization level of the production line, influence the dragout rate, affect emission control and plating bath energy efficiency, and directly affect coating costs. Thickness is directly proportional to the material consumption, process time, mist emissions, and finish-grinding effort. Other factors that will influence the absolute cost of any plating alternative are materials costs, waste treatment and disposal costs, energy costs, labor costs, and equipment upgrades. The assessments conducted under this study were based on the prevailing rates of the McClellan AFB shops and installation of new equipment.

Mass, energy, and effort balance diagrams were applied to each of the alternatives to compare costs and production capacity. All factors were entered into a spreadsheet that was used to calculate the cost per square foot for various thicknesses and production rates, including materials, waste, energy, and additional labor requirements. Liability associated with continued use of the hexavalent chromium was not factored into the decision process. The following is a brief summary of the outcome of this project.

HARD CHROME-PLATING ALTERNATIVES

Hard chrome plating is used presently at McClellan AFB because the original equipment requirements, as defined by the original manufacturers and military procurement specifications, specify this type of coating. It is used routinely for applications that require hard, wear-resistant coatings. The plated parts include hydraulic actuators and cylinders, as well as gears, pins, shafts, and bearings. The coating is applied relatively thick (as opposed to decorative chrome), generally 10–30 mils, for dimensional restoration.

The chrome-plating process is inexpensive, well understood, and easy to perform. The process involves degreasing, masking, and cleaning prior to plating. Following the plating step, the parts are removed from the bath, masking is removed from the part, the part is baked for embrittlement relief, and finishing (such as grinding, lapping, and polishing) is completed.

Several disadvantages of chrome plating are its high fatigue life debit, marginal corrosion resistance due to microcracking, high-power consumption, nonuniform coverage, poor penetration into holes and tube bores, and the evolution of hydrogen in the process. As a result of the hydrogen evolution, misting occurs that leads to high air emission rates and associated adverse health, safety, and environmental risks.

Potential process substitutions for hard chrome plating include electroless nickel, several nickel-tungsten plating options, and spray applications such as plasma spray or high-velocity oxygen fuel (HVOF) coatings. (Other possible substitutions, such as vacuum deposition processes and cobalt alloys, are not discussed because of poor material properties.) Of these alternatives, none has exhibited all of the desirable qualities of chrome plating. Certain trade-offs in physical properties, process time, and costs must be made.

A comparison of the characteristics of hard chrome plating with those of the above alternatives is presented in Table 1. Additional physical characteristics of the various HVOF coatings are listed in Table 2. A summary of the processing considerations is listed in Table 3.

Table 1. Plate Characteristics of Hard Chrome Plating and Prospective Alternative Processes

Characteristics	Chromium Electrodeposition	Low Phosphorus Electroless Nickel (Generic)	Ni-W-B Electrodeposition (AMPLATE)	Ni-W-SiC Electrodeposition (Takada)	Plasma Spray (General)	HVOF General
Thickness buildup	Up to 30 mil	Up to 15 mil (more uniform than chrome)	Up to 10 mil (more uniform than chrome)	Up to 15 mil (more uniform that chrome)	Up to 50 mil (rougher than chrome)	Up to 50 mil (rougher than chrome)
Coating adhesion (ASTM C 633)	> 10,000 psi	> 10,000 psi	> 10,000 psi	> 10,000 psi	> 8,000 psi (coating dependent)	> 10,000 psi (coating dependent)
Hardness (Hv, Rc, DPH_{300}	800–1,000 Hv	670–750 DPH_{300} 980–1050 (with heat treatment)	600–950 DPH_{300} (with head treatment)	800 to >1,000 DPH_{300}	800–1,200 DPH_{300} (coating dependent)	800–1,450 DPH_{300} (coating dependent)
Machine finish (rHr RMS)	< 8 microinches	< 8 microinches	< 8 microinches	< 8 microinches	< 8 microinches	< 8 microinches
Corrosion resistance (ASTM B 117)	> 24 hours	> 96 hours	> 400 hours	> 24 hours	> 24 hours	> 48 hours
Porosity	< 2 percent	< 1 percent	< 1 percent	< 1 percent	5–13 percent	< 2 percent
Abrasion resistance (Taber CS-10, 1 kg, Avg/1000 cycles to 10,000)	< 25 mg	< 35 mg (dependent on heat treatment and composite additives)	< 25 mg	< 20 mg	< 20 mg (coating dependent)	< 20 mg (coating dependent)
Coefficient of friction	0.16	< 0.20*	0.13	0.13	0.25*	< 0.20*
Falex wear rate	Good	Moderate/poor	Excellent	Excellent	Moderate/poor	Good*
Threshold galling wear	Good	Moderate/poor	Excellent*	Excellent*	Good*	Good*
Chemical resistance	Fair	Good	Excellent	Excellent	Good	Excellent
Coating stripping ability	Good	More difficult	More difficult	More difficult	Difficult	More difficult
Fatigue loss	As high as 60 percent	Less than chromium*	Less than chromium*	Comparable to chromium*	Less than chromium*	Less than chromium*

* Needs additional testing

Table 2. Physical Characteristics of HVOF Spray Deposited Coatings

Characteristic	Tungsten Carbide-Cobalt	Cobalt-Chromium Nickel-Tungsten	Nickel-Chromium-Molybdenum	Chromium Carbide-Nichrome	Iron-Nickel-Chromium
Thickness build-up	> 50 mil	> 50 mil	> 100 mil	> 25 mil	60 mil maximum
Coating adhesion (ASTM C 633)	> 13,000 psi	> 10,000 psi	> 10,000 psi	> 12,000 psi	> 11,000 psi
Hardness (Hv, Rc, DPH_{300})	Rc 64-69 DPH_{300} 800–1,650	Rc 53 DPH_{300} 550–700	Rc 30-34 DPH_{300} 350–450	Rc 65 DPH_{300} 800–850	Rc 45 DPH_{300} 550–650
Machine finish (rHr RMS sprayed))	150–250	200–300	170–250	100–170	250–350
Machine finish (rHr RMS ground)	< 8	< 8	< 8	> 8	< 8
Corrosion resistance (ASTM B 117)	> 48 hours*	> 48 hours	> 48 hours*	> 48 hours *	> 48 hours*
Porosity	> 1 percent	> 1 percent	> 1 percent	> 1 percent	> 1 percent
Abrasion resistance (Taber CS-10, 1KG, AFG/1,000 cycles to 10,000)	> 20 mg	> 20 mg	> 20 mg	> 20 mg	> 20 mg
Coefficient of friction	0.18	> 0.20*	> 0.20*	> 0.20*	> 0.20*
Falex wear rate	Excellent	Excellent*	Excellent*	Excellent*	Excellent*
Threshold galling wear	Excellent*	Excellent*	Excellent*	Excellent*	Excellent*
Chemical resistance	Excellent	Excellent	Excellent	Excellent	Excellent
Coating stripping ability	More difficult	More difficult	More difficult	More difficult	Difficult
Effect on fatigue properties	Less than chromium*	Less than chromium*	Less than chromium*	Less than chromium*	Less than chromium*

* Needs additional testing

Table 3. Process Characteristics of Chrome Plate Alternatives

Process Characteristic	Chrome Plate	Low Phosphorous Electroless Nickel	Ni-W-B Electro-deposition	Ni-W-SiC Electro-deposition	Plasma Spray (general)	HVOF (general)
Deposition rate	1.0 mil/hr	0.4–0.8 mil/hr	1.0–1.4 mil/hr	1.0–3.0 mil/hr	25 mil/hr[3]	50 mil/hr[3]
Current density (ASF)	360	N/A	85-130	180	N/A	N/A
Bath temperature (°F)	130–140	170–200	115–125	140–180	N/A	N/A
Chemical ingredients	Chromic acid	Nickel sulfite, sodium hypophosphite, sodium acetate	Proprietary: nickel, tungsten and boron metals	Nickel sulfate, sodium, tungstate, ammonium citrate, silicon carbide	CrC-NiCr, WC-Co, etc.	CrC-NiCr, WC-Co, etc.
Cost per ft² plated[2]	$77	$65 to $100	$84 to $100	$82 to $132	$80 to $180	$65 to $180
Make-up costs (per 1,000 gallon bath)	$10,000	$5,400	~ $30,000	~ $30,000	N/A	N/A
Pollution prevention (compared to chrome)	N/A	Use large volumes of nickel	Small volumes of nickel waste	Small volumes of nickel waste	Small volumes of powdered metal	Small volumes of powdered metal
Annual waste costs[1] (compared to chrome)	N/A	Slightly less	Much less	Much less	Minimal	Minimal
Process operations (compared to chrome)	N/A	Same	Same	One more	Fewer	Fewer

1 Specific to McClellan AFB process conditions, production level, and facilities
2 10 to 25 mil coating thickness
3 Dependent on equipment, coating materials, and base metal

Electroless Nickel

Electroless nickel (EN) plating is a process that has existed for many years as both a decorative and functional coating (e.g., wear and corrosion protection). EN is an autocatalytic process in which nickel ions are reduced to metal at the surface by chemical-reducing agents without the need for an electric current. A commonly used reducing agent is sodium hypochlorite, which donates electrons to the metal ions with the substrate acting as a catalyst for the reaction.

The use of EN as an alternative to chrome plating is limited by its somewhat poorer physical properties. As is evident from Table 1, the hardness and abrasion resistance of low-phosphorus EN is good, but lower than for chrome plating. The wear rate and galling resistance are poorer than those of chrome plating . Additionally, heat treatment is required to achieve full hardness. Brittleness of the deposits makes finish grinding difficult for thick deposits. EN cannot be cost-effectively plated as thick as chrome, but since it plates more evenly, the need for substantial overplating can often be eliminated. An advantage of EN is that the deposit follows all of the contours of the substrate without excessive buildup at the edges and corners, which is common with chrome plating.

The process bath, however, is more sensitive to impurities than is the chrome-plating bath. As a result, it must be monitored closely to maintain the proper concentrations and balance of the metal ions and reducing agents. In addition, the bath life is finite which requires frequent disposal and replenishment of the bath, especially when thick deposits are being applied. Deposition rate and coating properties are affected by temperature; pH; and metal, ion-reducing agent concentration. Many formulations will not deposit adherent films greater than 10 mils, which is the minimum requirement for finish grinding.

EN has not been adopted for aircraft actuator plating. EN has been well accepted for other ground-based, hydraulic component usage and other applications. Positive characteristics of EN are that it imparts greater corrosion protection than chrome plating and should not result in significant fatigue life debit.

Nickel-Tungsten Electroplating

Two nickel-tungsten based alloy electroplating processes are available as potential alternatives to chrome plating. These include: nickel-tungsten-boron (Ni-W-B) and nickel-tungsten-silicon carbide (Ni-W-SiC) composite electroplate (Takada 1990, and 1991).

The two processes are similar in that they are both electrolytic and they deposit a coating of nickel and tungsten with minor percentages of either boron or silicon carbide to enhance the coating properties. Each coating exhibits many of the desirable properties of chrome plating, but additional testing is required before widespread use is approved for critical applications. These processes use less energy than chrome plating for both rectification and heating. Both electroplates result in coatings that are more uniform than chrome plating, which can yield cost savings by allowing greater throughput and a minimal amount of overplating.

The processes are very compatible with the facilities and equipment used for chrome plating. The tanks can be converted with a liner, stainless anodes, additional circulation and filtration, and automatic chemical controllers. Both processes contain nickel, which is an EPA-17 listed chemical targeted for reduction; however, the baths contain 24–50 pounds of nickel in a 1,000-gallon bath, whereas chrome has nearly 1,200 pounds of metal in a 1,000-gallon bath. The reduced concentration in the bath directly influences the reduction in dragout rates, waste generation rates, and mist emissions of heavy metals.

Ni-W-B electroplating deposits an amorphous alloy that is approximately 59.5 percent nickel, 39.5 percent tungsten, and 1 percent boron. The coating has a bright, silver-white, highly lustrous appearance at thicknesses of up to 10 mils; above 10 mils it becomes matte in appearance. The coating has favorable chemical and abrasion resistance, high ductility, a low coefficient of friction, and plates very uniformly. A post-plating heat treatment is required to increase the hardness to a level comparable or slightly harder than chrome plating.

Ni-W-SiC composite plating is similar to Ni-W-B, except that it uses silicon carbide particles interspersed in the matrix to relieve internal stress and improve coating hardness. The resulting deposit is roughly 46.3 percent nickel, 46.1 percent tungsten, 4.3 percent silicon, and 3.2 percent carbon (Takada 1990). The appearance of the coating is similar to that of Ni-W-B, and heat treatment (~ 500° F for 4–6 hours) raises the hardness significantly to a level that is as hard as or slightly harder than chromium.

The major disadvantages associated with these two nickel tungsten processes are (1) their lack of maturity, (2) potential increased costs over chrome, and (3) their reliance on nickel. Neither of these processes have been scaled up to production levels and additional testing (which is ongoing at various locations) will be required to qualify the coatings for particular applications.

Metal Spray Coating Applications

Several metal spray coating applications have shown promise as potential alternatives to chrome plating. These technologies are not new. A similar metal spray coating process (Union-Carbide Detonation-Gun [D-Gun]), has been used successfully for many years on F-4 and other aircraft hydraulic actuators; however, it is only recently that metal spray systems with comparable performance to the D-gun and chrome plate have been become available. These processes are becoming more economically desirable due to increasing regulatory controls for chromium plating. Variations on the spray application include arc spray, flame spray, plasma spray, and HVOF spray. From a materials standpoint, HVOF spray has the best coating properties.

HVOF coatings are used presently in many industrial applications because they develop very hard, wear-resistant surfaces that have comparable performance requirements to those of chrome plating. In the HVOF coating application, an explosive gas mixture ignites in the barrel of the spray gun, which melts a powdered coating material and propels it at supersonic speeds toward the substrate. The superior coating properties are a result of the high velocities that are reached in the process—the higher the velocity, the greater the force of impact at the substrate, which results in fewer voids in the coating and more desirable properties.

The coating properties that are deposited vary with different equipment vendors due to the velocities and thermal environment that the particles experience. Table 2 lists the coating properties of typical HVOF coatings that may be applicable to chrome plating elimination. Several of the potential alternatives contain chromium, yet the HVOF coating will generate a significantly smaller mass of chromium containing waste and will emit less chromium metals. The powdered metal overspray can be easily captured and recycled by a dry filter system, and unlike a liquid waste stream, no chemicals are added to the waste volume to precipitate out the metals.

The limitation of the HVOF process is that the application is limited to line-of-sight areas of the parts; therefore, complex shapes, threads, and bores/holes cannot be coated. Unlike the nickel-tungsten electroplate that can use conventional finishing methods, the high hardness tungsten carbide-cobalt coatings will require changes in the finish-grinding methods used currently (one step with 120 grit SiC wheels). Diamond grinding wheels and two-step grinding may add significant cost and time. Grinding tests are ongoing at McClellan AFB. Fortunately, HVOF coatings can be applied much closer to finish dimensions, thus requiring less time for grinding. Preliminary results from piston rod and seal testing indicate that HVOF coatings and contacting seals last longer than chrome, thereby decreasing the frequency of rework. The chemical stripping of coatings for rework purposes is slow and will require additional testing and development.

McClellan AFB selected a pair of alternatives for implementation as chrome plating replacements for hydraulic actuator refurbishment. A composite Ni-W-SiC alloy will be used for parts with complex geometries, internal bores, and threaded surfaces, even though the Ni-W-B coating has not been ruled out yet. An HVOF metal spray process using tungsten carbide-cobalt will be adopted to restore dimensional tolerances on hydraulic actuator piston wear surfaces. Additionally, the existing EN capacity will be exploited more fully where applicable.

Testing specific to hydraulic applications is planned for fiscal year 1995 at McClellan AFB and will include, as a minimum, crossed cylinder wear (ASTM G 83), galling resistance (ASTM G 98), block-on ring wear (ASTM G 77), hydraulic actuator rod and seal wear testing (MIL-C-5503), and functional field performance testing (flight). The above tests will build on the results of testing that is currently being performed by the Oklahoma City Air Logistics Center and that is currently being performed by various researchers.

ALTERNATIVES TO CHROMATE CONVERSION COATING

Chromate conversion coating is a nonelectrolytic application to light metals—generally aluminum and its alloys. Chromate conversion coating offers numerous advantages, including greatly improved wet and dry paint adhesion; self-healing corrosion protection in case of scratched parts; simple application processes (spray, brush, and immersion); easy to maintain bath chemistry, and mature process applications. Presently, there are no "drop-in" substitutes for chromate conversion coating that will adequately match each of the advantages that chromate conversion coating offers.

The major disadvantage of chromate conversion coating is its use of hexavalent chromium. The chromate conversion coating process does not have the misting emission problem typical of electrolytic processes such as chrome plating; however, in applying the coating to an entire aircraft, the subsequent rinse process generates large quantities of chromium-containing wastes.

Several tests are used routinely to quantify the characteristics of conversion coatings. For example, paint adhesion can be measured using the wet tape adhesion method, scrape adhesion method, knife scribe test, cross hatch adhesion test, and others. Corrosion resistance is typically measured using the salt spray corrosion resistance test (ASTM B117), which is conducted on either unpainted or painted specimens. Measures of the performance of chromate conversion coatings in these tests are provided in Table 4, which also shows the performance of alternative coatings evaluated in this study.

Table 4. Coating Characteristics of Chromate Conversion Coating and Prospective Alternative Processes

Characteristic	Chromate Conversion Coating	Alodine 2000	Safeguard CC	Sulfuric Acid-Boric Acid Anodize
Salt spray testing, unpainted	> 336 hours	> 336 hours	> 168 hours	> 336 hours
SO_2/salt spray testing, unpainted	< 168 hours	Not available	> 168 hours	> 168 hours
Salt spray testing, painted	> 2,000 hours Pass	> 1,500 hours Pass	> 2,000 hours Pass	> 2,000 hours Pass
Paint adhesion, Crosshatch Test	Pass	Pass	Pass	Pass
Paint adhesion, wet tape	Pass	Pass	Pass	Pass
Electrical resistance	< 5,000 MΩ < 10,000 MΩ post salt spray	> 5,000 MΩ < 10,000 MΩ post salt spray	> 5,000 MΩ > 10,000 MΩ post salt spray	> 5,000 MΩ > 10,000 MΩ post salt spray

Table 5 shows the process characteristics of the chromate conversion coating and the alternatives, including cobalt/molybdenum (alodine 2,000), oxide layer growth (sanchem 6), and sulfuric acid-boric acid anodizing (SBAA). In general, the corrosion resistance and paint adhesion of the alternatives can be as good as those of chromate conversion coating, but each alternative has significant drawbacks as discussed below.

Cobalt/Molybdenum-Based Conversion Coating

Cobalt/molybdenum (Alodine 2000) is a developmental conversion coating process that was originally developed and patented by Boeing Aircraft Company. The process is being developed further by Parker+Amchem in preparation for commercial availability. The process uses an undisclosed proprietary formulation identified generally as cobalt and molybdenum-based. The cobalt and molybdenum ions, which are much less hazardous than chromium, behave similarly to chromium based on their proximity to chromium in the periodic table. Molybdate and cobalt have been found to inhibit pitting corrosion on aluminum alloys, but not as effectively as chromium. Therefore, a second step is required for the Alodine 2000 to meet the specification requirements. The second step is an organic emulsion seal that enhances both the corrosion resistance and paint adhesion. Laboratory tests of the product have shown that the coating is capable of meeting the corrosion resistance and paint adhesion characteristics, but the process has not been fully scaled to production levels.

Several aspects of the cobalt/molybdenum process increase its cost over that of chromate conversion coating. The cost of the bath chemicals has been estimated to be two to three times greater than for chromium. The process

Table 5. Process Characteristics of Chromate Conversion Coating and Prospective Alternative Processes

Characteristic	Chromate Conversion Coating	Alodine 2000	Safeguard CC Immersion Process	Safeguard CC Spray Process	Sulfuric Acid-Boric Acid Anodize
Pollution prevention considerations	Uses hexavalent chromium	Uses a dilute solution containing no chromium; organic seal may be of concern	Uses a dilute solution containing no chromium; simple, completely inorganic treatment; uses greater volume of rinse water	Uses a dilute solution containing no chromium; simple, completely inorganic treatment; uses greater volume of rinse water	Simple waste treatment; low waste volume; minimal amounts of chromium in process
Technological maturity	Well established and extensively used	Developmental—projected availability 1995	Developmental but commercially available; has been used in production, aircraft testing ongoing	Experimental; prototype equipment fabricated; testing ongoing; not commercially available	In production; McClellan AFB is setting up process; major drawback is its limited parts applicability
Cost of implementation	Not applicable	$240,000	> $400,000—testing at additional cost	About $130,000—will require equipment development and testing at additional cost	Minimal to $90,000—will be implemented at McClellan AFB to replace chromic acid anodize
Cost of production (per square foot of part coated)	$0.80	$2.02	$7.95—energy, maintenance intensive	$2.02—requires testing	$0.78
Maintenance concerns	Very easy to maintain	Solution has displayed instability; organic seals can be troublesome	Water quality difficult to control; more heated tanks require more maintenance	Equipment complex and all sprayed-on chemicals will be waste	Simple chemistry controls; racking, masking, touch-up add costs
Processing time	3–5 minutes	5–10 minutes	30 minutes minimum	Slower than chromate conversion coat	40 minutes plus racking time
Facilities modifications	None	Addition of one process and rinse tank	Addition of fours process and three rinse tanks	Installation of cabinet coater system with waste stream connections	None

requires one additional process tank and rinse step for sealing, which will increase the equipment investment. The process requires heated baths, which result in increased energy usage. This makes the estimated cost associated with the process about twice as much as that of chromate conversion coating based on McClellan AFB production levels (200 square feet per day). Greater production rates and capacity utilization will cause a decrease in the estimated unit cost. Potential liability costs, which could be significant, were not factored in to the costs calculations.

Advantages of the coating process are that it would be universally applicable to parts that are presently chromate-conversion coated. It is still a tank-based process compatible with the currently used immersion methods, (although the process is also being developed for spray, brush, and wipe applications), and it requires only slightly more time to apply than the present coatings. The greatest disadvantage, however, of the cobalt/molybdenum process is that it is still developmental and has not been scaled up to production.

Oxide Layer Growth in High-Temperature, Deionized Water

The oxide layer was developed and has been refined within the past decade (Bibber, 1987, 1988, and 1989). The process is somewhat more mature than the cobalt/molybdenum process. Several variations on the process, including immersion and steam spray, are in various stages of development. This coating is applied in a series of steps, including an oxide layer growth step in boiling deionized water, to build a corrosion-resistant paint base on aluminum. Both immersion and steam spray methods are being developed. This process does not use hazardous materials and is completely inorganic and nontoxic. Depleted baths and rinse waters require limited treatment before discharge to a sanitary sewer. The process can withstand greater temperature exposure than the chromate conversion coating and is thin, yet abrasion resistant. The chemical solutions used to apply the coating are very dilute, facilitating long solution life and simple solution monitoring and control.

The major drawback with the oxide layer growth process was found to be the cost. The process requires many additional steps involving numerous tanks of chemicals at elevated temperatures. Consequently, the energy cost and processing times as well as capital costs increase substantially for McClellan AFB production rates over chromate conversion coatings. While energy costs are somewhat offset by waste treatment reductions, the oxide layer growth processes have been estimated to cost up to ten times as much as the present process.

A variation on the process involves its spray application within a cabinet coater. This device is a chamber or series of chambers (conveyerized) large enough to handle the parts at McClellan AFB. Prototype tests of this process were very promising; the equipment will save on heating costs and chemical requirements. Much less floor space will be needed compared to the immersion method.

Other Chromate Conversion Coating Alternatives

Several additional processes may prove feasible in eliminating chromium from conversion coatings. These include SBAA, various phosphate treatments, and other emerging technologies.

SBAA, developed by Boeing to replace chromic acid anodizing, may prove valuable as a replacement to chromate conversion coatings on certain aircraft parts. The process imparts exceptional paint adhesion and corrosion protection at a cost that is comparable to that of chromate conversion coating. However, since SBAA is an anodic process it is not universally appropriate for all parts, especially parts with steel inserts or those having sharp edges, welds, crevices, and other areas that entrap fluids. This limits the applicability of SBAA as a more universal chromate conversion coating alternative.

Phosphate coatings do not provide a high-quality coating comparable to the present process. However, in those applications where the conversion coating/primer/topcoat is treated as a "system" for testing purposes (i.e., the *bare* salt spray corrosion resistance is not considered important), this type of coating could prove to be an appropriate substitute. It is in use within the automotive industry, but has the disadvantages of additional process steps, long process cycle time, and increased energy consumption.

Several experimental and developmental technologies that may lead to breakthroughs with respect to replacement of chromium in conversion coatings in some applications are listed in Table 6.

Table 6. Emergent Alternative Conversion Coat Technologies

Process Description	Status
Trivalent chromium conversion coatings	Meets 500 hours of salt spray; still contains chromium; electrolytic process
Hydrated alumina coating	Poor paint adhesion; meets 500 hours of salt spray
Hydrated metal salt coating (Mg, Ni, Mn, Sn, Ti, Fe, Ba, Cu, Co, Ca)	Does not meet salt spray requirement; poor adhesion
Oxyanion analogs (molybdates, tungstates, vanadates, and permanganates)	Moderate corrosion resistance; poor paint adhesion; molybdates with borate seem best; expensive
Potassium permanganate coating	Moderate corrosion protection (168 hours); poor wet tape adhesion; does not work well on 2024 and 7075; requires boiling DI water; multi-step process, expensive
Rare earth metal salts (cerium)	Corrosion protection close to chromium; good paint adhesion; unstable chemical bath; expensive; has future potential
Zirconium oxide/yttrium oxide in aqueous polymeric solution	Good paint adhesion; moderate salt spray protection (100 hours); contains flammable solvents; thickness dependent, must be cured; difficult to dispose of
Lithium-inhibited hydrotalcite coatings	Good corrosion protection on 1000-, 3000-, and 6000-series alloys; poor wet paint adhesion; single process bath; environmentally benign; very promising

"No rinse" conversion coating has the capability of reducing the amount of chromium discharged into waste streams. The Navy and Air Force have worked on the development of an appropriate conversion coating that may be applied to an entire aircraft with no rinse step required. The rinse step is where the majority of the emissions for brush or wipe application of the conversion coating occur.

IMPLEMENTATION PLANS FOR CHROME ELIMINATION AT MCCLELLAN AFB

McClellan AFB has selected to continue research level evaluations of the Sanchem CC spray application and to reroute specific parts to the SBAA process as appropriate. A viable alternative to chromate conversion coatings is not anticipated to be available commercially until 1996. SBAA processing will reduce the chromium emissions and waste generation from the facility by a modest amount in the interim period.

A combination of alternatives will be tested on a pilot-scale basis as alternatives to chrome plating for the refurbishment of hydraulic actuators. The Ni-W-B or Ni-W-SiC will be implemented to replace chrome that is applied to complex shapes, cylinder bores, and parts not amenable to HVOF coating. HVOF coating using tungsten-carbide-cobalt will be pilot-scale tested for chrome replacement for the refurbishment of hydraulic pistons, rotating shafts, and other suitable applications. An automated coating system is being procured from an HVOF vendor whose system and coatings meet the performance requirements set forth by McClellan AFB. In the interim period, increased utilization of EN will be emphasized where appropriate.

At the conclusion of the pilot-scale testing, applicable specifications and technical orders will be changed to allow for use of the alternative technologies. McClellan AFB has a preference for implementing industrial specifications for these processes since the time constraints and costs of revising military specifications are prohibitive.

CONCLUSION

Chromium is used widely for numerous applications within many different industries so its elimination, while perhaps warranted, is not a trivial problem. For hard chrome plating and chromate conversion coating applications, there are several viable process alternatives in various stages of development and production, but no one alternative should be viewed as a universal replacement. Significant testing still needs to be completed on these processes. In the end the engineers responsible for each particular product will need to be convinced that a particular alternative adequately meets the requirements for a chromium alternative.

For additional information on the chromium elimination program at McClellan AFB, interested parties are encouraged to contact Mr. Elwin Jang, McClellan AFB Project Officer, at (916) 643-6151, Mr. Barry Meyers at (916) 643-0531, or Mr. Steve Lynn at (703) 883-5799.

LIST OF REFERENCES

Amorphous Technologies, Inc., 1993, Vendor Literature.

Bibber, J., 7 November 1989, *Corrosion Resistant Aluminum Coating Composition*, U.S. Patent 4,898,963.

Bibber, J., 8 December 1987, *Corrosion Resistant Aluminum Coating Composition*, U.S. Patent 4,711,667.

Bibber, J., 5 July 1988, *Corrosion Resistant Aluminum Coating Composition*, U.S. Patent 4,755,224.

Meyers, B., The MITRE Corporation, November 1993, *Alternatives to Hard Chrome Plating at McClellan Air Force Base*.

Meyers, B., The MITRE Corporation, December 1993, *Alternatives to Chromate Conversion Coating at McClellan Air Force Base*.

Takada, K., 9 January, 1990, *Method of Nickel-Tungsten-Silicon Carbide Composite Plating*, U.S. Patent 4,892,627, .

Takada, K., 26–28 March 1991, *An Alternative to Hard Chrome Plating*, 27th Annual Aerospace/Airline Plating and Metals Forum, San Antonio, Texas.

Weisenberger, L., 1973, *Hardness and Wear Resistance of Electroless Nickel Alloys*, Allied Kelite Witco Company, Internal Publication.

POLLUTION PREVENTION MANAGEMENT PLAN

Oklahoma City Air Logistics Center

by

Robin Lee Stearns

OC-ALC/EMV

7701 2nd Street, Suite 220
Tinker AFB, OK 73145-9100
(405) 736-5102, DSN 336-5102

Abstract: The Oklahoma City Air Logistics Center has an aggressive Pollution Prevention Program administered by OC-ALC/EMV. This organization has received numerous awards within the US Air Force and DoD, such as the Air Force Pollution Program Award for 1993, as well as the DoD Pollution Prevention Program Award for the same year. The Pollution Prevention Management Plan consists of objectives, goals, and strategies. All of these items relate individually to each of the Program Elements such as Ozone Depleting Chemicals (ODCs), Hazardous Waste, Alternative Fuels, etc. Within this plan are specific Roadmaps"formulated to guide OC-ALC in achieving the US Air Force goal of Zero Discharge 2000. Each of these roadmaps relate to a major hazardous waste user/generator at the industrial overhaul facility, i.e.aircraft, engines and accessories. Additionally, roadmaps are being formulated for the Weapon Systems Managers in the Acquisition Pollution Prevention Program.

INTRODUCTION

The Pollution Prevention Program at the Oklahoma City Air Logistics Center is an award-winning program dedicated to the reduction of all wastes generated at production sites, to the maximum extent feasible. The Pollution Prevention Division is located in The Directorate of Environmental Management (EM). The EM Directorate was created in 1985 to provide a single point of contact for the public as well as state and federal regulatory agencies. It is the largest partner in the three member Integrated Environmental Team. The Base Safety Office and the Bioenvironmental Engineering Division form the other two important prongs of Tinker's innovative approach to environmental management. The Pollution Prevention Division of the EM Directorate is the single point of contact for all Pollution Prevention initiatives at Tinker AFB.

OBJECTIVES

The primary objective of the Pollution Prevention Program is to reduce pollution resulting from the Tinker Air Force Base operations through acceptable 'waste minimization" techniques. Additional Pollution Prevention Program objectives are to:

1. meet USAF, Federal, State and local pollution prevention policy goals;
2. continue the Base's compliance position with respect to Federal, State and Local environmental laws and regulations;
3. actively participate in and contribute to the identification, implementation and evaluation of new innovative ideas to reduce hazardous chemical usage and waste generation;
4. promote pollution prevention as an integral part of the Base's mission;
5. maintain and report emissions data to the EPA (SARA Title III reporting); and
6. maintain a positive posture and leadership role in interacting with local communities on common pollution prevention issues.

GOALS

The focus of the pollution prevention plan is to set pragmatic goals and achieve those goals through the process of assessment, aggressive programming, implementation, and re-assessment. The pragmatic goals are to use pollution prevention funds, as well as other funds, to replace polluting processes with the most modem, environmentally sound, and efficient industrial processes in the world.

The comprehensive goals of the Pollution Prevention Program are:

- Reduce ozone depleting chemical releases by 50% by the end of 1995 from a 1992 baseline;
- Reduce purchases of EPA 17 industrial toxics by 50% by the end of 1996 from 1992 baseline.
- Reduce hazardous waste disposal by 25% by the end of 1996 from 1992 baseline.
- Reduce municipal waste disposal by 30% by the end of 1996 from 1992 baseline.
- Eliminate purchase of chlorofluorocarbons, halon, and other ozone layer depleting substances by the end of 1997;
- Reduce municipal waste disposal by 50% by the end of 1997 from 1992 baseline.
- Reduce hazardous waste disposal by 50% by the end of 1999 from 1992 baseline.
- Reduce volatile air emissions by 50% by the end of 1999 from 1993 baseline.
- Reduce volatile air emissions by 50% at the end of 1999 from a 1993 baseline.

STRATEGY

During pollution prevention investigations, options will be identified ranging from better business practices to equipment replacement or process modification. Opportunity assessments will provide short, intermediate and long term pollution prevention alternatives.

Economics are important but not the only factor that will be considered when selecting a pollution prevention project. Other factors considered are benefits, completion time, technology availability, experience with technology, mission impact, degree of liability, compliance with laws and regulations, and environmental impact.

To achieve the goals and objectives, the Pollution Prevention Program strategy is based on the following:

1. Preliminary Assessment: TAFB has completed an assessment of the industrial processes and solid waste produced to define projects to reduce or eliminate the amount or toxicity of waste disposed;
2. Define pollution prevention options: TAFB will propose, screen and prioritize pollution prevention project options;
3. Perform feasibility study: TAFB will perform technical, environmental and economical feasibility studies of each proposed project;
4. Write assessment report: TAFB will complete an assessment report based on the above three areas;

5. Implement pollution prevention project: TAFB will select projects for implementation, obtain funding necessary to proceed and follow through with installation.
6. Measure progress: TAFB will conduct a re-assessment of the implemented project(s) to determine its effectiveness.

TAFB will use the following environmental management hierarchy while assessing each pollution prevention option:

1. Source reduction (i.e. environmentally friendly design of new products, product changes, source elimination);
2. Recycling (i.e. reuse, reclamation);
3. Treatment (i.e. stabilization, neutralization, precipitation, evaporation, incineration, scrubbing); then
4. Disposal (i.e. disposal at a permitted facility).

This strategy will be the basis for initiating pollution prevention projects for each of the following Pollution Prevention Program Elements.

POLLUTION PREVENTION PROGRAM ELEMENTS

The projects initiated by the Pollution Prevention Division are assigned to one of the following eight Program Elements:

- EPA 17 Industrial Toxic Program Chemical
- Ozone Depleting Chemicals
- Hazardous Waste Minimization
- Municipal Waste
- Affirmative Procurement for Recycled Products
- Alternative Fuels
- Hazardous Material Cell
- Acquisition Pollution Prevention

IMPLEMENTATION

The success of the Pollution Prevention Program depends on the implementation of the overall program. Pollution Prevention Projects that insert alternative processes and materials are managed by engineers in the Pollution Prevention Division. The expertise of the support engineering staff is key to successful implementation of PP Projects. Recently, the PP engineering staff has been expanded to include chemical engineering expertise. The main thrust of this initiative has been for ODC elimination. Other areas in which these engineers have expanded into EPA 17 and Hazardous Waste Minimization projects initiatives. Expertise through Program support personnel are key to this successful program.

CONCLUSIONS

The Pollution Prevention Management Plan at Tinker AFB has successfully eliminated 390 tons of EPA 17 Chemicals per year (since 1992), and 225 tons per year of ODCs (since 1991). Additionally, the organization won the Department of Defense Pollution Prevention Award in 1994. These achievements are a direct result of the Pollution Prevention Management Plan and the coordinated efforts of the Directorates of Environmental Management, Aircraft Management, Commodities Management, and Propulsion.

SESSION IX

EARTH FRIENDLY CONTRUCTION/STORM WATER POLLUTION PREVENTION

Session Chairpersons:
Laura Drasgow, USACERL
Bob Olsen, Law Environmental

Earth Friendly Construction: An Architect's Perspective

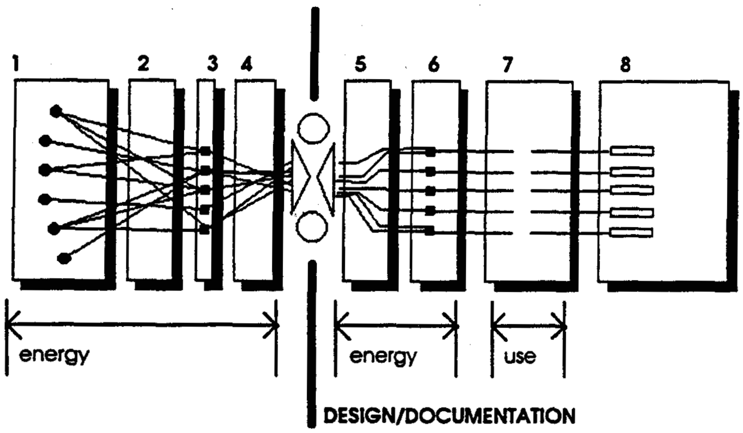
Capt Mark L. Gillem, RA
The Air Force Institute of Technology

AFIT/CEC 2950 P Street Bldg. 125
Wright-Patterson AFB, OH 45433-7765
(513)255-4552 DSN 785-4552

Abstract. This paper discusses a set of earth friendly construction strategies that architects and engineers can incorporate into new and renovated Air Force buildings. Simply put, earth friendly construction utilizes nature-driven and technology-driven strategies to reduce the environmental impact of a construction project. Nature-driven technologies employ passive solar techniques such as siting, orientation, and organization. They take advantage of existing natural resources such as the sun, air, and light to reduce the building's energy demand while improving the interior environment. Technology-driven strategies employ materials and methods that minimize heat flow through the building envelope, reduce energy consumption, and use recycled products. Earth friendly buildings can incorporate energy-efficient lighting, high-performance glazing, and thermally resistant insulation. Unfortunately, an improper focus on initial costs continues to hamper the application of these strategies at Air Force installations. A life-cycle approach to costing demonstrates the fallacy of basing design decisions on initial costs. Finally, two case studies demonstrate the application of nature-driven and technology-driven strategies. The first, a new facility designed by the author at a northern-tier Air Force base used orientation and organization techniques to capture energy from the sun and increase the fresh airflow through the interior spaces. It used off-the-shelf technologies to reduce heating and cooling requirements. The second case study demonstrates the applicability of these strategies to a renovation project. In addition to using natural and recycled materials, the renovated office incorporates an energy-efficient lighting scheme that significantly reduces the building's total energy consumption. By incorporating earth friendly construction strategies into new and renovated projects, architects can reduce a building's impact on the natural environment.

A Proactive Approach to Pollution Prevention

A Big Impact. A few statistics demonstrate the damage buildings can do to the environment. The building industry accounts for 35 to 40 percent of ozone depletion by chlorofluorocarbons (Wilson 113). Moreover, the built environment generates 30 percent of carbon dioxide emissions, as well as nearly 30% of municipal solid waste, and 35% of annual energy consumption (113). Buildings do impact the environment in a profound way. To reduce the impact of these structures and their utility systems on the ecosystem, architects and engineers



1. Utilize materials from natural resource base
2. Distribute raw materials to factories
3. Manufacture products
4. Disseminate product information
5. Distribute product to job site
6. Build
7. Operation
8. Final material strategy (recycle, reuse, landfill)

Figure 1: The life span of building products

must consider environmental issues at the project's outset. This is true because it is at the outset or the design and documentation stage of a project that key decisions lasting the life span of the building are made. Architects from the Croxton Collaborative developed the diagram at left (figure 1) to make architects aware of the life cycle of materials and energy use within the cycle. By narrowing at the center, where designers make key decisions regarding material selection, the diagram suggests the importance of proper planning at the design stage (Branch 75). When designers research and select products for use they are making decisions that impact the environment for an extended time period. If they make decisions based on total impact, architects can minimize damage that may result from their buildings.

Sustainability as a Model. Today, many architects and engineers incorporate strategies into their designs that decrease the demands placed on natural resources. Some call this sustainable design. Others call it green architecture. This renewed environmental awareness is changing the way architects think and work (72). Many of the techniques used today come from a history rich with examples of sustainable design. Cliff dwellings, igloos, and sod homes are examples of past successes that respond to specific microclimates while incorporating nature-driven or technology-driven strategies.

Nature-Driven Strategies

Using Nature. Nature-driven strategies employ passive solar techniques such as siting, orientation, and organization. Buildings utilizing these strategies take advantage of existing natural resources such as the sun, air, and light to reduce the energy demand while improving the interior environment.

Sun. Using the sun as a resource for heating and cooling can be simple and cost effective. To support this use, the Air Force developed the *Passive Solar Handbook* to help integrate passive solar concepts into the programming, design, and construction of military facilities. Included in the handbook are suggestions for site planning and building design along with recommendations for selecting a system that uses the sun to help heat or cool a facility. Through a combination of passive solar concepts, it is possible "to reduce the total energy costs [of facilities] by as much as 40%" (Holtz 1). Along with the cost savings, there are parallel savings in pollution prevention due to less energy demand.

On the basis of the energy demand of a facility and the availability of solar income at the site, numerous techniques are available that capture the heat of the sun and reuse that heat in the interior spaces. In the northern hemisphere, these range from direct gain spaces that have a large southern exposure with no heat storage potential to indirect gain systems with a storage mass that absorbs the sun's heat for redistribution into the space at an even rate. According to Brown (89) the glazing on solar heated spaces should be no more than 20 to 30 degrees from true south to maximize heat gain.

For cooling purposes, buildings can take advantage of the sun's absence at night to dump heat from the building into the cooler atmosphere. This stored heat can be removed without any mechanical assistance. Night mechanical ventilation or natural ventilation can be used as a supplement (Holtz 27).

Air. Utilizing the movement of air to increase passive cooling is yet another natural approach to reducing a facility's energy demands. In commercial facilities Holtz (11) found that over 44 percent of energy costs were for mechanical cooling. Using natural methods to cool a facility can reduce the overall energy use and energy cost. Cross-ventilation using parallel operable windows works well in many applications. Many apartment buildings fail to incorporate cross-ventilation into their designs and stagnant air results. When rooms open to the site's prevailing breeze the effectiveness of cross-ventilation is increased (Brown 90).

The School of Engineering and Manufacture, Leicester Polytechnic, England, generates high internal heat loads due to round-the-clock computer programs and heavy-duty machinery (Arcidi 82). To moderate the school's interior temperatures, the architects designed an innovative system of cross and vertical ventilation that ventilates 90 percent of the space without mechanical assistance (82). The latter approach, known as stacked ventilation, uses vertical flues to take advantage of the chimney effect: "when the temperature difference in the air between the top and bottom of the flue is greater than that of the air outside, warm air vents out" (82). This supports Brown's findings that high and low openings in tall rooms increase the rate of stack ventilation (98).

Light. Since artificial lighting accounts for over 46 percent of energy use in commercial buildings (Holtz 11), strategies for using daylighting to reduce this energy demand are becoming more popular. Researchers at the Center for Building Performance and Diagnostics at Carnegie Mellon University are developing a laboratory for in-depth study of building systems. According to Loftness, "The first commitment to a healthier workplace and to environmental consciousness in the Intelligent Workplace is the move away from large, deep floor plans with minimum window area, to a window for every workstation. The increased periphery maximizes environmental contact, eliminating buried, internal high use spaces" (21).

Research at Carnegie Mellon shows that despite the increased periphery and the increased percentage of glass in facilities using daylighting there is no energy penalty, "indeed an energy benefit [can occur] through daylighting and natural ventilation" (23). The increased periphery is due to the elongated aspect ratio of 5:1 as compared to compact buildings with a 1:1 aspect ratio. According to Holtz the elongated buildings have up to a 25% reduction in energy use over a similar sized compact building (7). This recognition of the importance of daylighting underscores the impact lighting has on environmental resources. Moreover, the acknowledgment that natural lighting and ventilation work together point to a holistic approach that incorporates earth friendly strategies in today's facilities.

Technology-Driven Strategies

Utility Systems. Since lighting accounts for the majority of a commercial building's operating cost, it makes sense to supplement daylighting with efficient artificial lighting systems. For example, replacing one 75 watt incandescent lamp with an 18 watt compact fluorescent lamp, saves 13 lamps and 570 kW over the life span of the lamp (Bailey, O.). A big step in conservation is cutting the ambient light levels from 50-75 foot-candles in a typical office to 25-30 foot-candles. At the Natural Resource Defense Council (NRDC) headquarters in New York, "ambient lighting is provided by ceiling-mounted 32 and 40-watt T8-type triphosphor-coated fluorescent tubes within parabolic fixtures which cast even illumination. Task lighting, supplied by 8-watt compact fluorescent fixtures directly over desks, boosts the light level to 75-100 foot-candles if needed" (Crosbie 87). The local power company found that NRDC consumed 0.4 watts per square foot, compared with an average office consumption of 2 watts. The estimated savings from the lighting alone is $12,500 a year not including reduced loads on the air conditioning system (87).

In addition to electrical systems, mechanical systems that recapture heat from people and equipment using heat exchangers work well. Heat pumps are another technology seeing more use. Mechanical systems that allow for greater variation, such as those that use variable air volume boxes and CO_2 sensors also reduce the overall energy demand. Also a centralized monitoring system can maximize efficiency.

Building Materials. A growing awareness of the importance of recycled materials and appropriate building enclosure systems has led to the creation of several manuals that can assist designers in earth friendly materials selection. The first is the American Institute of Architects' *Environmental Resource Guide.* This is a document that attempts to inform designers of the relative advantages and disadvantages of many building materials and systems. Likewise, the American Society for Testing Materials prepared a *Green Building Performance Standard Guide* (Branch 79). It too can help designers interested in learning more about building materials.

Life-Cycle Cost

Total Cost. Focusing on the perceived additional costs of earth friendly construction can be myopic. Two built examples worth noting are the Rocky Mountain Institute headquarters in Aspen, Colorado, and the Netherlands International Bank (NMB) headquarters in Amsterdam. The former, built in 1984, used numerous nature and technology-driven strategies at an initial additional cost of $6,000. The payback was ten months (Branch 76). The 538,000 square foot NMB facility used extensive daylighting and thermal storage to drop energy consumption from 422,801 British Thermal Units (BTU) of primary energy per square foot per year to 35,246 BTUs per square foot per year. This lead to an annual energy savings of $2.6 million with a payback of only three months (Browning 81). An additional benefit at NMB is lower employee absenteeism. Browning (81) notes that the head of NMB's development subsidiary, Dr. Liebe, attributes this to an enhanced working environment.

Moreover, over the life span of an Air Force facility, which can exceed 50 years, the costs of not incorporating these inexpensive strategies can be burdensome to the economy as well as to the environment. The author's schematic design for a 100,000 square foot administrative center at an Air Combat Command installation demonstrates the difference in total lighting costs. The standard approach will consume 2 watts per square foot while the author's proposed design, which incorporates narrow, light-filled wings with separate task and ambient lighting, will consume an estimated .5 watts per square foot (figure 2).

Figure 2: The Cost of Lighting 100,000 square feet of Administrative Space

	Illumination level of 2 watts per square foot	Illumination level of .5 watts per square foot	Annual Savings	Life-cycle savings over 50 years
Carbon Dioxide emissions (CO_2) pounds/yr.	1,397,760	349,440	1,048,320	52,416,000
Sulfur Dioxide emissions (SO_2) pounds/yr.	9,609	2,402	7,207	360,350
Total Suspended Particulate emissions pounds/yr.	6,988	1,747	5,241	262,050
All Nitrogen Oxide (NOx) emissions pounds/yr.	5,241	1,310	3,931	196,550
Coal used in pounds per year (.83/kWh)	725,088	181,272	543,816	27,190,800
Annual Lighting Cost in Dollars (using $.05/kWh)	43,680	10,920	32,760	1,638,000

Note: Emissions are based on those pollutants that would be generated by a coal-fired electric plant to produce the amount of electricity required for lighting the space (Bailey, K.).

Two Case Studies in Earth Friendly Construction

Construction of a New Military Family Housing Office. The author designed a new office building at Ellsworth Air Force base that incorporated many of the strategies discussed above to reduce the environmental and operating costs of the facility. By respecting the architectural theme developed at the base, the building fits into the surrounding environment while taking full advantage of the site's solar income. Since calculations demonstrated that the primary energy costs would be in the lighting and heating of the facility, strategies were used to minimize these costs. The predominant feature is a long east-west axis that maximizes the southern exposure. The facility's 379 square feet of south facing glass (17 percent of floor area) makes a dramatic statement while contributing significantly to the building's winter heating requirements. The space is direct gain. Other strategies used include:

- incorporating operable double pain, low-e windows that reduce the demand for artificial light
- installing long life fluorescent lamps parallel to the windows so they can be turned on in series as the light diminishes away from the windows
- using latex paint over a textured surface with light-reflecting interior colors
- adding interior windows to take advantage of the abundant natural light
- creating a narrow profile that improves cross ventilation
- installing a rainwater collection system that takes roof runoff to trees and shrubs
- using an infiltration barrier over six inch studs and increasing the insulating values
- wrapping the building in an additional layer of insulation to close the short-circuits that would exist at the studs

Taken together, the strategies used account for a 70 million BTU per year savings. Put another way, every year this represents a savings of 7,291 kW, 605,208 pounds of coal, and 1,331,458 pounds of carbon dioxide emissions.

Renovation of the National Audobon Society. For their new headquarters in New York city, the National Audobon Society renovated a 1915 building. According to the architects, "Our success at Audobon was achieved by upgrading the thermal shell, using a gas-fired heater/chiller and variable speed fans and motors, and creating a highly efficient lighting system" (Albrecht 62). Albrecht notes some of the strategies employed by the architects to reduce the building's environmental impact. They include:

- installation of operable high-performance windows that allow natural ventilation during the mild months and contribute to the ambient lighting
- use of an artificial lighting system, controlled by heat sensors and photoelectric cells that accounts for 40% of the total energy savings by using minimal ambient lighting
- installing user-controlled task lighting above each worksurface
- minimizing use of polluting materials through a careful analysis of the toxicity and manufacturing history of every element
- purchasing furnishings with maximum recycled content
- increasing the total number of air changes per hour to improve the indoor air quality
- installing a five-tube recycling system that makes recycling trash easier for the occupants and more efficient for the service workers

According to Albrecht (63), the result is a facility that uses 62 percent less energy than required by the 1990 New York State Energy Code. This design tactic translates into an energy savings of $100,000 per year (62).

Looking Forward

Tremendous opportunities exist for designers to reduce the impact of the built environment on the natural environment. By thinking creatively and with sensitivity, architects can minimize costs in terms of dollars and environmental damage. While we will continue to build places in which to live and work, we can take this opportunity to make those places sensitive to the needs of the users and to the environment.

References

Albrecht, D. "Urban Oasis." Architecture 6 (1993): 62-68.
Arcidi, P. "Sustainable Design." Progressive Architecture 3 (1993): 82-83.
Bailey, K. Personal interview. July 1994.
Bailey, O. Personal interview. July 1994.
Branch, M. "The State of Sustainability." Progressive Architecture 3 (1993): 72-79.
Brown, G. Sun, Wind, and Light. New York: John Wiley and Sons, 1985.
Browning, W. "Knock on Brick." Progressive Architecture 3 (1993): 80-91.
Crosbie, M. "Practice What They Preach." Progressive Architecture 3 (1993): 84-89.
Guntis, E. "Blueprint for a Green Future." Architecture 6 (1993): 47-49.
Harriman, M. "Designing for Daylight." Architecture 10 (1992): 91.
Herman Miller. Companies Go Green. Zeeland, MI: Herman Miller, 1991.
Holtz, M. ed. U.S. Air Force Passive Solar Handbook. Vol II. Boulder, Colorado: 1987.
Loftness, V., et al. Environmental Consciousness in the Intelligent Workplace. NeoCon94 Proceedings. Chicago, IL: NeoCon, 1994: 20-30.
Wagner, M. "Creative Catalyst." Interiors 3 (1993): 53-67.
Wilson, A. "Materials Alternatives." Architecture 5 (1993): 113-118.

Implementing Non-structural Best Management Practices for Storm Water Pollution Prevention

Paul Josephson, U.S. Army Environmental Center, Aberdeen Proving Ground, Maryland

Paul Somerville and Elizabeth Volk, Universal Systems Inc. (USI)
3675 Concorde Parkway, Chantilly, VA 22021
(703) 502-1391

The US Environmental Protection Agency reported in a 1990 study that approximately one third of the cases of water quality impairment are attributable to storm water discharges.(1) While industrial facilities have been recognized as significant sources of storm water pollutants, storm water discharges, for the most part, have been uncontrolled. Education and training are a key solution to controlling pollution in storm water discharges and compliance with the associated regulatory requirements.

This paper will implementation of non-structural Best Management Practices, particularly the importance of education and training. It will also discuss their application at "model" facility projects at Army installations.

BACKGROUND

The 1987 Clean Water Act Amendments mandated that the Environmental Protection Agency (EPA) establish permit requirements for storm water discharges. These permits provide a means for monitoring and controlling the discharge of pollutants from storm water runoff to waters of the United States. In 1990, the EPA published rules which required industrial activities to obtain and comply with a National Pollutant Discharge Elimination System (NPDES) permit for storm water runoff discharges. These regulations were put in place to avoid the detrimental effects storm water can have on the quality of our waters.

The NPDES permitting program applies to industrial activities that manufacture, process, or store raw material.(2) These industrial activities include transportation facilities; manufacturing facilities; hazardous waste facilities; landfills receiving industrial wastes; sewage treatment plants; steam electric power generating facilities, and; recycling facilities. Certain Federal facilities are required to obtain NPDES permits under these regulations. Many of these activities are further regulated by state and regional agencies. EPA and individual States permit requirements include:

- Monitoring and Sampling of storm water discharges from facility;
- Reporting and record keeping of significant spills and sampling results;
- Employee Training;
- Developing a facility specific Storm Water Pollution Prevention Plan (SWPPP), and;
- Implementing Best Management Practices (BMPs) in accordance with the SWPPP.

While NPDES permits for storm water are relatively new, the requirements are not completely new. The requirements build on the previously established Clean Water Act, the Resource Conservation and Recovery Act (RCRA), and the Emergency Planning and Community Right-to-Know Act (SARA Title III). Many of these requirements are incorporated in the facility's SWPPP, Measures and Controls section. This section of the plan identifies and describes storm water management controls needed for the facility. The facility SWPPP should identify potential sources of pollution at the facility and BMPs to address the source. This section also describes how these controls are implemented. These controls are referred to as Best Management Practices, or BMPs.

BEST MANAGEMENT PRACTICES

BMPs are processes, procedures, schedules of activities, and any other management practice that prevents or reduces pollution.(3) A facility SWPPP identifies Baseline and Advanced BMPs to manage storm water pollution at the facility. Baseline BMPs are practices that are inexpensive, relatively simple, and applicable to a wide variety of industries and activities. Baseline BMPs include good housekeeping practices; preventive maintenance; visual inspections; spill prevention and response; sediment and erosion control; and traditional storm water practices. Many BMPs are also required by RCRA or the Clean Water Act.

Advanced BMPs are practices that are tailored to address specific pollutant sources or activities at the permitted site. Advanced BMPs include flow diversion practices; exposure minimization practices; mitigative practices; and infiltration practices.

BMPs are also often differentiated by whether they are structural or non-structural in nature. Examples of structural BMPs include dikes, berms, oil/water separators, and storm water conveyances - engineering design solutions. Non-structural BMPs for transportation activities, for example, include most of the Baseline BMPs and certain Advanced BMPs such as vehicle positioning, the use of drip pans, and materials storage and handling for exposure minimization.

Generally, structural BMPs address the results of a pollution problem, not necessary the source of the pollution. A facility may spend considerable resources designing a storm water pre-treatment facility, the ultimate oil/water separator, or settling ponds to control pollutants in the facility's storm water outfalls. These examples treat the pollution resulting from industrial activities, but do nothing to eliminate or minimize the source of the pollution. Non-structural BMPs are processes and procedures which address pollution at the source as well as post source.

The first step in BMP development is to identify all potential sources of pollution in storm water runoff. This is required in the SWPPP to comply with the facility's storm water permit. The permit also requires that the SWPPP identify BMPs for each potential pollution source. When evaluating BMPs, begin with Baseline BMPs and then non-structural Advanced BMPs. These are generally cheaper, easier, and as discussed above, tend to address the source rather than the result of that source.

This non-structural BMP implementation diagram shows the development and implementation cycle. The key to proper implementation of BMPs is to first develop procedures and policy (as required) and then provide employees with the knowledge, skills, and abilities necessary to establish and implement these procedures. An effective training program develops these attributes.

The evaluation step of the diagram is accomplished through visual inspections and the facility sampling and monitoring program. This is a continuous process to refine, revise, or reinforce the BMP. Reinforcement is accomplished through formal and informal training.

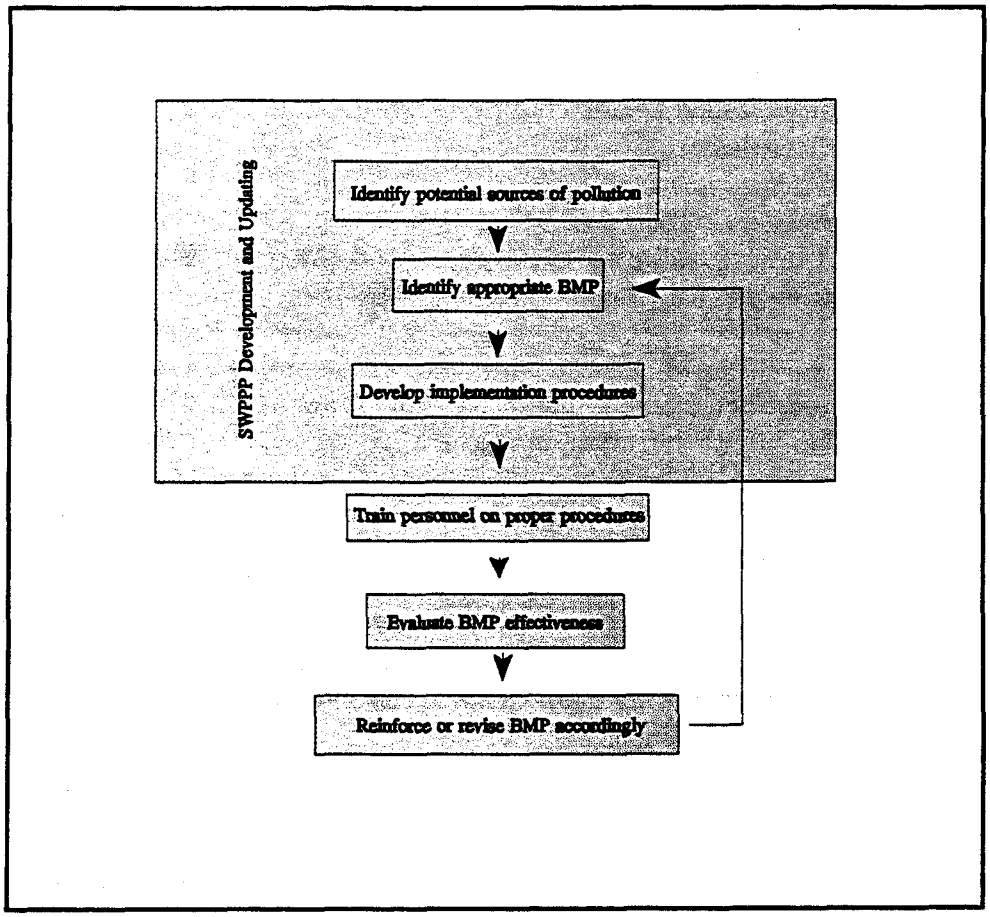


Figure 1. Implementation Diagram for non-structural BMPs.

TRAINING

The most effective storm water management programs are those that place emphasis on employee training. An effective employee training program takes BMPs from concepts, identified in the facility SWPPP, to effective pollution prevention practices. While employee training is required as a Baseline BMP for permit compliance it is also the key to implementing non-structural BMPs at a facility.

Under the US EPA General Permit and most state storm water permits, all employees require storm water training addressing their employer's storm water management program and SWPPP. This **required** training is very broad and may be loosely interpreted. To be effective, your storm water training program should address the following areas.

- Regulatory Requirements
- Permit Compliance
- The Pollution Prevention Team
- Implementation of the SWPPP
- Detailed instruction on the facility's non-structural BMPs
- An overview of the facility's structural BMPs

The training program must be tailored to the facility and use the facility SWPPP as the primary reference material. This is very important in providing the detailed instruction on the facility's BMPs. This instruction should address specific good housekeeping procedures, material handling and storage procedures, use of containment devices such as drip pans, vehicle fueling procedures, visual inspections, and all other non-structural BMPs identified in the facility SWPPP.

Training is a continuous process. This includes providing training for all newly assigned personnel, annual or semi-annual refresher training, and OJT/informal training which should occur on a daily basis. This informal training should include on-the-spot corrections, materials handling and storage procedures, and good housekeeping.

MODEL FACILITY

The Army Environmental Program is currently applying these concepts in its Storm Water Management Program. The U.S. Army operates, maintains, and manages facilities which are industrial activities. Many Army facilities which require storm water permits fall under the industrial activity for Transportation facility. This category includes maintenance shops, manufacturing facilities, and materials outdoor storage facilities. As industrial activities many of these facilities are subject to pollution prevention and storm water management requirements.

The Army Environmental Center (AEC) is leading a comprehensive effort to establish and implement effective storm water management programs at four "Model" facilities. AEC is conducting this effort in conjunction with the US Geological Survey, the US Army Construction

Engineering Research Laboratory, and Universal Systems Inc. The focus of the effort is pollution prevention at the vehicle maintenance activities. The project emphasis is employee training and education to implement effective programs. The participating facilities are an Active Army motor pool, an Army Reserve Equipment Concentration Site (ECS), and two Reserve Area Maintenance Support Activities (AMSAs).

The project team is gathering baseline information through audits and sampling to document the current quality of runoff from the facilities. After capturing the baseline data, the team will help the facility personnel implement their Storm Water Pollution Prevention Plan (SWPPP). This will include providing storm water training, and assisting in the implementation of all non-structural BMPs recommended in the SWPPP, including revising work processes to incorporate applicable BMPs.
The team will establish a comprehensive storm water management program at each facility which is integrated into existing programs such as physical security, spill prevention planning, preventive maintenance, hazardous substance handling and storage programs. Where applicable, storm water issues will be integrated into existing Standard Operating Procedures (SOPs). Training will include all aspects of establishing and maintaining an effective storm water management program as well as specific non-structural BMPs.

Vehicle maintenance is an example of an activity the project will address. The project addresses several non-structural BMPs identified in facility SWPPPs for this function. Examples include training personnel to perform maintenance indoors when possible, use drip pans, drain all fluids from wrecked vehicles, and using vehicle positioning to park leaking vehicles where they do not contaminate storm water runoff.

Each of these examples have specific procedures or policies which require training - the use of drip pans is considered simple and common place, however drip pans can create pollution if not implemented properly. Proper use of drip pans must take weather, location, and type of material into consideration. Employees must be trained to inspect drip pans and empty them properly, they need to know that they must be emptied more often during the rainy weather. Employees must also know how to dispose of the various types of materials collected in drip pans, what can be recycled, etc., while keeping the materials segregated.

Once the storm water program is established and all non-structural BMPs are implemented the project team will evaluate the effectiveness of the various actions. Evaluation will include continued monitoring and sampling, and reviews of practices and procedures. This will be documented and analyzed to develop a series of lessons learned.

CONCLUSION

Training and education are key components to an effective storm water management program. When used properly, they will not only ensure compliance with your permit, but provide non-structural BMPs which are generally more cost effective and easier to implement. The Army is using this approach effectively at several "model" facilities. The ultimate goal of the program is to evaluate the storm water program, document results, and identify lessons learned. These lessons learned will provide insight into which BMPs are effective and proper steps to implement those BMPs. AEC will share lessons learned with all Army activities with similar issues and requirements to improve their storm water management programs.

An effective storm water program will not only improve the quality of your runoff, it will also help in compliance with other regulatory requirements and with other programs. Storm water management is also helping the Army comply with RCRA, EPCRA, and various OSHA requirements.

REFERENCES:

1. U.S. EPA, Office of Water, "Environmental Impacts of Storm Water Discharges", June 1992.

2. U.S. EPA, Office of Water, "Overview of the Storm Water Program", March 1993.

3. U.S. EPA, Office of Water, "Storm Water Management For Industrial Activities, Developing Pollution Prevention Plans and Best Management Practices", September 1992.

Storm Water Training Support Package
A Key to Compliance

Paul Josephson, U.S. Army Environmental Center, Aberdeen Proving Ground, Maryland

Paul Somerville and Elizabeth Volk
Universal Systems Inc. (USI)
3675 Concorde Parkway, Chantilly, Virginia 22021, (703) 502-1391

Introduction

Employee training on the importance and implementation of storm water management is a required portion of the US Environmental Protection Agency's storm water regulations. Considered a baseline Best Management Practice, or BMP, training is an integral part of any storm water program. Recognizing this, the Army embarked upon an effort to implement storm water employee training a key part of its storm water program. The challenge the Army confronts is to effectively comply with storm water regulations and, meet storm water permit training requirements by training various audiences with their own storm water considerations. This paper describes the Army's innovative effort to successfully meet this challenge.

Background

The Army must comply with all aspects of the Clean Water Act (CWA), Resource Conservation and Recovery Act (RCRA), U.S. Environmental Protection Agency (US EPA) storm water regulations, and obtain and maintain National Pollutant Discharge Elimination System (NPDES) permits applicable to storm water discharges. Many Army activities and installations are affected by federal, state, and local regulations that require permits for storm water discharges "associated with industrial activity." (1) These permits give regulators the ability to monitor the quality of storm water discharges to U.S. waters and to establish and maintain measures and controls for storm water management (2).

As part of the Federal and individual state permit requirements, Army facilities are required to submit a Storm Water Pollution Prevention Plan (SWPPP). The SWPPP establishes responsibilities and procedures for storm water management. The plan also identifies potential sources of pollution which may affect the quality of storm water discharges associated with industrial activity from the facility. In addition to identifying these sources, it provides site specific pollution prevention measures or Best Management

Practices (BMPs) to prevent or reduce pollution of waters of the United States resulting from these sources. The SWPPP for each facility is a comprehensive document comprised of several sections; Planning and Organization, Assessment, BMP Identification, Implementation, Evaluation/monitoring, General Requirements, and Special Requirements (3).

The Army Environmental Center (AEC) spearheads the Army's storm water management program. AEC established programs to track federal and state regulations, and to develop SWPPPs specifically for permitted Army Reserve facilities.

To assist with the proper implementation of the SWPPPs, AEC contracted Universal Systems Inc. (USI) to develop a storm water Training Support Package (TSP). The TSP provides an overview of regulatory requirements, introduces the SWPPP (to include requirements, purpose, and development), and addresses BMPs. The TSP provides Army personnel with the training necessary to achieve compliance with storm water regulations, and meet the permit requirement for "employee training".

Initially, the training package was to be tailored to the Army Reserve. The Army Reserve has unique requirements because their permitted activities (predominantly transportation) are often stand alone facilities, as small as three acres. In many cases, their engineering and environmental support is several states and hundreds of miles away. The Army Reserve has maintenance activities located throughout the United States. These activates include Area Maintenance Support Activities (AMSAs), Equipment Concentration Sites (ECSs), Organizational Maintenance Shops (OMSs), Aviation Support Facilities (ASFs), and Marine AMSAs. Given the diversity of locations requiring training, range of available training facilities, and limited resources, the training package had to develop the required knowledge, skills, and abilities in the most efficient manner with minimal disruption of mission and resources.

Training Needs Analysis

The first step in the project was to conduct an analysis of the training requirements. To accomplish this, USI conducted a thorough analysis of the training needs and target audiences to ensure the TSP met the requirements mentioned above. USI conducted the Training Needs Analysis during the first phase of this project in accordance with the U.S. Army Systems Approach to Training (SAT), a version of the Instructional Systems Design (ISD) methodology. It included the analysis of training findings resulting from a comprehensive data collection effort.

The USI data collection team began this study with a thorough review of Federal and State regulatory requirements and the Army storm water management program. With this information as a foundation, USI developed a protocol to standardize the data collection effort. Using the protocol, the data collection team conducted site visits and interviews at three Army Reserve Commands (ARCOMs) and four AMSAs. The team also used this protocol to conduct telephone and mailout data collection from a representative sample of AMSAs and the majority of the ARCOMs. Upon completion of each site visit, the USI data collection team summarized their findings in a Site Visit Summary.

From the data collection, training requirements were defined and assimilated into the training needs analysis. The major requirements were; the issues of states with delegating authority to regulate storm water, the changeover to the multi-sector permit for group applicants, the different levels of knowledge required for implementing storm water management activities, and the delegation of training responsibilities considering the quantity of employees who needed training.

Currently, thirty-nine states have delegated authority from the U.S. EPA to regulate storm water. Each state is permitted to establish unique regulatory guidelines, which presented the challenge of training facility employees on state-specific storm water regulations. Another concern for training regulatory requirements was the proposed new multi-sector permit, which is still in draft form. Addressing these dynamic facets of storm water regulations became a challenge as the design of the training package proceeded.

The issues of target audience and training implementation surfaced in the needs analysis period. There were multiple groups of employees with similar, yet unique training needs. Facility managers, for example, were required to understand the implementation requirements of the SWPPP, while facility employees had to understand their role supporting in storm water management. Also, Army Reserve's marine and aviation activities had special storm water related issues to consider in implementing storm water management at their facilities. Target audiences had to be established to meet the unique training requirements of each group. Finally, the most efficient means of conducting the training had to be determined. Considering the limited resources, geographically diverse location of reserve activities, and differing work schedules, who would implement the training.

Learning objectives were established for each target audience based on these findings. The learning objectives were based upon the tasks performed by affected personnel. These objectives were integral to the development of the training materials discussed below.

Training Support Package

USI recommended an exportable training support package with the goals of providing facility employees with the necessary knowledge to comply with Federal and State storm water regulations and implementing the SWPPP for their facilities. This TSP provides all facility employees with a basic understanding of the storm water management program and their role/responsibilities.

This exportable TSP design considered the following constraints; limited resources, geographic diversity of installations and training facilities available, and diversity of audiences requiring the training. A modular approach to training design was selected to satisfy the requirements of the training and efficiently accommodate the above constraints. The TSP was developed in a series of training modules which are used as building blocks to tailor the materials to a specific target audience. The training was divided by both subject areas and target audiences. The following main subject areas, or modules, were selected; Regulatory Requirements, and Best Management Practices. These modules contain a basic core of information that is then tailored to address the specific issues of particular target audiences. The training modules are combined to create the four different courses for each of the target audiences (Facility Managers, Facility Employees, Marine AMSA personnel, Aviation Support Facility personnel).

The TSP includes a variety of tools to assist in implementating the training. Each of the items in the package adds value to the goals of the total package. The package includes training videos tailored to each target audience, a Regulatory Requirements Overview Video and a Best Management Practices Video, state-specific regulatory requirements brochures, a Trainer's Guide, and storm water awareness posters.

The training videos introduce the SWPPP, provide personnel with a common foundation of the Federal regulatory requirements, heighten awareness of sound storm water management practices, and emphasize the implementation of baseline and advanced BMPs. There are two baseline videos, which were altered to create two additional sets of videos for marine and aviation personnel.

State-specific regulatory brochures were developed to meet the requirement of training each state's storm water regulations. These brochures are included in the TSP, for facilities which are affected by states with delegated authority from the US EPA to regulate storm water. They were designed to be quick reference guides to supply facility managers with a summary of the current state regulatory considerations, and the name and phone number of the state point of contact. Paper-based brochures are also easily and inexpensively updated to keep up with the dynamic state storm water programs.

The Trainer's Guide was designed to be very straightforward for ease of implementation. The Guide includes training management materials, course lesson outlines, administrative instructions, and helpful hints to assist the trainer in conducting the training. The course lesson outlines are designed so the trainer can tailor the class discussion to an individual facility using the facility SWPPP as the primary reference material. The guide also includes administrative documentation materials so that the facility managers can record all training conducted and verify all employees regularly receive the required training.

The storm water awareness posters were developed to provide facility employees with a visual reminder of typical storm water issues. The posters were designed to reinforce key learning points from the training.

In order to receive the maximum benefit of developing a situation specific training package, and to accomplish one of the permit requirements, the Training Support Package was intentionally designed to meet the baseline Best Management Practice of "employee training". While the training meets current training requirements under the existing USEPA general permit, it will also meet requirements for facilities covered under the proposed Federal Multi Sector permit. In anticipation of the upcoming changes associated with the implementation of the Multi Sector permit, the package was designed using the training requirements set forth in the draft permit. For example, in Sector 18, Water Transportation facilities, which Marine AMSAs would fall under, some of the specific training items delineated in the permit are:

- material management practices
- used oil management
- spent solvent management
- proper disposal of spent abrasives
- proper disposal of vessel wastewaters
- spill prevention and control, and
- fueling procedures.

The training items were addressed in the marine training package. The training also meets most State permit requirements.

Training Implementation

Given the geographic diversity of the Army Reserve facilities, the limited resources available to conduct the training and considering minimal disruption to facility activities, the training implementation was planned in a series of steps. Training responsibilities were divided among ARCOM Environmental Managers and AMSA Facility Managers (shop foremen), with the intention of distributing the training workload. ARCOM Environmental Managers, responsible for anywhere from 10 - 40 reserve facilities, are responsible for training all facility managers. Ideally this training is conducted in a single group session. The Facility Managers are then delegated responsibility to take the TSP and train their respective employees, including facility tenants.

ARCOM Environmental Managers were trained at focused storm water training sessions in the Spring of 1994. In these sessions, they were given the opportunity to learn the details of the storm water program and understand the implications of the NPDES permit process. This training provided the Environmental Coordinators with the foundation to implement a storm water program for their ARCOM. The Environmental Managers are in the process of implementing the storm water management programs at each permitted facility, to include storm water training.

Expansion

The package is currently being modified for the Active Army. The Active Army has its own unique issues to consider in the implementation of a storm water program. By taking the lessons learned from the development of the reserve package and modifying the package to meet the specific needs of the regular Army, this package will continue to meet the storm water training requirements established by federal and state regulators, and will maintain the Army's efforts to comply with storm water regulations.

Conclusion

Employee training, a baseline BMP that is required by the storm water permit, is the key to permit compliance. By considering multiple issues, including both those that were regulatory related and training/administrative related, and incorporating methods to solve those issues into the training support package, the training package more than adequately satisfies permit training requirements.

References

1. Final NPDES General Permits For Storm Water Discharges Associated With Industrial Activity; Permit Language, 9 September 1992.

2. Overview of the Storm Water Program, U.S. Environmental Protection Agency, March 1993.

3. Storm Water Management for Industrial Activities; Developing Pollution Prevention Plans and Best Management Practices, U.S. Environmental Protection Agency, September 1992.

Storm Water Pollution Prevention

Johnny D. Combs
AFCEE/CCR-D
525 Griffin Street, Suite 505
Dallas, Texas 75202-5023

Polluted storm water runoff has become a major source of degradation for water quality in the U.S. In 1992, only 56% of our waters could meet this requirement, a result due primarily to pollutant loading from agriculture, industrial and municipal runoff. The goal of the 1972 Clean Water Act (CWA) was to make the waters of the United States "Fishable, Drinkable, and Swimmable." After twenty years of trying, why are we still barely halfway to the goal? To investigate this further, we need to first look at the pollutants and their sources.

The five leading causes of water quality impairment were:

Rank	*Rivers*	*Lakes*	*Estuaries*
1	Siltation	Metals	Nutrients
2	Nutrients	Nutrients	Pathogens
3	Pathogens	Organic Enrichment/Low DO	Organic Enrichment/Low DO
4	Pesticides	Siltation	Siltation
5	Organic Enrichment/Low DO	Priority Organic Chemicals	Suspended Solids

The most prevalent pollutants impacting our waters were defined as:

Nutrients - includes nitrates found in sewage and fertilizers as well as phosphates found in detergents and fertilizers.

Siltation - from agriculture, construction and mining operations which enter the waterways impairing fish respiration and plant production, reducing water depth and smothering benthic aquatic life and plants.

Organic Material - may come from sewage, detritus material (grass and leaves), or runoff from pastures and feedlots.

The most common sources of these pollutants based on the 1992 State Section 305(b) reports are:

Rank	*Rivers*	*Lakes*	*Estuaries*
1	Agriculture	Agriculture	Municipal Point Sources
2	Municipal Point Sources	Urban Runoff/Storm Sewers	Urban Runoff/Storm Sewers
3	Urban Runoff/Storm Sewers	Hydrologic/Habitat Modification	Agriculture
4	Resource Extraction	Municipal Point Sources	Industrial Point Sources
5	Industrial Point Sources	Onsite Wastewater Disposal	Resource Extraction

Agriculture - includes crop production, pastures, rangeland, feedlot and other animal holding areas.

Urban Runoff/Storm Sewers - includes runoff from paved areas, buildings, light industry and commercial facilities that enter the storm sewer before discharging to the surface waters.

Municipal Point Sources - include publicly or federally owned sewage treatment plants that receive indirect or direct discharges from industry and municipalities.

Industrial Point Sources - from facilities that have discharges associated with industrial activity.

Resource Extraction - runoff from mining operations, mine tailings, and petroleum drilling operations.

Hydrologic/Habitat Modification - results from dredging, dam construction, channeling, grazing, and farming.

The sources and pollutants may be varied but the results are the same; polluting our waters reduces the quality for everyone. To combat this problem the EPA and the states have initiated the National Pollution Discharge Elimination System (NPDES) and issued the first storm water permit guidance in 1992 which required facilities to utilize pollution prevention planning to reduce and eliminate sources of storm water pollution to the waters of the U.S.

The essence of pollution prevention can be summed up in the following phrases; "Don't use hazardous materials. If you do use hazardous materials, use the minimum amount possible. Make sure the minimum amount you use does not release to the land, water, or air." These phrases summarizes the requirements of the storm water permit that requires facilities to prepare a Storm Water Pollution Prevention Plan, determine the sources of pollution, identify current management practices, and recommended Best Management Practices (BMPs) to ensure that pollutants do not reach the storm water.

As shown by the tables above, the most common sources of pollution are not large volumes of toxic and hazardous chemicals but excess fertilizer, sediment and sewage discharges. These also primarily come from agriculture, cities, and non-point storm water runoff. The apparent success of major industry to control pollution is due in part to intensive regulatory attention and the awareness and emphasis placed on pollution prevention. The importance of properly managing materials that are hazardous or toxic and pose a threat to health, safety or the environment is now clearly understood in business today.

A more challenging problem for agriculture, municipalities, commercial and industrial facilities is when the pollutant sources are more common and come from less threatening sources such as excess fertilizer on our lawns, silt from eroding creek banks, or excess nutrient loading from sewage treatment effluent. The same people who have been extensively trained to respond to hazardous materials spills and releases will drive by an eroding creek bank, and watch excess fertilizer runs off their lawn without even concern. Our culture must change to accept that silt can kill fish in the creek just as certainly as any toxic chemical spill.

EPA and the states are moving toward a local watershed approach for setting and enforcing compliance standards, due to the variability and complexity of each watershed. EPA has also commented that pollution prevention is and always has been a compliance issue based on the certification on hazardous waste manifests "I certify that I have a program in place to reduce the volume and toxicity of waste generated..." This fact is made clear in the storm water permit guidance where those responsible for pollution can be fined and penalized $250,000/day and given 15 years in prison for a significant violation of the CWA. This make pollution prevention not only the right thing to do, but heavy compliance penalties could be the result of failure to prevent pollution.

So where do we begin, and how do we achieve the lofty goal of the CWA to make our waters "Fishable, Swimmable, and Drinkable?" We start with education, planning, and execution.

Education:

Education and training are the cornerstones for a good pollution prevention program. This may seem simplistic, but we are looking for a cultural change in our people that any discharge of pollutants to our waters are unacceptable. To get people to think about how much fertilizer they put on their yard, and to be concerned when the streets are full of mud from construction activity. Without an increased awareness from the public at large, improving the quality of our water will not be achievable. Effective education is being accomplished in our schools, as our children are taught that protecting the environment is necessary to life and not an additional duty. For facilities, effective training should educate the trainees on the potential sources of pollution and also give practical suggestions to prevent pollution.

Planning:

Effective planning means that you think about the potential sources of pollution at your facility, the possible pathways through which pollution could be released, and how you can prevent that from happening. Some examples follow.

Hazardous materials exposed to storm water are potential sources of storm water pollution but are not regulated under the Resources Conservation and Recovery Act (RCRA). Under the storm water permit, sources of significant materials exposed must be identified and a Best Management Practice put in place to control pollution from the source. Facilities should now treat outside hazardous material storage as if it were a hazardous waste facility and provide run-on/run-off protection. This usually means that a concrete slab with a curb, and a metal roof to keep the rain off should be employed. Another reason to implement the Pharmacy (single point supply and disbursement of hazardous materials) Concept of hazardous material management is to reduce the total quantity needed so that outside storage of hazardous materials is not required.

Sediment and erosion are not commonly thought of as pollutants but as shown by the 1992 states results, they are a major source of storm water pollution. Lining the bottom part of drainage swales with a narrow width of reinforced concrete can prevent scouring and erosion of soil. Constructing rock dams with varying sizes of rocks to filter the storm water runoff and reduce the sediment loading can be built where there is major erosion present. These structures are more permanent, more aesthetically pleasing, and require less maintenance than the silt fences or hay bales. For the most effective control of sediment, a combination of the rock dam, followed by a silt fence combined with hay bales can be used to capture even finer silts and sediments. Silt fences and hay bales are temporary structures and will require continual maintenance and replacement to work effectively.

Oil water separators (OWSs) are another concern for industrial facilities since many of these were constructed during the 1950's to 1960's when discharging to the surface water was acceptable. Many of these are not regularly inspected or the actual point of discharge known. The accuracy of as-builts indicating where these devices discharge is the first place to start. However, actual inspection and testing should be done to confirm that these devices do not discharge to the storm sewer system. Another concern for OWSs is their use on discharges from large parking lots or ramps. The problems arise from the usually sudden and large volume of water that will discharge to the OWS during a storm event. These large flows tend to nullify the effect of the OWS and to allow any oil or fuel that would be captured to pass through the OWS due to the turbulence caused from the large sudden flow. An alternative might be a combination system that allows the OWS to catch the "first flush" from the area which likely has most of the pollutants and then divert the majority of the flow to the surface allowing it to infiltrate or spread out. This OWS must be connected to the sanitary sewer system where the effluent can receive proper treatment.

Another area of concern for airports and especially in northern states is deicing fluid used on aircraft, runways, runways and vehicles. These glycol based chemicals increase the Biological Oxygen Demand (BOD) loading on the receiving waters degrading water quality. Containment of all liquid discharges is normally not feasible and other management means must be considered. The first is to think of deicing fluid as a hazardous material. The amount of deicing fluid should be kept to the minimum amount necessary. At airports, this means reducing the size of the deicing nozzle to a size appropriate to treat the aircraft but small enough to prevent excessive overspray.

Any large quantities of deicing fluid left on the ramp should be recovered for reuse if possible or for treatment. This will minimize the chances for a "dry weather" discharge of deicing fluid, allowing deicing fluid to reach the surface water without help from precipitation, which is forbidden in the storm water permit. Another method of minimizing deicing fluid use is to not use it all. Many times, especially in southern states, the ice storms are short lived and waiting 2-3 hours following the storm will allow the ice to thaw and the aircraft or vehicle to be used safely without applying deicing fluid.

Surveying the storm sewer system for cross connections is a potential significant source of pollution that must be identified. Before hiring a contractor to send a video camera through your storm drains, consider a dry weather inspection of your storm drains. Simply open your storm drain manholes during a time when their has not been any rainfall for one week or more. If there is a discharge, follow this discharge until you find the source which may involve running water through floor drains or reviewing the as-builts for a facility to determine the source. Many times condensate drains, floor drains, shop sinks, or even additional bathrooms were purposely or mistakenly connected to the storm sewer. These can significantly degrade water quality in the receiving waters and may have gone unnoticed for years. A visual inspection or simply dye testing will identify the majority of cross connections which must be eliminated to comply with the storm water permit.

Execution:

The execution of the storm water pollution prevention program starts with the realization that the storm water is a self implementing program. The requirements that you specify in your Storm Water Pollution Prevention Plan, will be the yardstick that the regulator will use to measure your performance by. Be certain that all the elements of the plan are achievable, are consistent with the facility goals, and make good sense. Once the plan is written a process of inspections, sampling and project execution begins without waiting for a visit from a regulator to remind you. Make sure that management has bought into the plan and that someone is assigned primary responsibility for implementing the plan.

Summary:

The measure of success should be how you change the culture of the people at your facility to accept pollution prevention as a necessary part of life. Then we will improve the chances of meeting the goal of the CWA of having waters that are "Fishable, Swimmable, and Drinkable."

SESSION X

POLLUTION PREVENTION INITIATIVES INFORMATION EXCHANGE

<u>Session Chairpersons</u>:
Jack Silvey, Dynamac Corporation
Linda Bassham, TECHCONNECT

THE POLLUTION PREVENTION PARTNERSHIP
A COLORADO VOLUNTARY PRIVATE/PUBLIC INITIATIVE

Paul Ferraro, P.E., Vice President
Geraghty & Miller, Inc., Environmental Services
1099 18th Street, Suite 2950
Denver, CO 80202
Tel: (303) 391-8791

INTRODUCTION

The Pollution Prevention Partnership was not formed using an existing or theoretical model of public/private cooperation. On the contrary, it evolved over a two year period that started with discussions between two individuals concerning a difficulty in a public/private working relationship. The discussions soon expanded to several individuals meeting on a regular basis, then to informal breakfast meetings with representatives from industry, U. S. Environmental Protection Agency, Region VIII (USEPA) and the Colorado Department of Health (CDH). From the beginning the group has sought practical and measurable approaches to pollution prevention. Eventually other organizations representing the public interest joined the discussions. The League of Women Voter's of Colorado and the Colorado Public Interest Research Group (CoPIRG), an environmental research and promotion organization, now are actively involved in the Partnership. This "breakfast club", focused on shared concerns and clearly defined goals, finally formed the Pollution Prevention Partnership

PURPOSE AND GOALS

The Colorado Pollution Prevention Partnership is a non-profit, voluntary alliance of government, business, and public interest groups organized to develop and promote pollution prevention and waste minimization in Colorado industries.

The Partnership includes senior management representatives from the USEPA and CDH; industry representatives from Martin Marietta, Coors, Hewlett Packard, Public Service Company of Colorado (PSCO), AT&T, and Kodak; public interest representation from Colorado League of Women Voters and Colorado Public Interest Research Group (CoPIRG); and Geraghty & Miller, environmental consultants.

The goals of the Partnership are clear:

- Strengthen the working relationship between private and public sectors.
- Improve capabilities for anticipating and avoiding environmental problems.
- Pool resources and focus staff attention on the goal of pollution prevention.
- Exchange information and expertise, and help transfer it to medium and small companies and the general public.

ORGANIZATIONAL STRUCTURE

The Partnership is organized exclusively for charitable, educational, and scientific purposes under Section 501 c(3) of the U.S. Federal Internal Revenue Service Code. It consists of a Board of Directors, an Advisory Committee and a SolvNet Committee. The Board of Directors manages the affairs of the Corporation and presently consists of four members. Originally, the founders wanted all members to serve on the Board of Directors, but lawyers for the public entities indicated a possible conflict of interest. The League of Women Voters of Colorado was the only public entity that joined industry on the Board of Directors. The Advisory Committee, appointed by the Board of Directors, guides the Board's decisions through advice and recommendations. The Advisory Committee has eleven representatives. The SolvNet committee has representatives from the groups represented on the Board and Advisory Committee. It implements the Partnership's goal in pollution prevention. Other committees are formed as needed.

PPP activities are funded through corporate donations. As a non-profit entity the Partnership also qualifies for some grants through USEPA and other environmental concerns. Member companies agree to commit to the goals of PPP, to accountability in reaching those goals, and to share in Partnership expenses in an equitable manner. Currently, PPP has a budget of approximately $65,000 of in kind donations from member companies and approximately $30,000 in actual expenditures. Companies typically donate $5,000 annually to pay for project costs.

The Partnership membership list remains relatively small in order to facilitate a flexible, result oriented approach to problems rather than a rigid, bureaucratic approach. However, prevention programs are not limited to member companies. The Partnership maintains an active outreach and mentoring program for small and medium size companies. In this way the Partnership addresses both large and small prevention and waste minimization problems.

PRACTICAL SOLUTIONS AND MEASURABLE SUCCESS

In the SolvNet I project, four original member companies committed to significantly reducing use of 1,1,1- trichloroethane (TCA). TCA is widely used in industry as a solvent to clean products and metal surfaces before further processing. It is also a major ozone-depleting chemical. Companies in the SolvNet I group wanted to cut their combined TCA use 70% by December 1991. They used 1988 as their base year. The pollution prevention measures used were: (1) Process modification - eliminating the need for TCA, (2) Chemical substitution - finding safe alternativesm abd (3) Revised operating practices - reducing use at the source through education and management practices.

Colorado Public Interest Research Group analyzed TCA use and emissions for the base year, 1988 and for 1991. The PPP companies provided data from SARA Title III Right to Know reports on a questionnaire. As part of their responsibilities to the Partnership, CoPIRG provided SolvNet results during the fall of 1992. The four companies reduced annual use of TCA by a combined total of 1,128,100 pounds, representing a 90% reduction from 1988.

GETTING THE WORD OUT ABOUT POLLUTION PREVENTION

Word is spreading about the Pollution Prevention Partnership. Its commitment and results spark interest from public and private organizations. By anticipating and avoiding environmental problems, achieving measurable reductions in pollution through prevention and sharing information and technology, PPP wants to make pollution prevention the new industry standard. To keep spreading the word, the Partnership developed a Technical Assistance Program.

Business helping business is generally recognized as a very effective way to facilitate technology transfer of pollution prevention strategies. So far, the Partnership's Technical Assistance Program has completed several exchanges. A CEO luncheon introduced PPP to the industrial community. Dr. Harry Edwards of the Waste Minimization Assessment Center, Colorado State University, completed two on-site waste assessments at local companies. Next, member companies gathered for a technical interchange regarding solvents. Coors and Martin Marietta sponsored workshops to exchange other technical information. Also, PSCO included pollution prevention information in two mailings to business and residential customers. In addition, PPP sponsored several workshops with the Colorado Department of Health. Many people also heard of the Partnerships efforts through a slide presentation given at national conferences and meetings including: Eco World '92 in Washington, DC, Federal Restorations Programs 1992 Annual Conference in Washington, D.C. and the Hazardous Materials Control Annual Conference in Washington, DC. The Greater Denver Chamber of Commerce in 1993 awarded the Pollution Prevention Partnership a "Milestone Award" citing the Partnership's "significant contribution through its creation of a voluntary initiative to reduce environmental pollution."

SOLVNET II

Building on the successes of SolvNet I, PPP is looking ahead to more hazardous waste reduction through voluntary prevention in SolvNet II. Since each member company uses different hazardous materials, reduction goals needed to be customized. In SolvNet II each company chose chemicals to reduce over the next 3 to 5 years. They will reduce emissions or use by one-quarter to two-thirds through pollution prevention measures

SolvNet II member companies submitted reduction plans to the PPP Advisory Committee, and all have begun implementing their plans.

SolvNet II companies also plan to continue helping smaller companies implement pollution prevention. The member companies would like to "mentor" companies with similar processes through short, process specific, discussion meetings. SolvNet II also includes a study of 300 smaller companies to gather information concerning their pollution prevention needs and resources.

In keeping with the business to business mentorship philosophy, the Partnership has again hired the Colorado State University Waste Minimization Assessment Center to conduct four on-site assessments of small businesses and then develop a waste minimization plan for each firm. The businesses are extremely diverse, ranging from screen-printing to chromium plating and various auto repair services. The Partnership will then sponsor workshops for similar and related industries to share the findings. This method allows many small businesses facing similar waste problems to receive sound technical advise without the high cost of individual assessment.

RESULTS OF A STUDY OF POLLUTION PREVENTION PRACTICES AND ATTITUDES

This study investigated the pollution prevention practices and attitudes of Colorado's smaller businesses. The study attempts to answer several broad questions:

- **How well do Colorado's small and medium-sized businesses understand pollution prevention?**
- **What pollution-reducing behaviors are Colorado's smaller businesses currently practicing?**
- **Where do Colorado's small and medium-sized businesses go for the information they need?**
- **What barriers prevent smaller businesses from engaging in pollution prevention?**
- **What incentives would motivate small businesses to increase their pollution prevention efforts?**

To answer these general questions, the Partnership contracted with the CSU Center for Research on Writing and Communication Technology to do a random phone survey of 300 small and medium-sized businesses across Colorado. For the purposes of this study, "small and medium-sized businesses" are defined as having fewer than 500 employees.

The sample consisted of businesses from the following 14 industries:

Furniture manufacturing
Printing and publishing
Rubber and plastic manufacturing
Fabricated metal manufacturing
Electrical machinery manufacturing
Instrument manufacturing
Dry Cleaning
Pulp and paper manufacturing
Chemical manufacturing
Primary metal manufacturing
Machinery manufacturing
Transportation manufacturing
Photo finishing
Auto maintenance and repair

The results of the study provided some interesting answers to the Partnership's research questions.

- **How well do Colorado's small and medium-sized businesses understand pollution prevention?**

  Businesses generally comprehended what pollution prevention means. Most of the respondents knew the term, and could choose a definition that fit well with the EPA definition.

Further, many respondents provided detailed and accurate definitions of pollution prevention. However, it should also be noted that a large minority of businesses were confused about pollution prevention.

- **What pollution-reducing behaviors are Colorado's businesses currently practicing?**

  It is clear that the businesses surveyed have actively implemented pollution-reducing practices in the past year. They have engaged in a number of pollution-reducing activities, ranging from chemical substitutions to construction of new production facilities. The most common action appears to be the use of alternative solvents.

- **Where do Colorado's small and medium-sized businesses go for the information they need?**

  When given a choice, businesses contacted sources which they perceived to be particularly knowledgeable. Suppliers, other businesses and printed materials are the most frequent sources of information. When respondents were asked to compare workshops, newsletters, magazines, and site visits, they rated them all as being equally useful. Businesses indicated that they did not like information clearinghouses.

- **What barriers prevent smaller businesses from engaging in pollution prevention?**

  Businesses spoke of several barriers to the widespread use of pollution prevention. First was the perceived cost of pollution prevention. Although most of the businesses sampled felt that prevention was cheaper than waste storage or treatment, many of them noted that prevention would only save them in the long term. A second and more serious barrier was the antagonistic relationship that the companies perceived to exist between small business and the government. Survey takers noted very strong, negative attitudes toward the government in response to this survey question.

- **What incentives would motivate smaller businesses to increase their pollution prevention efforts?**

  The most frequently mentioned pollution prevention incentives were "intrinsic motivations." Essentially, these are motivations that have nothing to do with tangible rewards or outcomes. They are largely moral or ethical motives. The second most frequently mentioned incentive was government support. Respondents were very interested in having the government subsidize their prevention efforts. Business contacts mentioned grants, loans, and tax credits as ways the government could help reduce the cost burden.

  The third most frequently mentioned incentive was maintaining profitability. The responding businesses indicated a desire for the government to help them bear the costs of initiating prevention measures. Surveyed businesses also wanted to be sure that pollution prevention would pay for itself, have a demonstrable effect on the environment, or improve employee health.

Based on conclusions drawn from the study, the following actions are recommended for the Partnership to support pollution prevention in small and medium-sized businesses.

- Work with the preferred information sources identified in the study. Determine the industries with the most pollution prevention expertise and work with the suppliers, consultants, trade associations and publications in those industries.
- Provide formal and informal opportunities for companies in the same industry to exchange pollution prevention information. Programs could include both interaction with large, cutting-edge companies in an industry and with "peer" companies.
- Publicly honor companies that have made strides in reducing pollution. Encourage both the public and government to recognize the pollution prevention efforts of small and medium-size businesses.
- Promote cooperative relationships between government agencies and small businesses. As a possible means of overcoming the small businesses' distrust and antagonism towards government, examples of government and business cooperation must be shown and publicized to the small businesses community.
- Work with government agencies to recommend specific government monetary incentives for pollution prevention in small businesses. These monetary incentives could be grants to help defray the cost of installing new equipment and processes, matching funds for research into cleaner technologies, and tax incentives.
- Do not create an information clearinghouse.

CONCLUSIONS

The Partnership members are pleased to have formed the first Colorado pollution prevention public/private partnership. They hope their experience and successes will provide models and impetus for other cooperative efforts. Anyone interested in learning more about the Pollution Prevention Partnership is encouraged to contact any of its members or the secretary, Paul Ferraro at (303) 294-1200, Pollution Prevention Partnership, 1099 18th Street, Suite 2100, Denver, Colorado, 80202

ACKNOWLEDGEMENTS

The author wishes to acknowledge Pollution Prevention Partnership members and assistants for contributing material for this paper.

Title: **PRO-ACT: A United States Air Force Environmental Resource**

Presenter: James E. Lanoue Jr.
PRO-ACT (Dynamac)
HQ AFCEE/EP
8106 Chennault Road
Building 1161
Brooks AFB, TX 78235-5318

DSN 240-4214
Commercial (210) 536-4214

Subject: The Air Force's PRO-ACT service-- its capabilities, resources and benefits for Air Force customers.

Presenter Bio: James Lanoue, Jr., is currently working as a technical research specialist for PRO-ACT. Mr. Lanoue has been working as a PRO-ACT researcher since 1993 and is part of Dynamac's 11 person technical team who manages and operates the PRO-ACT program for the Air Force Center for Environmental Excellence.

Introduction

PRO-ACT is the Air Force's environmental clearinghouse and research service. This presentation will define the driving forces behind PRO-ACT, the services available to Air Force members and the benefits of those services. Examples and statistics of the volume of work PRO-ACT has accomplished since its inception and information on how PRO-ACT services can be accessed are available at the PRO-ACT display in the exhibit area.

PRO-ACT offers a broad range of services which are free of charge to all Air Force, Air National Guard, and Air Force Reserve personnel. PRO-ACT is funded to provide up to 40 hours of free research for any single question. A requestor is not limited to the number of questions that may be asked. Projects which exceed the 40 hour allocation will be accepted on a case-by-case task order basis and at the requestor's expense.

PRO-ACT... Behind the Scenes

The Air Force is recognized for its ongoing commitment to the cutting edge of pollution prevention initiatives and technology. The Air Force is known within the Federal government for its environmental leadership: it is proactive in environmental compliance, aggressive in its pursuit of pollution prevention solutions, and is a Federal leader in land stewardship and environmental planning. The word **proactive** fuels many Air Force environmental initiatives, the PRO-ACT program, quite obviously, was one of those campaigns.

Approximately two years ago, the Pollution Prevention Directorate within the Air Force Center for Environmental Excellence, recognized the need to provide assistance to Air Force personnel in meeting complicated environmental compliance guidelines and Air Force pollution prevention goals. PRO-ACT was established to provide this assistance. Dynamac Corporation was awarded the contract to manage and operate PRO-ACT.

PRO-ACT is staffed by professionals who have a full understanding of environmental and Air Force regulations-- at the breadth and level necessary to locate alternative sources of information and provide complete and correct responses. PRO-ACT researchers keep up with the latest environmental issues and regulations affecting Air Force installations and properties. To maintain currency, PRO-ACT researchers continuously draw on the resources of management and operating contacts at various Air Force locations, other federal and DoD agencies, the U.S. EPA, state agencies, national R&D laboratories and industry.

<u>PRO-ACT Services</u>

PRO-ACT responds to requests for many kinds of information, including: regulatory compliance support and regulatory interpretation; requests for pollution prevention support to include: product substitutions, source reduction, recycling, reuse, reclamation, waste minimization options, and new technologies. Within the research hours assigned to a request, PRO-ACT may produce regulatory alerts and updates, fact sheets, or detailed data listings. Other requests may call for bibliographic assistance, database and literature searches, or lessons-learned reports.

In addition, PRO-ACT prepares and distributes a bimonthly information sheet (CrossTalk) devoted to pollution prevention and environmental compliance information. Quarterly, PRO-ACT mails an information crossfeed package to approximately 1000 Air Force environmental points of contact.

PRO-ACT provides copies of all technical inquiries, fact sheets, success stories and CrossTalk to the Defense Environmental Network and Information Exchange (DENIX) for uploading to the PRO-ACT bulletin board. These are available for downloading via modem. We also publish a list of all technical inquiries on DENIX. This list is available from PRO-ACT and is also distributed with the quarterly PRO-ACT mailing.

PRO-ACT's busiest service is responding to Technical Inquiries. Technical Inquiries (TIs) are environmental questions received from an authorized user. Questions usually pertain to pollution prevention, compliance, waste minimization, recycling, materials management, natural resources, source reduction, technology transfer, training or education, and treatment and disposal requirements. PRO-ACT researchers provide quick responses to multiple and simultaneous inquiries. All PRO-ACT answers are provided both in verbal and written format-- a verbal response within five working days and a written response within 14 calendar days of the request.

PRO-ACT also develops fact sheets and pollution prevention success stories to disseminate current information to Air Force installations. Fact sheets are usually developed in response to a technical inquiry, which, upon review, is determined to have information that will be beneficial to more than one Air Force installation.

In addition to fact sheets and day-to-day technical information crossfeed efforts, PRO-ACT specialists are continually on the "look-out" for Air Force Pollution Prevention Success Stories. These Success Stories highlight and circulate innovative pollution prevention actions or strategies which result in significant waste/source reduction, energy-savings, cost-savings and/or increased revenues.

PRO-ACT specialists also review various technical documents such as Installation Restoration Program (IRP) materials, Environmental Assessments, closure plans, permit applications, spill plans, waste minimization plans, and pollution prevention plans. Our review focuses on technical accuracy and comprehensiveness and is accompanied by a written response containing our recommendations.

PRO-ACT specialists assist requestors with military specifications, technical order and material safety data sheet reviews to ensure nonhazardous materials are substituted for hazardous materials wherever possible. For example, PRO-ACT recently identified several "environmentally friendly" alternative products for various applications with emphasis on ozone depleting substances and the EPA-17 priority chemicals. PRO-ACT specialists coordinate all such work with the Item Manager, System Program Office, System Engineers, and/or Equipment Specialists to identify recently approved products. At no time does PRO-ACT recommend a product for use under a technical order and/or military specification that is not approved or has not been coordinated through the equipment technical experts.

PRO-ACT's Primary Resource Centers

PRO-ACT utilizes numerous resources to research your questions including:

- HQ AFCEE: PRO-ACT frequently consults HQ AFCEE technical personnel. Areas of expertise include: construction management; design group; environmental planning and conservation; environmental restoration; legal; public affairs; contract support; and pollution prevention.

- Major Commands: PRO-ACT researchers routinely coordinate with each MAJCOM, as appropriate, to determine their policies. MAJCOM requirements are typically included in the written responses to technical inquiries while maintaining caller anonymity.

- HQ Air Force Civil Engineering Support Agency (HQ AFCESA): PRO-ACT consults with the research, development and acquisition, fire protection, construction cost management, maintenance, systems engineering, communications-computer systems, and readiness sections of AFCESA.

- Armstrong Laboratory: PRO-ACT coordinates with various technical experts at the Air Force's Armstrong Laboratory. PRO-ACT maintains continuous contact with the laboratory's services such as; occupational medicine, and bioenvironmental engineering (on issues regarding toxicity, air and water quality, hazardous waste analytical techniques, and hazardous materials).

- USAF School of Aerospace Medicine (USAFSAM): PRO-ACT works with USAFSAM concerning training requirements and available courses. Technical coordination with the USAFSAM staff frequently is required to adequately address training inquiries.

- Headquarters Defense Reutilization and Marketing Service (HQ DRMS): PRO-ACT researchers maintain close contact with HQ DRMS regarding environmental policies and procedures, demilitarization requirements, and disposal options.

- General Services Administration (GSA): PRO-ACT coordinates with GSA Commodity Centers around the country to obtain National Stock Numbers (NSN) and information on environmentally friendly products.

- Environmental Protection Agency (EPA): PRO-ACT maintains an open dialogue with EPA (HQ and Regional) contacts concerning current and upcoming regulatory issues to determine intent and effect on Air Force installations and properties. PRO-ACT also coordinates with EPA points of contact regarding proposed rules in order to clarify applicability, assess impact, and possibly provide comments. PRO-ACT researchers often request information regarding applicability of federal regulations to a given issue.

- State Environmental Agencies: PRO-ACT coordinates with each state to determine whether there are any additional state requirements that must be addressed in answering your question. Many, including California, New Jersey, Alaska, and Minnesota have more stringent requirements than the U.S. EPA.

- Trade and Professional Organizations: PRO-ACT specialists have established contacts within the civilian sector to identify new approaches or technologies which may be applicable to Air Force issues and problems. Over time, PRO-ACT has developed working relationships with numerous organizations including the Electronic Industries Association, Lead Industries Association, National Rifle Association, Independent Battery Manufacturing Association, Chemical Manufacturing Association, National Fire Protection Association, and many others.

How to Access PRO-ACT

Finally, PRO-ACT may be accessed in numerous ways. PRO-ACT researchers are accessible via telephone, mail, fax, WANG and Internet e-mail through DENIX.

It Pays to Use PRO-ACT

The services provided by PRO-ACT are of great benefit to the Air Force. They effectively augment your staff and save you time which is your most valuable commodity. You can concentrate on other issues comfortable in the knowledge that a PRO-ACT researcher is handling your request.

SESSION XI

EDUCATION & TRAINING

Session Chairpersons:

Captain Dave Maharrey, HQ USAF/CEV
Kevin Palmer, SAIC

ENVIRONMENTAL SHORT COURSES AT THE USAF SCHOOL OF AEROSPACE MEDICINE

Major Richard McCoy
Chief, Environmental Protection Division
Department of Bioenvironmental Engineering
USAF School of Aerospace Medicine
2513 Kennedy Circle
Brooks Air Force Base, Texas 78235-5123
(210) 536-3831

Our society's emphasis on environmental awareness, Congressional action, and Presidential Executive Orders have brought a raft of new duties to Air Force personnel in all specialities. As a result, the need for quality training in the environmental sciences has become almost painfully obvious. Your best source for some of the training you need may not seem intuitively obvious to you - may I recommend the Human Systems Center's USAF School of Aerospace Medicine (USAFSAM) at Brooks Air Force Base.

The USAF School of Aerospace Medicine's place in environmental training has grown from a tradition of environmental involvement more than 50 years old. The United States Air Force Medical Service has been intimately involved with environmental issues since the formation of the Air Force as a separate service. The Bioenvironmental Engineer (BEE) and his forerunner the Sanitary Engineer have been the focal point for environmental matters within the Medical Service. Until the passage of the National Environmental Policy Act (NEPA), environmental issues were, for the most part, centered on those matters which directly impacted the public health - prime examples being potable water production and distribution, and the disposal of domestic waste. The BEE's responsibility was the monitoring of these programs to ensure the protection of the public health. This monitoring included sampling and analysis, the interpretation of data, and the technical evaluation of equipment and facilities. The education and training in environmental sciences these engineers required was, and still is, provided by USAFSAM.

USAFSAM's role in environmental training is changing and expanding to help meet the Air Force's obligations to environmental challenges in modern society. Environmental training at the School is no longer for BEEs only - in fact while we still offer a wide range of environmental training specifically for BEEs, the BEE community is not the preferred audience for some of our most recent course offerings. The Secretary of the Air Force has directed the Air Force Surgeon General take the initiative to make all Air Force personnel more aware of and more familiar with the environmental standards of their jobs, in order to comply with them on a daily basis. To implement the initiative, USAFSAM has been charged with developing a series of environmental training courses to further educate Air Force personnel whose day-to-day duties are in the environmental arena. Some of these new courses are open to people of all Air Force Specialty Codes with environmental duties as well as members of our sister services and other federal agencies with similar duties and training needs. These courses are developed and presented by USAFSAM under a Memorandum of Understanding (MOU) between USAFSAM and The Air Force Institute of Technology (AFIT), Armstrong Laboratory, and other agreements with The Community College of the Air Force, The University of Texas, and other environmental agencies.

The USAF School of Aerospace Medicine and AFIT's School of Civil Engineering are the only two Air Force Schools recognized as providers of environmental education by the Interservice Environmental Education Review Board (ISERB). This board, which provides DoD level oversight of environmental education and training, grew out of the Interservice Training Review Organization (ITRO), and includes representatives of the US Army, Navy, Air Force, Marines, Defense Logistics Agency, and the Coast Guard. USAFSAM's charter is to focus on technology-based environmental education.

USAFSAM enjoys some natural advantages when it comes to providing the environmental training you need. A significant advantage with a positive impact on the quality of the training you will receive is our location. Co-located on Brooks AFB in San Antonio with both HQ AFCEE and Armstrong Laboratory - USAFSAM's professional faculty receives the benefit of a close and continuing relationship with experts at these service centers. These same experts bring the latest information to our students in the classroom as members of the School's adjunct faculty. Who doesn't need to watch their training and TDY budget? Air Force training slots are centrally funded - there is no cost to the unit for attending USAFSAM courses. There is no tuition or registration fee for members of other services, their unit pays only travel and per diem costs.

Current USAFSAM courses open to environmental personnel include:

Site Restoration Tools, Techniques, and Technologies (SRT[3]): This five-day course is intended for professional personnel with Installation Restoration Program (IRP) responsibilities - primarily technical project managers for sites managed under the Defense Environmental Restoration Account. Designed for Air Force and DoD personnel who must ensure their installation complies with the Environmental Protection Agency (EPA) and their State's equivalent agencies in remediation efforts, it provides the attendee with the detailed information needed to make logical decisions in selecting the best remediation technology for a given situation. Several software tools for regulatory information, technique selection, and cost estimation are examined in detail. Employing case studies and computer based instruction (CBI), the students will learn the techniques necessary to incorporate liability, risk assessment, site investigation, sampling results, and public acceptance into the remediation technique selection process. An in-depth review of well-proven, as well as new and innovative, technologies is performed throughout the course. Each of these technologies is compared to their relative costs, time needed for full implementation, removal / cleanup efficiencies, and public acceptability. The course culminates in a review of sucessful site restoration case studies. The SRT course has been very well received by attendees, and is garnering recognition throughout the DoD and internationally. We have hosted students from all services as well as federal agencies outside the DoD.

SRT(3) Prerequisites: Minimum educational requirement is a Bachelor of Science Degree. Air Force personnel should first attend the Installation Restoration Program Course offered by AFIT. Other DoD personnel should attend their service's equivalent introductory course.

Pollution Prevention Tools, Techniques, and Technolgies (PPT(3)): This five-day course is intended to further the continuing education of DoD and Air Force personnel who are significantly involved in the Pollution Prevention Program (PPP). Personnel in all Air Force jobs are responsible to manage the efforts to reduce hazardous waste and recycle solvents and solid wastes in order to greatly reduce the need for "end of pipeline" treatment and disposal. This course will assist these personnel in reducing the amount of hazardous wastes created by operations as well as complying with the most current standards in the handling and disposal of these wastes. These efforts will ensure that future clean-up problems are minimized and ultimately reduce weapon system life-cycle costs. This course is directed toward personnel working in environmental management, environmental planning, bioenvironmental engineering, maintenance, and logistics career fields.

PPT(3) Prerequisites: Air Force personnel should attend Pollution Prevention Operations and Management Course offered by AFIT. Other personnel should attend their service's equivalent management course.

Environment, Safety, and Occupational Health (ESOH) Conference: This three-day conference Provides for exchange of information on health, safety and environmental issues. Current topics of concern to EPA, OSHA, NIOSH , ATSDR , DoD and USAF are addressed. The focus of this broad based, interdisciplinary conference is the interface between civil engineering, medical, fire and safety, public affairs and legal professionals in the resolution or abatement of environmental, safety, and occupational health problems.

ESOH Prerequisites: Professional and technical Air Force personnel with primary responsibilities in ESOH are encouraged to attend. Personnel with similar specialties within DoD or other government agencies may attend on a space available basis when approved by USAFSAM/ED.

Hazardous Waste Operations and Emergency Response (HAZWOPER) Course: This course provides attendees 40-hours of initial training required by the Occupational Safety and Health Administration (OSHA) rule 29 CFR 1910.120e to individuals involved in hazardous waste operations, site restoration or environmental management duties. This training is usually required for access to DoD Installation Restoration Sites and is mandatory for workers involved in tasks at sites on the EPA National Priorities List (NPL) . This course does not qualify individuals as level III Hazardous Materials Technicians or Level IV Hazardous Materials Specialists as defined by AFI 32-4002, Atch 6. The course is open to all DoD enlisted, officer, and civilian personnel working in hazardous waste operations, site restoration, and site investigations including sampling, or environmental management duties. This course has received EPA approval to be taught by USAFSAM as EPA Course 165.5, Hazardous Material Incident Response Operations; Course attendees will receive an EPA graduation certificate upon completion of the course.

HAZWOPER 40hr Prerequisites: Enlisted, officers, and civilian personnel working in hazardous waste operations, site restoration, site investigations including sampling, or environmental management duties.

8-Hour Hazardous Waste Operations and Emergency Response (HAZWOPER) Refresher Course: Provides 8-hours of refresher training required by the Occupational Safety and Health Administration (OSHA) 29 CFR 1910.120 to individuals involved in hazardous waste operations, site restoration or environmental management duties. The 8-hour course must be repeated annually for the individual to maintain "HAZWOPER Certification" for hazardous waste site workers. Uniform for this class is BDUs for military, equivalent utility cloths for civilians. Funded quotas (per- diem) for this course may be available if this class is taken in conjunction with an additional USAFSAM course, coordination of funding must be made in advance through the MAJCOM and USAFSAM/ED.

HAZWOPER 8hr Prerequisites: Enlisted, officers, and civilian personnel working in hazardous waste operations, site restoration, site investigations including sampling, or environmental management duties, who have attended a 40-hour HAZWOPER (i.e. EPA Course 165.5, USAFSAM Course B3OZY0000E-001 or equivalent) basic course are eligible to attend.

Other USAFSAM offerings currently available or planned are more specifically for the BEE and other medical personnel. Their focus is to more fully prepare the BEE and her technicians to better support the base's environmental team effort. They include ATSDR for Team Aerospace, Funding Workshop for BES, Lead Inspector Training, Resource Conservation and Recovery Act (RCRA) for BEEs, and Asbestos Inspector / Supervisor.

USAFSAM has a selection of courses you need and the quality you want at a price you will like. We hope to develop and offer many new environmental courses over the next few years. The remaining question: "How do I get a slot to attend?"

All Air Force personnel obtain quotas for our courses through their unit or MAJCOM/SG training managers. All USAFSAM courses are listed in chapter 2 of Air Force Catalog (AFCAT) 36-2223, Air Force Formal Schools. These entries should tell your training manager everything they need to know to obtain a quota for you.

Members of other DoD agencies or non-DoD federal agencies request quotas by letter through their respective training manager to: USAFSAM/EC, Attn: Mr Deosdade, 2513 Kennedy Circle, Brooks AFB TX 78235-5123. Letters of request must include student's name, grade, ssan and SHORT justification (a couple of sentences). Have a unit commander or designee sign.

Offerings Available in FY 95 include:

Course Name, Start Date:

SRT(3)	PPT(3)	ESOH	HAZWOPER 40	HAZWOPER 8
17 Oct 94	31 Oct 94	1 Aug 95	3 Oct 94	14 Oct 94
6 Feb 95	30 Jan 95		31 Oct 94	8 Nov 94
3 Apr 95	13 Mar 95		9 Jan 95	17 Jan 95
5 Jun 95	1 May 95		10 Apr 95	9 May 95
10 Jul 95	19 Jun 95		26 Jun 95	2 Jun 95
11 Sep 95	24 Jul 95		18 Sep 95	17 Jul 95

31896a PDF

EFFECTIVE POLLUTION PREVENTION TRAINING

Linda Reinders Taylor, P.E.
Environmental Resource Center
101 Center Pointe Drive
Cary, North Carolina 27513
(919) 469-1585

Pollution prevention requires teamwork from everyone on base. Everyone from the Airman on the flightline to the mechanic at an AGE shop, to the contracting officer, to the temporary painting contractor must understand the hazards of the waste they generate, the benefits of pollution prevention, and how to begin minimizing waste. They need to understand what impacts their actions have on base operations and their surroundings in order to protect their health and safety and the environment. Effective training is the key to ensuring that all base personnel and contractors share a common understanding of just what pollution prevention is, why it is important, how it can limit future liability, prevent future clean-up operations, and save money.

Although pollution prevention is not a new concept, it has taken on new importance in the United States as landfill space becomes scarce and state and federal regulations begin to mandate pollution prevention. Federal facilities are now required to undertake pollution prevention planning as required by the Federal Facilities Compliance Act and through Executive Order 12856 signed by President Clinton on August 3, 1993. Department of Defense Directive 4210.15 (Hazardous Material Pollution Prevention, July 27, 1989) establishes pollution prevention requirements for DOD facilities, as do the Air Force Action Memorandum (Pollution Prevention Program, January 1993), Air Force Policy Directive (19-4) and Air Force Instruction (19-40). With all of these regulations and regulatory policies, you may be wondering just what is pollution prevention, how do I implement it, and where do I begin? The answers lie in pollution prevention training.

Training Content and Approach

The purpose of pollution prevention training is to assist base personnel in understanding the concepts of pollution prevention and how to include pollution prevention considerations in the hundreds of decision that they make every day which impact the amount of hazardous waste generated, air emissions released, or the quality of waste water produced. There are several types of pollution prevention training with the type of training most suitable for each facility depending on the needs and backgrounds of base personnel. The three specific types of training which we will discuss include introductory training, process specific training, and hands-on training.

Introductory training is typically the first type of pollution prevention conducted at a facility. Personnel learn what pollution prevention is, why it is important, and steps that they can take in virtually any job which can produce less pollution. This training will provide base personnel with a common framework regarding the subject and understanding of some of the jargon. Introductory training must stress that pollution prevention is *preventing* the generation of pollution at its source. There is a hierarchy which emphasizes prevention as the most desirable means of achieving reductions in waste generation. After prevention, the hierarchy includes, in order of preference, recycling, treatment, and disposal. Although out-of-process recycling and treatment are more environmentally beneficial than disposal in this hierarchy, they are not typically considered to be pollution prevention options because the pollution was not prevented at its *source*.

Process-specific technical training should follow introductory training. This must be tailored to employees who work with specific processes such as corrosion control, degreasing, NDI inspection, etc. It should also involve those that work with the process in a continuous problem-solving system. In other words, this level of training should teach shop personnel how to think about pollution prevention in every activity they perform. Process-specific training therefore must be developed on-base by the active players: Base Supply, the Environmental Coordinator, and key shop personnel involved in the process. These key players should form a team which meets to identify some initial pollution prevention opportunities for the students to work on in a problem solving workshop atmosphere. The active players should consider: 1) type and quantity of wastes generated by the process; 2) potential waste reduction techniques; 3) impact of the techniques on process effectiveness and Technical Orders, and 4) costs. This initial information should then be presented at the workshop for students to evaluate. The students should also be encouraged to identify their own pollution prevention alternatives. The students should be required to evaluate each option, based on criteria which is applicable to their specific situation. Such criteria may include: technical feasibility, cost, time constraints, supplies of raw materials, impact on the mission, volume and hazard of wastes generated, availability of markets to reuse or reclaim waste materials, and impact on other operations on base.

A third type of pollution prevention training that can and should be conducted is hands-on training. Individuals who participate in the training process, rather than just passively observe, are more likely to retain what they have learned. Participants can be presented with a mock industrial process, assigned specific roles, and then be asked to come up with specific pollution prevention alternatives based on information provided in the training. A brief presentation to "management" concerning the alternatives warranting further study or implementation should be prepared. One of the purposes of this type of training is to teach participants how to evaluate industrial processes. In addition, interactive training can help individuals understand obstacles to pollution prevention, such as labor relations, customer demands, management policies, and technical difficulties that may arise. Team members in this type of training will learn how important communication is in achieving the goal of pollution prevention. Already there are several well developed interactive training modules available to help meet these training needs.

Training is most effective when the size of training sessions is limited to small groups of 15-25 people. This strategy allows for more discussion and participation within the group. Practical exercises and a U-shape layout also facilitate more interaction among training participants.

Information Resources

A major focus of the Pollution Prevention Act and subsequent regulations and agency directives is dissemination of pollution prevention information. Process personnel understand the technical issues of how their processes operate and need to understand the more technical solutions for pollution prevention that are available through electronic bulletin boards, databases and libraries. The USEPA created the Pollution Prevention Clearinghouse (PPIC) which includes the Pollution Prevention Information Exchange System (PIES) to serve as a repository for all types of pollution prevention information. A special database has been created on PIES to exchange information on federal agencies pollution prevention efforts. The available information includes policy statements, program descriptions, manual and guidance documents, notices of conferences, seminars and training course, and case studies of successful pollution prevention projects. There are literally dozens of other bibliographic databases that contain citations to the literature related to pollution prevention from journals, books, dissertations, conference proceedings and reports. There are also other sources of information available to Air Force personnel such as the Environmental Technical Information System (ETIS). Through this system, Air Force personnel can access the Computer-aided Environmental Legislative Data System (CELDS) which provides abstracts of the current environmental regulations for all 50 states, the District of Columbia, Puerto Rico, and the Federal government.

Training Sources

The Air Force has incorporated pollution prevention into its hazardous waste management training program, which was developed under contract by Environmental Resource Center. Train-the-Trainer programs were held throughout the U.S., Europe, and Asia in 1993. Environmental Resource Center also offers applied pollution prevention training at locations throughout the U.S. The author may be contacted for information regarding training locations and dates.

Conclusions

Federal facilities have a significant influence on the environment, whether as policy makers, purchasers of goods and services, generators of pollution, managers of facilities, or researchers of technologies to prevent pollution. Federal facilities are coming under increasing scrutiny by the public, and more stringent environmental regulations lay ahead. With greater budget constraints, pollution prevention should be a top environmental priority. The Air Force can take a proactive role in improving the environment of its host communities, by laying the groundwork for improved environmental management today through implementation of effective pollution prevention training of all personnel. The bottom line: if you do not train your personnel how to create less waste, they'll create as much or more waste, year after year.

SESSION XII

POLLUTION PREVENTION INITIATIVES

<u>*Session Chairpersons:*</u>

Major Tracey Walker, HQ AFMC/CEVV
Captain Marvin Smith, HQ SPACECOM/CEV

INDUSTRIAL PROCESS DATA COLLECTION FOR POLLUTION OPPORTUNITY ASSESSMENTS AT VANDENBERG AFB, CA

Joe Walters, Carolyn Howk, Cpt Marvin Smith
Engineering-Science, Inc.
199 S. Los Robles, Suite 400
Pasadena, California 91101
(818) 585-6194

INTRODUCTION

As part of Air Force Space Command's (AFSPC's) program for conducting Pollution Prevention (P2) Opportunity Assessments, Engineering-Science (ES) completed a 1993 initial survey for significant industrial-activities (processes) at Vandenberg Air Force Base (VAFB). As part of the data acquisition, hazardous material usage, waste releases, and pertinent process information are obtained for industrial-type activities. The primary focus of the study is on process hazardous material usage and fate of U.S. Environmental Protection Agency (EPA) 17 industrial toxic project chemicals and ozone depleting compounds (ODCs).

The overall objective of the project is to conduct a comprehensive P2 opportunity assessment at VAFB. As presented in this paper, this includes a data survey, "materials accounting," and prioritization of significant industrial processes. As part of the same contract, ensuing efforts will include a review and economic analysis of "prioritized" processes followed by recommendations for reducing the use of hazardous materials and generation of air emissions, wastewater, and hazardous wastes.

BACKGROUND

Vandenberg Air Force Base is one of two national launch facilities operated by Air Force Space Command (AFSPC) which provides spacelift and intercontinental ballistic missile (ICBM) launch operations. Military, civil, and commercial satellites are launched into orbit, and Peacekeeper and Minuteman ICBMs are maintained and tested at VAFB.

VAFB occupies 98,400 acres along the south-central coast of California. The base is located approximately 140 miles west-northwest of Los Angeles and 55 miles northwest of Santa Barbara. VAFB is a self-supporting small city with large residential and industrial areas, its own fire department, police department, theater, restaurants, housing, library, medical clinic, and chapel. The majority of the base activities occur within its ten-square mile cantonment area, with the remaining activities generally dispersed along the 35 miles of coastline at various launch facilities. The primary facilities consist of:

- The airfield centrally located on the base;
- Six Space Launch Complexes (SLCs) on the southwestern coast of the base; and
- Various Minuteman and Peacekeeper missile silos on the northwest coast of the base.

Air Force support groups and squadrons, as well as industrial support facilities, are located throughout VAFB. These support organizations assist in the maintenance and refurbishment of aircraft engines; rocket motors; Minuteman and Peacekeeper missile systems; Atlas, Titan, and other launch vehicles; SLCs; communications and communication equipment; refueling operations; and general facilities.

INFORMATION COLLECTED

Sixteen military and federal organizations and 15 civilian contractors were surveyed. From these facilities, information on 176 processes were recorded into the base-wide survey data and evaluation.

The level of process information obtained from each Base facility varied; little or no information was obtained from several organizations. The inability of obtaining some data was due to the time constraints imposed by the tight schedule, the busy mission, launch, and overall schedules of some facilities during the period covering the ES site visit. Based on field estimates, some processes were considered to use relatively small quantities of hazardous materials (HM) and generate minor amounts of wastes and were excluded from the survey. In addition, VAFB resources did not list all civilian contractors, and there were many more industrial activities encountered than originally scoped.

DATA COLLECTION

As part of the pre-data collection activities, data for Base processes or activities that use HM and generate wastes was collected by reviewing existing HM and HW reports and database information, site visits with VAFB organizations, and completion of related worksheets.

A number of pre-data collection activities was undertaken in an effort to coordinate and expedite the site visits as well as the survey. These activities included scheduling data collection appointments with facility contacts, obtaining HM and hazardous waste (HW) database information and previous studies and reports to assist with identifying industrial processes and activities, and telephoning and reconfirming site visit schedule with facility contacts.

Information sources were used to identify: (1) potential processes prior to conducting site visits, (2) determine the types of hazardous materials used and wastes generated from organizations (and in some cases identified processes), and (3) quantities of HM usage and waste generation. The databases and information resources consisted of the following:

1. Source Reduction Review and Plan, Performance Report, and Associated Summaries as required by SB14
2. Air Toxics Inventory Plan
3. Jacobs Engineering Services (JES) "Annual Summary of Hazardous Waste Disposal Activity" for 1993
4. M15 Requisition and Waste Reports
5. Jacob Engineering Services "Process Waste Questionnaires" (PWQ)
6. Miscellaneous 1993 Santa Barbara County Air Pollution Control District (APCD) reports for materials used in permitted painting operations

For the data collection effort, information on each process or activity using hazardous materials was recorded on a set of five worksheets. Data collection worksheets 1, 2, and 3 were completed with the use of pen-activated notebook computers. The following information for these worksheets was collected:

Worksheet 1, "Facility Information." General facility, health & safety, permitting, and process related information

Worksheet 2, "Input Materials Information." Hazardous or non-hazardous chemicals used in the process were documented; corresponding material National Stock Numbers (NSNs) or material safety data sheets (MSDSs) were also collected. Equipment or parts were not considered an input stream for this worksheet and were identified in Worksheet 4.

Worksheet 3, "Process Waste Information." Waste streams, including hazardous waste, wastewater, air emissions, and solid waste, generated by the process were recorded.

A corresponding process flow diagram was sketched, and P2 options previously implemented, attempted, or suggested were noted in Worksheets 4 and 5, respectively.

DATA ANALYSIS AND COMPILATION

Data analysis and compilation consisted of: (1) uploading the data collected during the site visits into a database, (2) revising, and adding to the data collected in the field (based on other data sources and the results of a quality control / quality assurance (QC/QA) check), (3) performing a rough materials accounting of the target chemicals (TC; ODCs and EPA 17 chemicals) for each process, (4) preparing process flow diagrams, and (5) prioritizing the processes based on selected hazardous conditions of each process. The hazardous conditions consisted of annual HM usage, HW generation, wastewater discharge, air emissions, TC (ODC and EPA 17) usage, number of personnel involved in the process, and personal protective equipment associated with the processes.

A point system was used to rate hazardous conditions of each process, and all processes were prioritized for evaluation of source reduction opportunities. The range of total points assigned to any process had a minimum of 0 and a maximum of 16. The processes with the highest point total have the highest priority for further pollution prevention evaluation.

DATA RESULTS

The collected data and materials accounting assessments for processes (or activities) using HM and generating wastes are summarized Base-wide and by organization. The assessments are evaluated by reviewing output of the following distributions:

- Process identification and quantity using AFSPC process codes,
- HM usage for each organization,
- Waste generation including air emissions, HW, and wastewater,
- Target chemical usage, and
- Prioritization of each process included into the database.

A Base-wide summary by organization of the process distribution is shown in Table 1. Twenty-one percent (21%) of the total recorded processes are petroleum-type fluid changes, while painting, industrial, and solvent operations make up approximately 10% each. Abrasive blasting, laboratory or non-destructive inspection, photographic, contractor solvent washes and miscellaneous operations constitute nearly 35% of additional processes Base-wide. These eight process groups represent more than 85% of the total processes recorded at VAFB.

Based on the prioritization scores, materials usage, and waste generation, processes can be easily sorted, identified, and prioritized for their hazardous conditions and potential for evaluation of P2 technical options. Table 2 is a summary evaluation of the top 70 processes and shows the percent of HM, HW, wastewater, air emissions, ODCs, and EPA 17 chemicals represented by the top 70 processes in the

Basewide survey. Prioritization allows for more focus of technical options and economic analysis on these 70 processes in the second phase of the study.

Table 1
Basewide Process Distribution

Process Description	Quantity	Process Description	Quantity
Abrasive Blasting	9	Industrial Waste Treatment	3
Aircraft Cleaning	1	Laboratory/NDI	9
Battery Shops	5	Miscellaneous	15
Biological Operations	2	One time only	3
Chemical Paint Stripping	1	Painting Operations	20
Avionics/Electronics	2	Photo/X-ray	14
Fluids Changeout/Purging	38	Spill Clean-up	7
Industrial and Facility Maintenance	1	Stillbottoms	2
Industrial Operation	17	Off-base Solvent Recovery	11
		Solvents/Degreasing	16

Table 2
Basewide Coverage of Top 70 Processes

Processes	Hazardous Material Qty (lbs)	Hazardous Waste Qty(lbs)	Waste-water Qty (lbs)	Air Emissions Qty (lbs)	ODCs Qty (lbs)	EPA 17 Qty (lbs)
Top 70	1,489,250	333,819	46,247,750	167,558	57,667	87,565
All (176)	1,583,775	428,601	50,086,285	178,525	60,869	88,177
% Captured	94%	78%	92%	94%	95%	99%

Implementing a Household Hazardous Waste Collection Program

Ronald E. Lamb
Dynamac Corporation
2275 Research Boulevard
Rockville, MD 20850-3268
(301) 417-9800

You can really tell a lot about people by what they throw out. If someone litters by throwing a cup down or out their car window, it says something about the person. On the other hand, if someone separates all recyclables and takes them to a recycling center, this also tells you something about the person. In the same way, what we dispose of and how we dispose of it says something about us as a society.

For this reason, it is important to consider how we dispose of Household Hazardous Waste (HHW). This paper will discuss the following three topics: the definition of HHW, why we should care about HHW disposal, and how to set up a HHW collection program.

What is Household Hazardous Waste?
First of all, we are talking about municipal solid waste: trash from residences, offices, stores, and institutions such as schools or hospitals. This is not industrial or manufacturing waste from your Defense-related operations or production facilities. The distinction is that the disposal of HHW is not currently regulated by the Federal government. The Code of Federal Regulations specifies that solid waste from households is <u>not</u> a hazardous waste. For example, consider a 42-gallon barrel of a cyanide solution. If it is from a manufacturing facility, it is considered a hazardous waste; but if it is from a household it is not a hazardous waste. I chose this example for a reason. I was working as a volunteer at a waste collection day in June, 1993, when a woman actually drove up with a 42-gallon drum of cyanide solution.

The Environmental Protection Agency (EPA) defines HHWs as products discarded from residences which contain substances already regulated under RCRA as an industrial hazardous waste. However, no Federal regulations exist for HHW. This means it is not necessary to obtain a permit to store HHW. Liability under CERCLA, however, may be incurred by a municipality transporting or disposing of HHW at a site. In 1989, half the states in the United States were reported to have laws and/or regulations addressing HHW.

HHWs are products that are flammable, corrosive, toxic, or radioactive. Products in a typical residence that may contain hazardous ingredients include insecticides and pesticides, motor oil and automotive supplies, paints and thinners, stains, varnish, glues, heating oil, medicines, cosmetics, batteries, cleaners, polishes, and smoke detectors. More than 100 substances that are listed as RCRA hazardous wastes are present in household products.

HHW products that may be found in offices, schools, or hospitals include as cleaning supplies, toner cartridges, paints, solvents, preservatives, waxes, polishes, and pool chemicals. Chemicals from chemistry, biology, physics or photographic labs, woodworking or graphic arts classes, or maintenance departments also may be hazardous waste.

Many products and packaging materials contain potentially harmful metals and organic chemicals such as mercury, lead, and cadmium. Mercury is found in most household batteries as well as fluorescent light bulbs, thermometers, mirrors and mildew-proof paints. The largest source of lead (two-thirds) is automobile batteries; other sources include electronic components, rust-proofing paints and paint pigments, ceramic glazes, inks and wire and cable insulation. Cadmium is found in metal coatings and plantings, rechargeable household batteries, paints, and inks.

In addition, under RCRA, businesses that generate less than 100 kilograms (about 220 pounds or about half of a 55-gallon drum) of certain hazardous wastes per month are exempt from the Federal hazardous waste regulations. Such small businesses are called Conditionally Exempt Small Quantity Generators (CESQG). In general, CESQGs must not store more than 1,000 kg of hazardous waste at their facility at one time, and they must send their hazardous waste to a recycling facility; a hazardous waste facility; or a facility permitted, licensed, or registered by the state to manage municipal solid waste (usually a municipal solid waste landfill or incinerator). These businesses may include vehicle maintenance shops, florists, dry cleaners, pesticide application services, and others. CESQGs are often unaware that they produce hazardous waste, and as a result, sometimes store and dispose of wastes improperly.

Why We Should Care About Collecting HHW

Most people dump HHW out of ignorance. Too often it is dumped in the backyard, down a storm sewer, or in a septic tank. Such actions need to be strongly discouraged. EPA estimates that the average U.S. household generates 20 pounds of HHW each year. As much as 100 pounds can accumulate in the home, often remaining there until the resident moves or undertakes an extensive "spring cleaning." In San Bernadino County, California, for example, the paint brought to HHW collections is an average of 10 years old.

Household hazardous waste is a relatively small one percent of a typical community's solid waste stream. However, nationwide, this one percent represents almost two million pounds of hazardous materials. It is also the most toxic portion of the waste stream. Proper disposal of household hazardous wastes is crucial. Many materials do not belong in garbage cans or down the drain. The chemicals in these products are harmful to our water and can pose significant problems if they are disposed of improperly. In addition, we are likely to see more and stricter regulations, and someday segregated disposal of HHW may become mandatory in most communities.

The U.S. Supreme Court ruled in late April, 1994, that municipal solid waste incinerator ash that tests toxic must be disposed of as hazardous waste. Many people are interpreting this to mean that fewer waste-to-energy plants will be built. However, these plants have advantages, so instead, the company or municipality picking up your garbage and taking it to an incinerator may be increasing its efforts to make sure that the materials that could make the ash hazardous are separated for special disposal.

So, if HHW doesn't go into the trash, where does it go? Down the drain. In June, 1994, EPA's Region VI office announced its plans to require communities of over 100,000 people to establish HHW collection systems in order to qualify for their stormwater discharge permits. This is the first time EPA has mandated special collection of HHW; it is not likely to be the last.

The **Baltimore Sun** recently ran a story about a resident who parked his car next to a storm sewer and proceeded to drain his car's coolant. It seems that a policeman saw this and stopped him. The man was jailed. The article said he was facing 30 days in jail and up to a $50,000 fine.

While hazardous waste regulations might seem complex, program planners should remember that there is potential liability associated with taking no action at all to manage HHW. By complying with the Federal, state, and local requirements, a facility can reduce its overall liability.

The potential consequences of mismanaged HHW; soil and ground water contamination, hazardous emissions at landfills, interrupted water treatment, and contaminated effluent at water treatment plants, can result in high monetary, societal, and environmental costs.

Setting Up Your HHW Collection Program

How do we go about creating an HHW collection program? This is actually easier than it seems; you don't have to invent anything. Many communities have established special collection programs for hazardous materials. About 1,200 communities nationwide now have Household Hazardous Waste Collection programs. There are many resources, publications, and consultants to help you.

One of the first things to remember is, although there is no Federal regulation, many states or local governments may require HHW collection programs to obtain operating permits. Therefore, one of your first calls should be to your state RCRA office to determine your state's HHW regulations. They are also likely to know the names and locations of nearby Treatment, Storage, and Disposal Facilities (TSDF). This is particularly important since some TSDFs are willing to sponsor local HHW collection programs as a community service.

Issues to consider when setting up your HHW collection program are:

Define the Problem: What To Collect and Estimating Quantity and Type of Materials. The type of HHW can differ considerably. For example, in the Pacific Northwest, residents use much more oil-based paint because of the weather. Latex paint is more common in the mid-Atlantic region. However, the mid-atlantic has more pesticides than areas like the Southwest where people put less insecticide and weed killer on their lawns.

What do you have and what do you want to collect? Most programs collect at least oil paint, solvents, used oil, anti-freeze and pesticides. What you collect will greatly affect program costs.

Montgomery County, Maryland, is a diverse community adjacent to Washington, D.C. In 1993, the county's program was honored by the National Association of Counties as the most innovative new public environmental program in the country. Highlights from Montgomery County's 1993 program included participation by 5,300 households with the average participant delivering 60 lbs. of materials. The average participation was 330 households per event, and the average amount of material collected was 57 pounds per household. The following materials are collected:

- 45% flammable paints, thinners and polishes
- 18% organic acids
- 16% pesticides
- 12% fuel and solvents
- 8% other materials
- 2% heavy metals

A profile of Montgomery County participants showed that 89 percent lived in single family detached homes, eight percent lived in townhouses, and two percent lived in apartments or condominiums. This may mean that most apartment residents do not have much HHW; they do not paint their own homes, maintain lawns, or have a garages in which to store material. On the other hand, it may also mean that what HHW they do have goes right into the garbage. In these cases, a convenient place to collect these materials may be in order. Such a place might be battery collection center.

Choose a Collection Type. There are many HHW collection methods. Most fall into one of the following categories: one day, permanent facility, mobile facility, door-to-door pickup, curbside, and point-of-purchase.

One Day. Most communities have one or two collection days per year at a single site. The events are usually scheduled in the spring or fall, on a Saturday or Sunday, start in the morning, and end in the afternoon. Montgomery County has expanded on this idea, holding about 18 collection days, Saturday and Sundays, at four or five locations around the county.

Permanent Facility. The second most common type of collection program is a permanent drop-off collection center. The challenges in this program are finding a facility for on-site storage of HHW, training staff to handle HHW properly, locating a stable long-term funding source, adhering to additional state or local regulations, and meeting ongoing publicity and education needs.

Drop-off at a Mobile Facility. For large regions, a mobile facility and equipment can provide periodic collections on a regular schedule at different sites.

Door-to-door Pickup. This is convenient for elderly residents and will work well if there are only a handful of potential participants.

Curbside Collection. This should be limited to a few selected wastes collected from households on a regularly scheduled basis. A long list should be avoided, but should include used oil, household batteries and paint.

Point-of-Purchase. A few types of HHW, such as household batteries, can be returned to stores. Some states require retailers to take back automobile batteries and used motor oil.

Disposal Method Affects Cost. A variety of techniques exist for the safe management of HHW, and the manner in which the materials are disposed of affects the costs. Recycling or reusing a material—either in industrial processes or as useful products—is generally the least costly way to go. This is particularly appropriate for used paint. Partially full cans can be used as is, or blended and used by institutions, community groups, religious and recreational centers, and schools. Paint exchanges can reduce the amount of paint being disposed of at HHW collections by as much as 90 percent. Lead acid batteries can be recycled, as can the heavy metals from household batteries, used oil, and anti-freeze. Montgomery County separates solvents and oil-based paints and sells them where they can be blended with fuels and burned in a lime or cement kiln. This is still expensive, but less so than sending it all to a TSDF; a RCRA Subtitle C permitted facility, usually a hazardous waste landfill or hazardous waste incinerator.

Detoxification by neutralizing material through a chemical or biological process to make it less hazardous, or incineration at high temperatures destroys some hazardous wastes. The methods are dictated by the types of waste, proximity to treatment facilities, and cost. Materials such as banned pesticides must go to a TSDF. You should always receive documentation verifying the waste's final destination.

The proximity to a TSDF is also a factor affecting cost. Competition and transportation affects costs. The Southwest has fewer TSDFs. Regulations dictate what type of material goes where. For example, certain pesticides have to be incinerated while others have to be landfilled. Finally, some materials which cannot be treated by any other method can be safely isolated from the environment in a RCRA permitted hazardous waste landfill.

Publicize and Educate. A HHW collection program does little good if nobody knows about it. Publicity should include information on how HHW can contribute to pollution, why people should participate in the HHW collection programs, specific instructions about how to participate on collection day, waste minimization efforts, what to bring, and what specifically will not be accepted, and how to transport it safely. Also, be prepared to give advise on how to dispose of excluded wastes, such as smoke detectors, propane canisters, etc.

Make sure all information is consistent and includes the date, day of week, time, location, waste which should be brought for collection, and names of sponsoring organizations. Examples of public education methods include use of the media; establishing a central information hotline/phone number; mailings and mailing inserts; posters, handouts, and brochures; garbage can labels; displays and exhibits; speakers bureaus; point-of-purchase information; workshops; conferences; or formal classes.

Coordinate With Police and Safety Officials. Develop a safety plan for preventing spills and a contingency plan for the unlikely event of an accident or spill. Designate a Safety Officer and inform local police and fire departments of your plans. In addition, you may want to consider involving nearby residents in your program as a way to demonstrate your commitment to the community. But be careful. Since each resident's participation can cost $80 or more, try to get the local government to finance the costs for their residents.

Program/Collection Day Logistics. Select a collection site that is well known, centrally located, and easily accessible yet away from residences, parks and environmentally sensitive areas. A paved parking lot that is not in use is a good choice. For most programs you will need one to two acres (10,000 square feet). Establish clear entrance and exit locations, a receiving area, a sorting area, a packing area, a temporary storage area, a break area for staff and a special parking area for participants who need extra attention, such as those bringing in large quantities of unknown materials.

Financial Considerations. Average costs for a one-day HHW collection range from $10,000 to $100,000, depending on the number of households that participate, the types and amount of waste collected, and the waste management methods used. On average, each participant brings 50 to 100 pounds of HHW to a collection, at a cost from $50 to $100 per participant. Participation rates usually range from one to three percent of the population, but can be as high as ten percent.

Since its program began, Montgomery County has averaged between 5,000 and 6,000 cars going through a collection center every year. Total program costs is approximately $500,000, or about $83 per car. The average cost nationally is between $70 and $90 per household. Smaller programs can be much more expensive.

Nationwide, at least 50 percent of HHW program costs go to paying for disposal fees to send the waste to a TSDF. In Montgomery County the figure is closer to 85 percent, because they have been very careful to hold down administrative costs such as labor, transportation, supplies, publicity, the collection facility.

Pesticides, especially those containing dioxin, and solvent paints and other materials containing PCBs can be very expensive to manage ($850 per 55-gallon drum in 1991). Burning used oil and solvent-based paint as supplemental fuel typically costs $175 to $250 in management fees. In 1991, the cost of sending most other wastes to a hazardous waste incinerator or land disposal facility ranged from $350 to $500 per drum.

Finally, it is very important to investigate the soundness of the facility where the waste will end up. Remember to ask for copies of the permits for all proposed facilities.

For more information

- Household Hazardous Waste Management; A Manual for One-Day Community Collection Programs, USEPA Office of Solid Waste, RCRA Hotline, 800-424-9346
- The Waste Watch Center, Andover, Mass., 508-470-3044
- North American Hazardous Materials Management Assoc. 802-223-9000
- Institute of Chemical Waste Management, NSWMA, 1730 Rhode Island Avenue, N.W., Suite 1000, Washington, D.C. 20036
- Solid Waste Association of North America (SWANA); Peer match program, 301-585-2898; Solid Waste Information Clearinghouse, 800-67SWICH
- International City Managers Association (ICMA) peer match program, 202-962-3672

References

"Facing America's Trash: What Next for Municipal Solid Waste," U.S. Congress, Office of Technology Assessment, 1989.

"EPA Region Sets for Household Hazardous Waste Collection Requirement," Inside EPA Weekly Report, June 24, 1994.

Richard Malinowski, Clean Harbors, Baltimore, Maryland, personal correspondence.

Household Hazardous Waste Management; A Manual for One-Day Community Collection Programs, USEPA, August 1993.

The National Listing of Household Hazardous Waste Collection Programs, The Waste Watch Center, 1993.

Aron Trombka, Montgomery County, Maryland, personal correspondence.

The Role of a Toxicity Reduction Evaluation
In Pollution Prevention Initiatives at Ft. Campbell, Kentucky

William Goodfellow, Greg Johnson, Lee Gustafson, and Steve Tyahla; EA Engineering, Science, and Technology, Inc., 15 Loveton Circle; Sparks, Maryland 21152; (410) 771-4950; Tim Powers and Gary Sewell; Ft. Campbell; Department of Public Works; Ft. Campbell, Kentucky; Kevin Jasper; U.S. Army Corps of Engineers; Nashville District; Nashville, Tennessee.

ABSTRACT

Ft. Campbell is a very large facility with two airfields, support services, and cantonment of the 101st Airborne and Air Assaults Schools as well as other major tenant units. The facility is located between two states (Kentucky and Tennessee) and four counties and contains approximately 105,350 acres. Final effluent from the WWTP at Ft. Campbell, Kentucky was identified as being unacceptably toxic to *Ceriodaphnia dubia* (water flea) and *Pimephales promelas* (fathead minnow) with regards to the facility's NPDES permit. This unacceptable toxicity required the performance of a Toxicity Reduction Evaluation (TRE) by the facility. As part of the overall strategy, monthly chronic toxicity identification evaluation (TIE) studies were conducted with the most sensitive test organism (*C. dubia*) along with chemical analyses to determine which constituents in the wastewater were the cause of toxicity. The results of the chronic TIEs identified petroleum fuel products and solvents used in tanker purging operations as the principle toxicant in the wastewater.

Additional operations were evaluated post-wide as part of the pollution prevention initiative and TRE in order to determine their input to the WWTP as well as the impact on treatment. These studies included an assessment of airfield activities, oil/water separators, central aircraft and vehicle washing facilities, hospital, laundry, boiler blowdowns, aboveground fuel tanks, photolaboratories, and individual troop units with regards to the wastewater characteristics and resulting effluent quality. This paper discusses the findings of the Toxicity Reduction Evaluation, including identification and confirmation of the toxic effluent components and the investigation to find the sources which are contributing the toxicants to the WWTP. In addition, this paper will discuss the benefit of TREs to assist individual federal facilities with prioritizing their environmental compliance and pollution prevention initiatives. This successful case study for pollution prevention within the environmental regulatory challenges of two states has recently been acknowledged by Ft. Campbell being selected as the Army's and Department of Defense's Facility of Environmental Excellence.

Background

In response to an Administrative Order from the State of Tennessee, Ft. Campbell initiated a TRE to evaluate the cause of observed toxicity from the facility's wastewater treatment plant (WWTP). Ft. Campbell is located in southwestern Kentucky and north-central Tennessee. Ft. Campbell's WWTP is located in and discharges to Tennessee waters, thus the facility's National Pollution Discharges Elimination System (NPDES) permit is with Tennessee. The plant was originally built in 1942, and was expanded in 1976 in an effort to meet more stringent NPDES effluent limitations. The facility has a rated capacity of 4.0 million gallons per day (MGD). The normal daily flow typically ranges from 1-3 MGD. However, during rain events the wastewater flow has increased to approximately 7 MGD. The WWTP provides primary and secondary treatment for domestic and industrial wastewaters collected from the cantonment area, Campbell Army Airfield, former Clarksville Base, and Sabre Heliport. Treatment of wastewater consist of grit removal and screening, primary sedimentation, trickling filtration, secondary clarification, and disinfection by chlorination prior to August 1992, and ultraviolet sterilization/disinfection after August 1992.

The WWTP only accepts sewage that is discharged to the sanitary sewer system and portable toilets that are used as part of troop activities. The sanitary sewer system is used primarily for domestic sewage but is also used as a means of non-domestic waste disposal by many of Ft. Campbell's facilities. These are six major source types that may impact the influent quality of the WWTP. These are:

- Motor Pools and Vehicle Maintenance Facilities
- Industrial Maintenance, Small Arms Shops
- Paint Shops
- Photography, Printing and Art/Craft Shops
- Hospital, Clinics, and Laboratories

Other sources that have a potential to impact the influent quality to the WWTP include heating and cooling plants, laundry and dry cleaning facilities, the Entomology (i.e., pesticide preparation) Department, fire departments, electrical maintenance shops, degreasing agents added to lift stations, mess halls, and individual troop units. Apart from typical sanitary waste constituents, these facilities may contribute various industrial wastes to the WWTP including battery acids, oils, petroleum distillates, fuels, surfactant, mineral spirits, halogenated solvents, aromatic hydrocarbons, spent reagents, and hospital wastes. In addition, there is the potential for non-point source surface water to enter the system through the Post's oil-water separators.

Beginning in September 1991, a TRE was initiated in order to characterize the observed effluent toxicity from the facility's WWTP and investigate other associated activities and processes that may be contributing to effluent toxicity. A TRE is a phased approach that systematically evaluates the WWTP as well as sources of potential toxicity and develops control options to remove or reduce the effluent's toxicity to acceptable levels and achieve longterm compliance with the facility's NPDES permit

Findings

As part of the TRE, a Toxicity Identification Evaluation (TIE) was performed on final effluent from the WWTP in order to characterize and identify the potential toxicants in the effluent from the WWTP. Based on historic data and screening toxicity tests with *Pimephales promelas* (fathead minnows) and *Ceriodaphnia dubia* (water flea), the TIEs were performed using *C. dubia* since it was the most sensitive test species. In addition during the program, chronic toxicity tests were initiated on each of ten final effluent samples taken daily to determine the daily variability of chronic toxicity of the effluent. Samples from various industrial sources were also evaluated in an effort to evaluate the toxicity and toxicants from the various sources to the WWTP. Because a TRE is a process which by necessity, is flexible and subject to ongoing evaluation and development, the results of each phase of the study provides direction to subsequent, the results of each phase of the study provides direction to subsequent phases and reassessment and redirection to ongoing phases. The results of the TIEs conducted on the final effluent, the daily chronic toxicity tests conducted to determine toxicity variability and the source identification studies are presented in this paper in order to provide a complete "picture" of the entire TRE and its role in pollution prevention initiatives.

Based on the results of the acute and chronic TIEs and historic data it appears that the effluent samples that were evaluated monthly from 28 January 1992 to 21 January 1993 were occasionally chronically toxic to *C. dubia* and fathead minnows (Figure 1). During this period, five of the 12 samples had observable toxicity and of these, only two samples demonstrated chronic toxicity below the minimal acceptable level based on the facility's NPDES permit (49 percent effluent). The TIEs performed on the samples that were sufficiently toxic, indicated that chlorine was a major toxicant in samples collected prior to the facility changing from the use of chlorine as the disinfection agent. However, since the sample is dechlorinated for NPDES compliance testing, chlorine should not be considered a suspected toxicant which contributed to the unacceptably toxic effluent samples observed at this facility. Two potential classes of toxicants that were consistently characterized from the TIEs were non-polar organic compounds and metals.

Discussion of Findings

The Ft. Campbell WWTP is operating sufficiently to meet the discharge limitations for most of the parameters required to be monitored in its NPDES permit. Historically, the WWTP has had difficulty in meetings the permit limitations for BOD and TSS removal efficiency and acute and chronic toxicity. In addition, the WWTP was failing to meet its residual chlorine discharge limitations on a consistent basis until the facility converted to UV radiation as its disinfection system rather than chlorination. There were no obvious sources of acute and chronic toxicity identified in the combined influent to the plant or within the treatment plant during the Plant Performance Evaluation.

The oil/water separators (approximately 60 individual units) at the post have been identified as one of the major sources of oil/grease and hydrocarbon loading to the WWTP. As part of the Source Identification Evaluation, a study was performed to identify and quantify petroleum, oil, and lubricant (POL) loading to the oil/water separators and evaluated the capacity of the oil/water separators to remove POL's under all loading conditions. This study determined that very few of the separators functioned properly and a substantial loading of the POL's to the WWTP could be eliminated by functioning oil/water separators. Based on these findings, an aggressive project has been implemented to replace and/or upgrade oil/water separators that were found not to be functioning efficiently.

Fuel tanker purging practices and equipment appear to have historically contributed to the hydrocarbon loading at the WWTP. The purging practices and equipment at Ft. Campbell were evaluated. It was found that the majority of the observed acute and chronic toxicity samples occurred when a large portion of the tanker purging fluids (i.e., citrus based solvent/surfactants) entered into the oil/water separators and ultimately to the WWTP as a slug. Since September 1991, purging activities are being restricted to the larger most efficient oil/water separators and on a daily basis they are tightly managed by reducing the numbers of tanker purged.

TREs are an excellent opportunity to evaluate the effect various influent sources have on WWTP operations. By understanding the role that Post activities have on the wastewater characteristics at Ft. Campbell, we have been able to prioritize the items or activities that need to be immediately addressed and their influence on WWTP operation and effluent quality. The TRE at Ft. Campbell was originally performed to address the Administrative order. However taking a pro-active approach has allowed the Post to develop a focussed environmental compliance agenda that not only addressed effluent quality but addresses other pollution prevention initiatives.

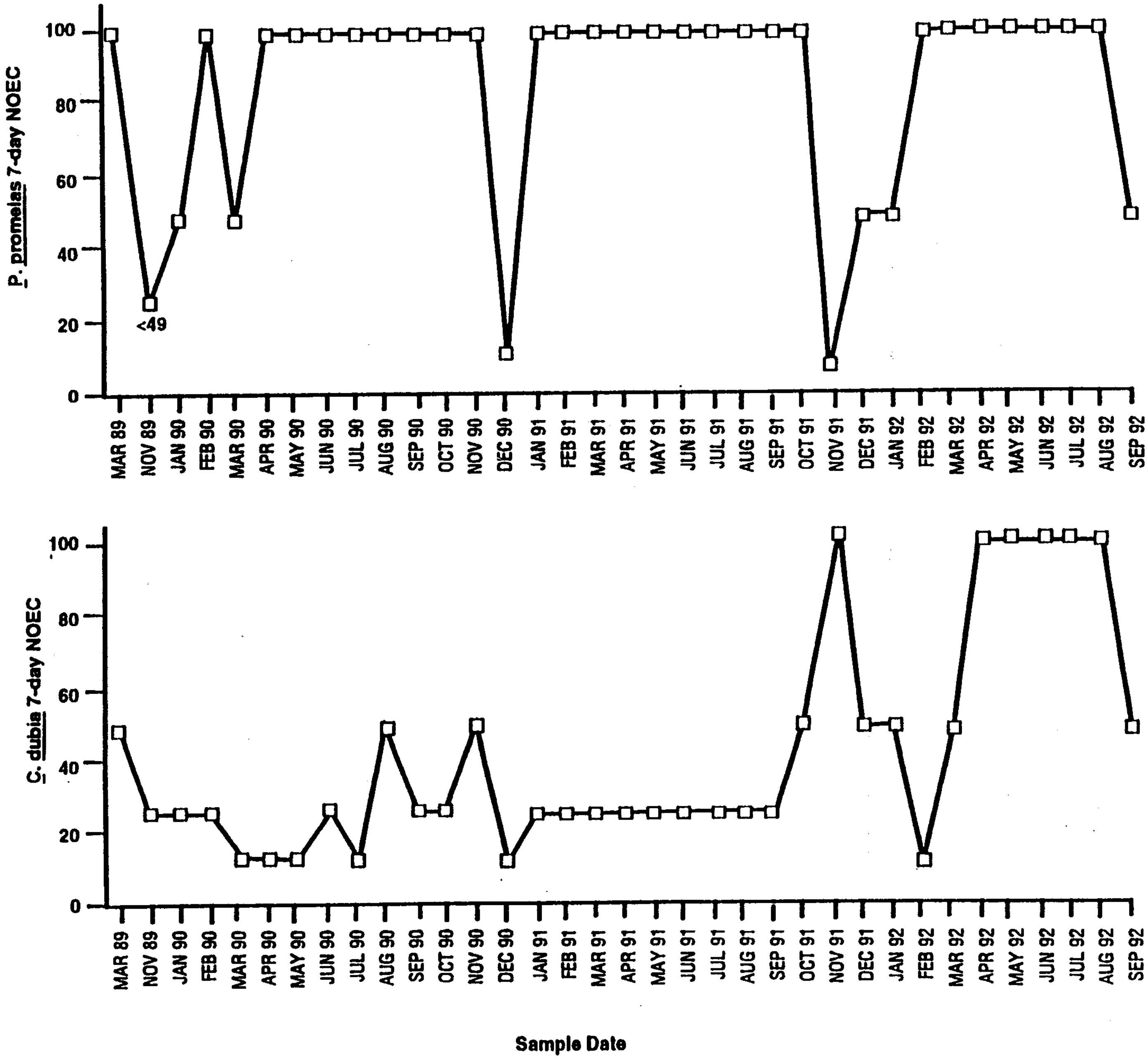


Figure 1. Fort Campbell Chronic toxicity data March 1989 - September 1992

OPPORTUNITIES FOR BATTERY HAZARDOUS WASTE REDUCTION

Tod R. Whitwer - Rebecca Godley, P.E. - Steven J. Anderson
Dames & Moore
7500 N. Dreamy Draw Drive
Phoenix, AZ 85020
602/371-1110

Jeff O'Connor, P.E.
Naval Facilities Engineering Command, Southwest Division
1220 Pacific Highway, Code 1818.JO
San Diego, CA 92123
619/532-2454

Several types of batteries are used at the Marine Corps Air Station, Yuma, Arizona (Station). The batteries are used to operate communication equipment, start vehicles, provide emergency power, operate flashlights, test equipment, and power other equipment. The types of batteries used in the greatest quantities that contribute to the battery hazardous waste stream are lithium, magnesium, and alkaline. Depending on the type of battery, its level of charge, and the composition of the battery, it is either classified as hazardous or nonhazardous. The Marine Corps classifies batteries that have been removed from the manufacturer's packaging as used. Used batteries must be disposed of according to federal, state, and local regulations.

DETAILED ASSESSMENT

This section will describe the types, uses, and the classifications of the batteries in use at the Station. The problems associated with the batteries with respect to their generation, storage, and disposal will be presented. This discussion will be separated into three sections for lithium, magnesium, and alkaline batteries.

Lithium Batteries - The lithium batteries used by the Station are the BA-5000 series batteries. Lithium batteries accounted for 83 percent of the total waste batteries shipments greater than 200 pounds in 1991 and 1992. This relates to approximately 4000 pounds in 1991 and 7,500 pounds in 1992. The primary use for these batteries is to operate communication and cryptographic equipment during field operations. They are used in both man-packs and in mobile units. The following is a list of RCRA classifications and waste codes and bioassay classifications for the various BA-5000 series batteries.

Lithium batteries (BA-5590, BA-5598, BA-5599, etc.), as currently deployed in military communications applications, utilize a lithium sulfur dioxide electrochemical system. The organic electrolyte used in this electrochemistry generally consists of the following materials: sulfur dioxide (70%), acetontrile (24%), and lithium bromide (6%). The quantity of sulfur dioxide within the electrolyte decreases as the cell is discharged to its useful end voltage. The useful end voltage is usually 2.0 volts per cell. However, at this voltage cutoff, some residual capacity remains within the cell (approximately 10-15 percent) and, as a result, it must be discharged to zero volts to react the remaining quantity of sulfur dioxide and lithium within the cell. Residual sulfur dioxide contained within fully discharged cells is dependent upon the stoichiometric proportions of lithium and sulfur dioxide used by the manufacturer.

Problem No. 1: Lithium Batteries with Any Remaining Charge are Hazardous Waste - Lithium batteries are primarily used in the communication security equipment (KY-57), the wire line adaptor (HYX-57), and the AN/PRC-77 radio set. Lithium batteries that contain charge are classified as hazardous waste because they are ignitable (D001) and reactive (D003).

A March 18, 1987, document from the EPA to the U.S. Army Laboratory Command states that lithium batteries that have been fully discharged to zero volts are considered to be non-reactive (EPA, 1987). This letter stresses that each cell within each battery must be completely discharged. This evaluation is based on information provided to the EPA by the U.S. Army Electronics Technology Devices Laboratory (LABCOM). It is the responsibility of the generator to characterize their hazardous waste and determine if the discharged batteries exhibit a hazardous waste characteristic.

Several battery types have self-contained resistors to continue battery discharge beyond its useful cutoff voltage in an effort to deplete the active materials within each cell. While this discharge technique is highly beneficial in reducing the quantitative amount of residual active materials, the method is not always effective since end of life is not achieved simultaneously in multi-cell battery packs. As the first cell in the battery approaches zero volts, the internal impedance increases substantially which reduces the discharge current flowing through the remaining cells. Complete discharge of multi-cell batteries can generally be accomplished by a forced discharge protocol using an external power source to continue the discharge of the remaining cells in the battery to deplete all active materials to the maximum extent possible.

Option No. 1: Deactivate Lithium Batteries with a Complete Discharge Device (CDD). Most of the lithium batteries currently manufactured are equipped with a CDD for charge depletion. Additionally, many lithium batteries that are not equipped with a CDD can be discharged with an external CDD. It is expected that lithium batteries used at the Station can be fully discharged and disposed of as a non-hazardous solid waste. All batteries with a CDD should be deactivated according to the manufacturer's and the U.S. Army CECOM directions (Source: Message 060103Z OCT 93 ZYB, CMC Washington). Battery storage and transportation is difficult during field operations where the unit is mobile. A battery labelling, storage, and transportation procedure should be developed for field operations to transport the batteries back to the Station for later discharging. Alternately, retrieval of the used batteries from the field can be arranged after field operations are completed.

Fully discharging the battery would reduce the battery to solid waste. Making procedures easier and identifying the inherent benefits provides an incentive for proper disposal practices. The cost savings for this option is expected to be significant. Over the last 3 years, 66 to 83 percent of the battery disposal shipments greater than 200 pounds were lithium batteries with the RCRA classification waste code D003 corresponding to reactivity.

Option No. 2: Order Only Batteries with a CDD. Where possible, make it a supply policy that the lithium batteries purchased have a CDD. Batteries equipped with a CDD can be disposed of as non-hazardous waste when each cell is completely discharged. This option is easy to implement, but requires training for units and supply personnel. The cost of this option will probably not be significant and the internal CDD contributes significantly to the ease of depleting remaining charge.

Option No. 3: Replace Batteries with Power Plug. The use of a power supply plug that eliminates the need for lithium batteries in certain applications should be further investigated. The 2nd LAAM Bn has designed and fabricated a power supply plug that eliminated the need for lithium and magnesium batteries in vehicle-mounted communication equipment during field operations. The power supply plug, however, will not replace the batteries required for the man-packs that are used during some field operations.

The power supply plug could significantly reduce the amount of batteries used as shown in the following analysis. There are normally eight sets of communication equipment (16 radios) used during field operations. Each communication set has two field locations. The power plug that the 2nd LAAM Bn designed and fabricated is connected to an extra port on the power supply and replaces the batteries in the KY-57 and HYX-57 modules. This eliminates use of four batteries from each field location or eight batteries from each communication set. Under these conditions, the entire battery savings during a typical 30-day field operation with eight communications sets would be 960 batteries.

The development and implementation of the power plug is beneficial in several respects. Communications batteries to be purchased, transported, installed, discharged, and disposed may be reduced by more than 80 percent as a result of implementing this option. This option is significantly less complex than the existing procedure, so there is a high degree of certainty that this option will be successful. The environmental benefits of this option are significant. No solid or hazardous waste is generated that could be improperly disposed of. The cost associated with the purchase and disposal of lithium and magnesium batteries are expected to be reduced by more than 80 percent with the implementation of this option. The cost to produce the plugs needed by one unit is estimated to be approximately $1,000.

Option No. 4: Purchase and Use a Lithium Battery Test Set. Chemtronics Ltd. manufactures a lithium battery test set that determines the remaining charge in BA-5588, BA-5590, and BA-5598 lithium batteries. If sufficient charge is remaining, these batteries can be labeled with "Remaining Life" and reused during field operations.

This option is easy to implement. However, the test set costs about $6,000.

Problem No. 2: Operating the Complete Discharge Device (CDD) can be Hazardous - A number of hazardous conditions can be created when operating a complete discharge device. Discharge of spent lithium batteries should be conducted under controlled conditions because sufficient energy is contained within "partially depleted" batteries to cause cell venting of sulfur dioxide and/or potential for ignition of active lithium material. This presents a safety hazard because sulfur dioxide is poisonous and an irritant to humans and the lithium can ignite in the presence of air. Sulfur dioxide is also classified as a criteria air pollutant. Because lithium will react violently with water to generate hydrogen gas, any fire involving molten lithium must be controlled using Lithex or equivalent. In cells which contain an inadequate quantity of sulfur dioxide to react with the lithium (as a result of underfilling at the factory or leakage in the field), lithium may react with residual acetonitrile in the electrolyte causing the formation of cyanide-containing compounds.

Option No. 1: Establish a Discharge Area. A well-ventilated and safe discharge area where the batteries can be placed during the discharging process should be established. All manufacturer and U.S. CECOM (Source: Message 060103Z OCT 93 ZYB, CECOM Washington) procedures for discharging the batteries should be followed.

Establishing an area for battery discharge would require a number of controls for explosion and fire contingency and would be moderately difficult to implement and would require minimal training. Some form of containment should be provided to protect against environmental releases from leaking or cracked battery cases and there should be adequate ventilation. The costs to set up a discharge area are estimated to be minimal and the cost savings associated with this option is significant because lithium batteries comprised a majority of the batteries disposed of as hazardous waste over the last three years.

Option No. 2: Develop a Storage and Transportation Plan for Field Operations. Label, store, and transport all used batteries back to the Station during field operations for future discharging. Alternately, develop a plan for later retrieval of the batteries from the field after the field operation is complete.

Storing the used batteries safely in the vehicles for transport back to the Station should be as easy as transporting them to the field. This option will decrease the likelihood of improper disposal in the field. The cost of implementing this plan is estimated to be minimal and meets the objective of safe discharge and proper disposal of the batteries as a non-hazardous solid waste.

Problem No. 3: Lithium Batteries that Contain Hazardous Material are Considered Hazardous Waste Upon Disposal - If a lithium battery intended for disposal contains a hazardous material resulting in concentrations above regulatory limits for toxicity, then it is classified as a RCRA hazardous waste. Furthermore, if it contains a hazardous material resulting in concentrations above the bioassay limits for the state in which it is disposed, then it is classified as a hazardous waste.

Option No. 1: Purchase Only Batteries that Contain no Hazardous Material. An effort should be made by the user and supply units to order and purchase only batteries that do not contain hazardous materials. The MSDS and manufacturer's specifications should be researched to identify batteries that do not contain hazardous materials that would result in concentrations above RCRA regulatory limits for toxicity. Also, inquiries through battery manufacturer technical services should be made to evaluate whether interchangeable non-hazardous batteries can be utilized.

This option is easy to implement but requires some training for unit and supply personnel to identify hazardous materials in batteries. The cost of implementing this option are expected to be low to moderate.

Magnesium Batteries - The magnesium batteries used at the Station are the BA-4000 series. Magnesium batteries accounted for 17 percent of waste battery shipments greater than 200 pounds in 1991 and 1992. This relates to approximately 800 pounds in 1991 and 1600 pounds in 1992. These batteries are used for communication and cryptographic equipment during field operations.

Magnesium batteries are used in the same field communication equipment as the lithium batteries. The BA-4386 (magnesium) and the BA-5598 (lithium) batteries are interchangeable except in special applications. Magnesium batteries are significantly less expensive than lithium batteries. The Marine Corps requires that the most economical batteries be used during training. Therefore, the magnesium batteries are favored for training use. However, there are several performance differences in electrical characteristics and performance between lithium-sulfur dioxide batteries and magnesium batteries. Lithium battery characteristics include:

- Higher operation cell voltage and increased energy density (nearly twice that of magnesium batteries)
- Operation under a broader range of temperature (-40°C to +70°C)
- Substantial capacity retention characteristics after prolonged storage at elevated temperatures
- Shelf life of 8 to 10 years
- Lighter weight
- Capable of powering equipment at substantially higher discharge current levels.

Problem No. 1: Magnesium Batteries with Charge are Hazardous Waste - The EPA hazardous waste code for a BA-4000 series battery with more than eight hours of charge remaining is D007. This classification corresponds to chromium being present above RCRA regulatory limits for toxicity. However, the BA-4000 series battery with less than eight hours of charge remaining is not classified as a hazardous waste upon disposal. The chemical form of the chromium in a discharged magnesium battery, with less than eight hours of charge remaining, is in a non-hazardous form and does not result in chromium being present in the test leachate at concentrations above the RCRA regulatory limit for toxicity.

Option No. 1: Replace Batteries with Power Plug. Using the power supply plug developed by the 2nd LAAM Bn eliminates the need for batteries in some situations. The power plug is described in the Lithium Battery Section. The cost savings associated with the purchase and disposal of lithium and magnesium batteries are expected to be 80 percent with the implementation of this option.

Problem No. 2: Lack of Methods to Discharge and Test the Remaining Charge of Magnesium Batteries - Magnesium batteries are not equipped with a CDD. Although there are Marine Corps-approved test methods for assessing the remaining charge and discharging the batteries, the Station Environmental Department has not approved these methods for use by individual units. They have expressed concern about making sure the batteries are discharged to an adequate degree before disposal as a solid waste. Consequently, all the magnesium batteries are ultimately disposed of as hazardous waste.

Option No. 1: Test and Deplete. This option is to develop and implement a battery testing and deactivation program for magnesium batteries. If the batteries are discharged to the appropriate degree, they can be disposed of as solid waste. The cost savings associated with this option are significant because magnesium batteries accounted for 15 to 20 percent of the hazardous waste shipments of batteries that exceed 200 pounds.

Alkaline Batteries - The alkaline batteries used at the Station are the BA-3000 series. Alkaline batteries accounted for 19 percent of waste battery shipments greater than 200 pounds in 1993 or approximately 1000 pounds. These are "D", "C", and "AA" cells that are commonly available to the general public. These batteries are used for flashlights, test equipment, communication equipment, to maintain continuous equipment memory, and power other equipment. The RCRA classification and waste code and the bioassay classification for the BA-3000 series batteries are NHSW and HW, respectively (Source: Message 010103Z October 93 ZYB, Headquarters of the Marine Corps, Washington).

Problem No. 1: Quantity of Alkaline Batteries Disposed of as Hazardous Waste - In 1993 alkaline batteries were disposed of as a hazardous waste with the RCRA waste codes D002 and D006 for corrosivity and cadmium, respectively.

Conversations with units at the Station indicate that all alkaline batteries are presently (January 1994) disposed of as a solid waste. This would be the correct waste designation, unless the batteries were disposed in a state requiring bioassay: Alaska, California, Minnesota, Rhode Island and Washington. Battery manufacturers have also confirmed (February 1994) that alkaline batteries are now manufactured with amounts of hazardous materials that do not result in concentrations above RCRA regulatory limits for toxicity.

Option No. 1: Replace Alkaline Batteries with Rechargeable Batteries. There are currently two types of rechargeable batteries on the market that are designed to replace non-rechargeable alkaline batteries.

These two types of batteries are nickel-cadmium (Ni-Cad) and alkaline. Both types can be used successfully in many alkaline battery applications.

Ni-Cad batteries cannot be used in some applications that specifically require an alkaline battery. When Ni-Cad batteries are fully charged they do not last as long as the alkaline battery they are replacing and the discharge characteristics are also different. However, the Ni-Cad battery can be recharged up to 1000 times according to one manufacturer. For best performance of Ni-Cad batteries, the manufacturer recommends that the batteries not be partially charged or discharged because this leads to a loss of functional capacity. Ni-Cad batteries cost about 18 times as much as the corresponding alkaline battery but are equivalent to approximately 75 to 601 alkaline batteries. These Ni-Cad batteries must be disposed of as a hazardous waste due to the presence of cadmium in amounts that reslt in cocentations above RCRA regulatory limits for toxicity.

Renewal® rechargeable alkaline batteries, manufactured by Rayovac®, are new to the battery market. These batteries can be recharged 25 times or more and provide about the same life and discharge characteristics as the non-rechargeable alkaline batteries they replace. In addition, these batteries can be used in all applications that require alkaline batteries and do not experience the loss of functional capacity that Ni-Cad batteries do from partial charging and discharging. The Renewal® rechargeable alkaline batteries are non-hazardous and can be disposed of with normal refuse when they no longer perform as required. Renewal® rechargeable alkaline batteries cost about the same as the corresponding alkaline battery and is equivalent to about 25 alkaline batteries. The Renewal® rechargeable alkaline batteries require a specific battery charger that is manufactured by Rayovac®. Remington Products, Inc. manufactures a special battery charger that can increase the life of normal "AA" and "AAA" alkaline batteries by up to 10 times. The battery charger will not work on "C" or "D" cells.

Implementing the use of any type of rechargeable battery is expected to be easily accomplished both economically and is environmentally advantageous.

Option No. 2: Purchase Non-Hazardous Batteries. Rechargeable and non-rechargeable alkaline batteries can be purchased that do not contain any hazardous materials that would result in concentrations above RCRA regulatory limits for toxicity. This option is easy to implement but requires some training for unit and supply personnel on hazardous materials in batteries.

RECOMMENDATIONS

1) Follow the manufacturer's and the U.S. CECOM (Message 060103Z OCT 93 ZYB CMC, Washington) discharge procedure for depleting the remaining charge in lithium batteries.
2) Purchase only batteries with complete discharge devices.
3) Research non-hazardous replacement batteries for other applications. Make an effort to purchase only batteries with no hazardous material constituents.
4) Develop, distribute, and utilize 2nd LAAM Bn's power plug for vehicle-based communication units during field operations.
5) Utilize rechargeable batteries, where possible.
6) Develop and implement a testing and discharging program for magnesium batteries.
7) Transport batteries back to the Station for testing, depletion, and disposal.
8) Purchase and use a Chemtronics LTD. Model LS-94 Battery Test Set to determine the remaining charge in the BA-5588, BA-5590, and BA-5598 lithium batteries. Reuse the batteries that have sufficient charge remaining.

SESSION XIII

HAZARDOUS MATERIAL CONTROL & TRACKING

<u>Session Chairpersons</u>:
Lt Col. Michael Winters-Maloney, HQ PACAF/LGQ
MSgt Brian Au, HQ AMC/CEV

CHARACTERIZING AND TRACKING TOTAL WASTE OUTPUTS AND COST IN RELATION TO INDIVIDUAL SOURCE REDUCTION INITIATIVES

Prepared by:
Thomas F. Stanczyk, Sr. Vice President
Recra Environmental, Inc.
10 Hazelwood Drive
Amherst, NY 14228

SUMMARY

The functionality and design specifications of AWARE®, a pc-based integrated information management system, allow businesses engaged in chemical processing, manufacturing, finishing and assembly the flexibility in tracking variances in the generation and characteristics of hazardous and solid wastes, discarded raw materials and multi-media releases of toxic chemicals. These documented variances can be analyzed at desired levels of interest in relation to defined origins, causes, chemical usage rates, product output(s), cost and ongoing source reduction initiatives.

The resulting measurements and relational analyses can be monitored in relation to individual pollution prevention projects and programs, taking into account targeted waste and actions that are strategically aligned with total quality management plans and practices. By integrating waste data with chemical consumption and production data, normalized waste to product indices are generated at desired origins, and stages of production activity.

INTRODUCTION

Throughout the United States, businesses and governmental agencies are embracing pollution prevention as a preferred environmental management strategy.

Businesses engaged in chemical processing, manufacturing, finishing and assembly are utilizing information systems as analytical tools supplementing pollution prevention and waste minimization plans and progress reports.

In comparison to the elements of a successful TQM program, the planning, assessment and implementation phases of a pollution prevention and/or a waste minimization program are somewhat identical in principle. Both programs are viewed as proactive strategies and processes that dictate measurements to document and communicate progress in continuous improvement. Without these measurements, employees motivated by awareness, attention to detail, root-cause analyses and cost allocation will not achieve their common goals, i.e, reduce production loss and environmental liabilities, while improving profitability and customer satisfaction.

A successful TQM program resulting in the reduction of regulated waste will take full advantage of an integrated information management system to document and track achievements and measurable benefits attributed to: reduced operating costs as productivity improves, optimum resource utilization, improved profitability with quality production and avoidance of regulatory compliance costs.

Resulting measurements will depict analytical trends in both raw material and waste transactions as a function of changes in production activity during targeted accounting periods. At the same time, the information management system serves as a tool assisting employees in their efforts to:

- Eliminate the origins and causes of production loss
- Minimize the generation of regulated waste including multi-media chemical releases in relation to raw material consumption
- Demonstrate commitment by documenting progress and accomplishments in reducing waste at their points of generation

0171.air

- Allocate the true costs of generating waste to the department responsible for its generation
- Justify investments in source reduction technologies
- Respond to customer requirements and interests
- Comply with state-mandated pollution prevention planning and reporting regulations

This paper summarizes how AWARE® can be used in support of pollution prevention plans and programs requiring periodic progress reporting. To illustrate the system functionality and data collection requirements, the contents of this paper reference applicable initiatives of manufacturing facilities pursuing integration of manufacturing, cost and waste management information systems.

DEFINING THE SOFTWARE FUNCTIONALITY

As illustrated in Figure 1, AWARE® employs a modular design that allows the end user to manually or electronically interface the modules with other existing systems managing chemical consumption, disposal costs and product output.

The functionality of the software supplements the documentation, analysis and reporting elements of the facility's waste minimization and pollution prevention programs. In addition, the software serves as a relational analytical tool accounting for all discarded resources by each department. The accounting and relational analytical capabilities allow the end user to link waste reduction and cost savings with source reduction initiatives viewed as quality improvements.

In support of facility-specific responses to required planning and reporting requirements, the software can provide the following functionality:

- Referencing applicable process and material flow block diagrams, the software documents uniform codes and descriptions of each source or origin of hazardous waste generation. The system provides the end user with an electronic representation of:
  - Pre-defined routes for raw material used at a defined source
  - Product yielded by the source
  - Wastestreams managed within as well as outside the plant boundaries

- The system provides standardized directories for documenting raw material, product and waste characteristics including pertinent physical properties, chemical composition and hazard analysis. The system allows the end user to document applicable field measurements, hazard identification, test methodologies, sampling protocol, theoretical estimations and engineering calculations supplementing each waste profile.

- At various sources of interest, i.e., plant boundary, Building 300, Department B-2 (Phase 1) or work station (S-43 WS Photoresist Stripper), the software system can help the end user track waste generation as well as raw material consumption. Using these tracking transactions, the system automatically computes summarized accounting records relating targeted wastes and constituents to applicable causes, management practice and production activity.

- For each area of interest, the system analyzes costs associated with defined production loss and waste management practices. The end user can use the findings to allocate all or part of the costs to the source(s) responsible for its generation.

- For each targeted raw material, waste and/or waste constituent, the system documents and analyzes defined source reduction strategies and programs. For each opportunity the system documents applicable project descriptions including associated goals, evaluation requirements, scheduled actions, economic investments and anticipated versus actual performance results.

- For the entire facility, the system assimilates all source reduction initiatives. Using assigned methods of reporting progress, the system will prepare relational analyses reflecting waste generation trends in relation to product output.

0171.air

To optimize the effectiveness of the software as a management tool, waste generators have to establish policies and procedures for collecting and applying in-plant measurements and information. The end users must address the following key elements.

- Ensure conformity in the meanings of 'waste' and 'point of generation'. In an ideal situation, the end user is accounting for the quantities of discarded as well as reusable resources prior to in-plant material management.
- Correlate source codes. Ideally, the codes and origins assigned to each targeted wastestream are the same or somewhat related to the source codes and descriptions used by manufacturing.
- Specify routes and destinations. This is one of the key design features of the system. The codified routes and destinations allow the end user to leave an 'electronic trail' that can be used for source analysis and cost allocation.
- Define tracking requirements and responsibilities.
- Identify required relational indices and methods of monitoring and reporting progress.
- Link waste generation trends and chemical releases with economic gains and quality improvements. The end user should correlate pollution prevention accomplishments with ongoing TQM initiatives.
- Formalize policies and procedures for reviewing and modifying the resulting databases.

PLAN DOCUMENTATION (Example)

An electronic component manufacturing and assembly operation generates a number of hazardous and solid wastestreams such as:

- Caustic cleaners
- Flammable solvents, xylene, IPA
- Waste oils
- Volatile halogenated solvents
- Various acid mixtures and oxidizers
- Ferricyanide solutions
- Glycerin/EDTA mixtures

Most of these wastestreams are generated by in-plant processes such as metal masking, cleaning, finishing and assembly. In addition, there are a number of auxiliary operations that also contribute unique wastestreams, such as fuel oil, contaminated carbon and ion exchange resins, wastewater treatment sludges, excess packaging, production scrap, fluorescent tubes and other facility maintenance debris, laboratory chemicals, electronic storage batteries, industrial coolants, lube and hydraulic oil.

The usage of raw materials containing SARA 313 constituents directly influences multi-media releases of pollutants further dictating pollution abatement equipment that also contributes to solid waste quantities.

The assessment of source reduction opportunities requires a systematic approach to collecting and analyzing data and process information that collectively provides the basis for a documented waste minimization/pollution prevention plan. This summarized approach is schematically illustrated in Figure 2.

Some of the key data collection, management and reporting elements of each step are summarized as follows.

Step 1 Develop Process Flow or Block Diagrams

The process flow is one of the most important references in the development and implementation of a written pollution prevention plan. At a minimum, the facility should reconstruct a simplistic block diagram for the operation associated with each identified origin of regulated waste. This diagram should illustrate:

- Codified origins or sources of regulated waste corresponding to regulatory assessments of 'point of generation'
- Material inputs as well as outputs
- In-plant material routes as well as destinations

0171.air

The level of detail on the block diagram may vary to accommodate specific business interests as well as areas of quality improvement. As an example, a Phase I foil masking operation can be viewed as one department or cost center consuming raw materials as well as generating waste requiring control and proper residual management. The treated foils continue on to the next major department responsible for plating.

A root-cause analysis of the foil masking operation would result in a block diagram illustrating ten unique workstations. Each workstation has a specific formulation in the process of yielding a quality product. Each formulation has unique raw material requirements and operating protocol. While some of the workstations generate similar wastes that are generally categorized as halogenated solvents, it is necessary to breakdown these wastes on the block diagram to accurately depict origins that are deemed different on the basis of chemical content.

Step 2 *Account for Material Flow*

For each source, building, department or workstation, account for material flow using a relational analyses that depicts all discarded waste as a function of raw material consumption and product output. This relational analysis utilizes several information systems for data input. The software integrates the system inputs and provides a number of relational analyses that will serve as a basis for ongoing monitoring and reporting of quality initiatives resulting in source reduction.

In the process of assimilating this data, it is important to consider:

- The quantities of raw materials consumed by each source. Consumption differs from what is inventory or what is purchased.
- The types and quantities of waste that can be recycled or reused with or without purification.
- The individual causes as well as quantities of waste requiring proper management.
- Product outputs corresponding to the targeted source.
- Auxiliary raw material feedstock contributing to waste quantities such as: pallets, filter bags, maintenance oils.

In-plant tracking transactions allow the facility to account for quantities of each material consumed as raw material as well as managed as waste. This relational analysis can be expanded to illustrate cause and destinations of each product and by-product. To avoid inconsistencies in data entry, all raw materials, products and waste are assigned unique identification codes and each route/destination is codified.

Step 3 *Prepare Raw Material and Waste Profiles*

In the context of a pollution prevention plan, the generator needs to characterize raw materials and wastes for properties and content influencing hazards to the workplace and the environment.

The integrated software system provides modular directories for documenting in a uniform format, all targeted raw materials and wastestreams. The directories are key system components. Without documented characteristics, the integrated software cannot function.

The Waste Directory allows the facility to document the following information for each wastestream identified at the point of generation:

- Individual waste descriptions and codes depicting waste contents and origins
- Physical properties influencing hazard identifications, in-plant material handling and off-site transportation
- Chemical content determined by process knowledge, actual measurements, lab analysis or theoretical estimates
- Hazard analysis reflecting EPA/state definitions and workplace safety concerns
- Predefined methods of handling and containerization
- Approved destinations and methods of recycling, treatment and disposal

0171.air

The Raw Material Directory allows the facility to uniquely codify each feedstock from the time it is procured and stored to the time it is actually distributed within the plant and consumed. The system's design allows consumption or usage to be tracked and interfaced with a centralized chemical inventory system. Using a unique part code, the system indicates whether chemical requisitions exceed budgeted quantities. The purchasing component also flags restricted materials, such as ozone depleting chemicals. This feature assists purchasing in chemical procurement.

In the context of the pollution prevention plan, the Raw Material Directory will document constituents causing specific hazards identified at each origin. The functionality of this module is similar to the Waste Directory.

Step 4 Define Tracking Requirements

The facility's pollution prevention plan requires the environmental staff to track the movement of waste, including targeted chemical releases. The tracking requirements account for daily transactions of both waste and raw materials within as well as outside plant boundaries.

The functionality of the resulting tracking modules dictates the use of an internal manifest system. The facility employs a dedicated staff for material distribution and collection as well as documentation. The documented transactions leave an electronic footprint of material movement using routes that are employed by manufacturing.

The system's tracking capabilities allow the facility to monitor generation and usage rates from desired sources, as well as trends in recycling, treatment and disposal.

One of the unique features of the software is its ability to account for variable loadings of pollutants released from each targeted source. The facility is able to compute origins of individual pollutants released to wastewater and debris enhancing the opportunities for hazard reduction by source segregation.

Step 5 Accounting for True Costs

The pollution prevention plan requires the facility to monitor the true costs associated with the generation and management of waste including production scrap. These costs are allocated to the department(s) or origins responsible for its generation. The system's functionality allows the facility to document and allocate the cost associated with in-plant waste handling, waste treatment, off-site disposal, regulatory fees and taxes, management oversight, and production loss.

The facility's opportunity assessments factor in the resulting costs to prioritize project investments and determine return on investments.

Step 6 Monitor and Assess the Results of Scheduled Actions

The pollution prevention plan requires the facility to document and assess source reduction opportunities having the potential for reducing waste quantities and their hazards. The system's Waste Minimization module allows the facility to document applicable source reduction strategies as well as elements of individual waste minimization opportunity assessments, i.e.:

- A description of each viable project including:
  - The project coordinator
  - Targeted waste and source
  - Applicable source reduction strategy
  - Scheduled actions and milestones
  - Project costs and commitments

- Successful accomplishments minimizing regulated waste, chemical waste and production scrap

- Economic benefits

0171.air

With maintenance, the facility is able to measure and report trends in waste reduction for each targeted wastestream. The system will provide project updates relative to scheduled actions, milestones and budget.

This module also assists the facility in analyzing the potential effects of implementing a source reduction project taking into account federal and state regulatory submissions as well as quality improvement projects. For each documented project, the system reports its effects on:

- RCRA hazardous and solid waste
- CAA hazardous air pollutants
- SARA 313 multi-media chemical releases
- Off-spec product

With a centralized system, the facility optimizes reporting capabilities in a manner that minimizes redundant data entry and analysis.

Step 7 Formalize Progress Reporting Indices

The pollution prevention plan requires the facility to measure the progress of source reduction initiatives using a numerical index that relates waste generation to product output at the defined points of generation.

Due to variability in the types of products as well as product specifications, the facility has selected multiple indices relating waste quantities to production units and activity.

The facility system is capable of interfacing with manufacturing data computing product yield and scrap. Using the Raw Material/Product Directory and the Waste Tracking modules, the facility is able to interface the Waste Minimization module to calculate relational indices. The relational indices are allowing the facility to account for reduction in waste quantities as a function of variable production activity.

Pollution prevention plans require ongoing analyses of source reduction opportunities and progress reports relating trends in waste reduction in relation to production activity. Using an integrated information management system, a generator is able to document waste, product and raw material characteristics as well as source reduction initiatives. The system serves as a relational analytical tool as well as a total material accounting and cost allocation system.

The system optimizes the use of existing data avoiding redundant data entry and error prone transfers by electronically interfacing existing environmental and manufacturing information systems.

The pollution prevention information system dictates standard data collection and entry procedures to avoid inconsistencies that could adversely influence its sustained use. To ensure ongoing commitment to the software, ongoing pollution prevention investments must be closely aligned with strategic business interests affording opportunities for improved profitability.

SYSTEM IMPLEMENTATION CONSIDERATIONS

An integrated environmental information management system should be implemented using a systematic phased approach that considers data adequacy and accuracy, system flexibility, modular use, report writing and standardization, required resources and time needed for systems analysis and the maintenance of software usage, compatibility and long-term use of commercial software, simplicity, and graphics capability.

FIGURE 1

ELECTRONIC INTERFACE CAPABILITIES OF THE FACILITY'S INTEGRATED INFORMATION MANAGEMENT SOFTWARE

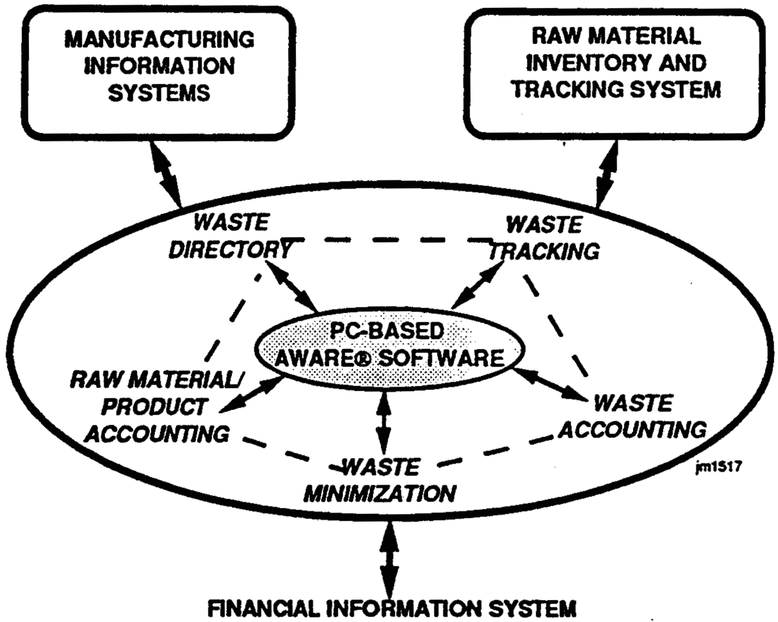
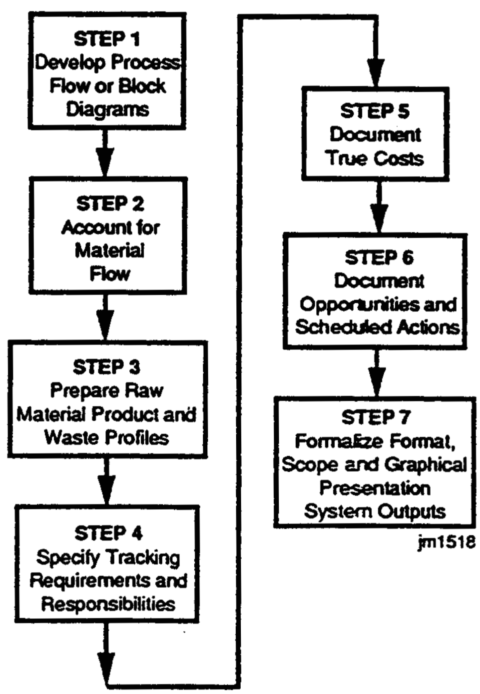


FIGURE 2

SYSTEMATIC APPROACH TO COLLECTING AND DOCUMENTING DATA SUPPLEMENTING POLLUTION PREVENTION PLANS



0171.air

INGREDIENTS FOR A HAZARDOUS MATERIAL CONTROL AND TRACKING SYSTEM

by

Mr. Sean M. Tomasic, Mr. Ronald M. Thomas, Mr. Craig A. Karhan
Modern Technologies Corporation
Environmental Technologies Division
4032 Linden Avenue
Dayton, OH 45432
(513) 252-9199

Introduction and Background

Current federal, state and local environmental laws and regulations have brought upon a need for businesses to track pertinent environmental and environmental-related information regarding hazardous materials. With a computerized tracking system, companies can make sound business decisions regarding every aspect of a hazardous material from purchasing through disposal. By the use of a hazardous material control and tracking system, issues regarding a company's environmental, safety and health responsibilities to its workers and the surrounding environment can be met in a greater and more timely manner. With an efficient tracking system, and defined policy and operating procedures, a business can improve its performance and efficiency.

Requirements of the System

There are many areas of concern when addressing the design of a tracking system. The following topics for design should be weighed against monetary demands, personnel requirements and current environmental needs:

1. Hardware / Software Interaction
2. Functional Requirements - User vs. Management
3. Environmental, Safety and Health Data / Reporting Requirements
4. System Application

1. Hardware / Software interaction

The choice of the computer systems architect is a very critical first step. Matters regarding cost, flexibility and interaction with existing systems need to be considered. The selection of software can be placed into three components: 1) program language, 2) database engine and 3) system platform.

These three components have many criteria in common for selection. A company must consider the common acceptance, support and future enhancements regarding these components. Selecting a product/tool that is widely accepted in the market will allow for a long product life in which upgrades will be available. The ability to receive current and future support is also very critical.

Along with common criteria for the components, there are separate needs of the components to be addressed. The database engine along with the platform needs the ability to interact/support other network operating systems. This allows operation over either a Local Area Network (LAN) or Wide Area Network (WAN). This function will allow the system the ability to retrieve/use databases of information from on-site or off-site locations. Also, the ability to link company locations across a large geography can prove very beneficial for the simple fact of commonality.

2. Functional Requirements - Users vs. Management

Anytime a new component enters the workplace, many questions arise regarding the necessity and usefulness of the tool. The computer system must address functionality requirements from a user and management perspective. Any consideration for needs without regard to both users and management will cause the system to fail - both requirements must be met.

Users must see that the tool will improve their ability to perform duties and not hinder or burden them. Management needs raw data and reports in order to meet regulatory reporting requirements, along with the ability to assess opportunities for the purpose of waste reduction and inventory control.

3. Environmental, Safety and Health Data / Reporting Requirements

One of the most difficult decisions for the system is what data needs to be tracked. If too little data is included, the system maybe deficient, too much and it becomes cumbersome. A starting point for data collection is to look at current needs with an eye to the future.

Current state, local and federal requirements will dictate to a great extent what environmental, safety and health data needs to be tracked. However, considering that the system will be used in tracking the life cycle of the hazardous material, (See Figure 1) other data besides the "traditional" data such as chemical name, quantity, hazards and location may need to be tracked. These could include costs for procurement and disposal, material process usage, material releases, digitized/image files of material safety data sheets (MSDS) and material substitutions.

The ability for a company to not only write its own data requirements, but to upgrade them as well, is a great benefit. When regulations change, having the flexibility to customize data fields to satisfy these regulatory changes is essential. Programs which do not allow for field customization can quickly become obsolete.

4. System Application

To effectively implement a hazardous control and tracking system, policies and procedures must to be established. Due in large part to environmental responsibilities crossing many paths, procedures regarding ownership, operation and maintenance often are overlooked or neglected.

The development of how a system will operate inside a company is as much of a key as what it will track. Duties must be assigned to the company's "players" involved and their respective "buy-in" must be obtained. In most cases, the computer system should be stationed in an organization who has the prime responsibility for environmental, safety and health issues within the company. Once the location of the system is determined, the flow of environmental data from within the company's site now has a focal point.

Future Requirements

With continuing advancement in computer technology and more stringent environmental regulations, a hazardous material control and tracking system can quickly become inadequate. With proper design criteria met regarding the software, hardware and environmental data to be tracked, enhancements from new regulations and computer advancements can be easily met.

Conclusion

The ingredients for a useful and successful hazardous material control and tracking system stem much further than viable computer software and hardware. The integration between policy, procedures and a computer system will effectively allow an organization to become more responsible in meeting its environmental duties while continuing its course of business.

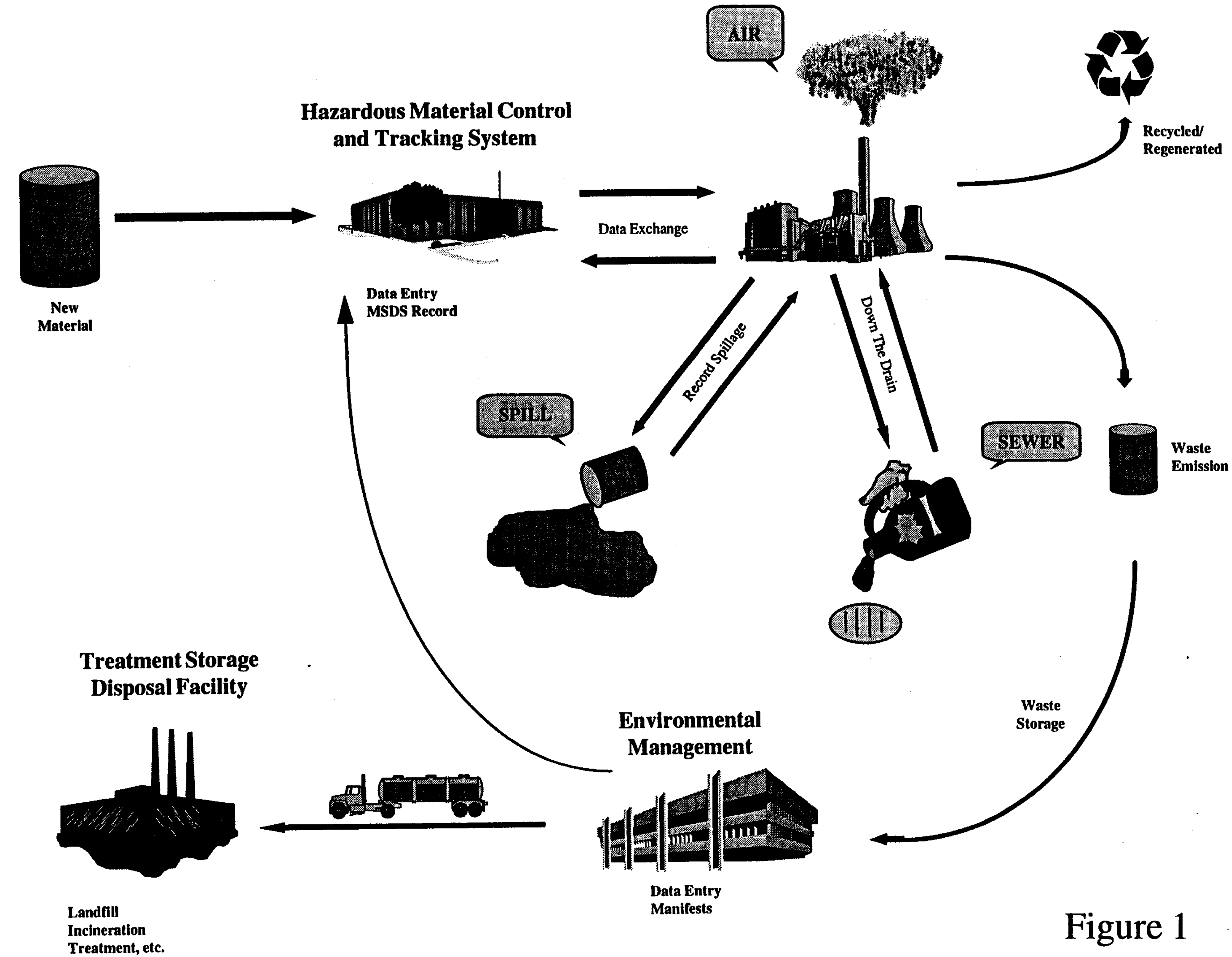
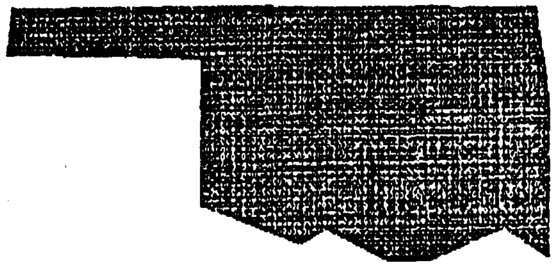

Hazardous Material Control and Tracking System
New Material
Data Entry
MSDS Record
Data Exchange
AIR
Recycled/
Regenerated
Record Spillage
Down The Drain
SPILL
SEWER
Waste
Emission
Waste
Storage
Treatment Storage
Disposal Facility
Landfill
Incineration
Treatment, etc.
Environmental
Management
Data Entry
Manifests

Figure 1



HAZARDOUS MATERIAL PHARMACY (HMP)

Lt Colonel Michael R. Glaspy
Director, Environmental Management
Altus AFB, OK

- *HMP Major Pollution Prevention Initiative*
  - *12 personnel, variety of organizations*
    - *Personnel assigned under LSS*
    - *HMP Chief reports to LG/CC*
  - *Vehicles*
    - *3 cushmans*
    - *1 pickup truck*
    - *1 shared forklift*
  - *Operations*
    - *24 hour/day*
    - *Deliver HM*
      - *Survey organizations, actual use*
  - *Contracts specifications language*
    - *Impact Card*
    - *Policy letters*
  - *Status*
    - *All base organizations*
  - *Accomplishments*
    - *Over 11,000 deliveries since October 1993*
    - *No major external ECAMP HM writeups*
    - *Savings over $100K in reusable HM excess*
    - *In excess of 700 manhours per week*
      - *Tenfold reduction in # of personnel handling HM*
  - *Benefits*
    - *Eliminates duplicate HM items*
    - *Eliminate swapping of HM (Unauthorized users)*
    - *Ensures trained personnel handling of HM*
    - *Reduces potential NOV's (Centralized problem area)*
    - *Eliminates EPA 17 through substitution*
    - *Proactive shelf life extension program*
    - *EPCRA too!*
  - *Critical components*
    - *Backing of Wing CC*
    - *Motivated personnel*
    - *Brick layers*

Pollution Prevention Strategies
for
Regulatory Compliance and Cost Reduction

Suzanne T. Thomas, P.E., QEP,
Jane Penny, P.E.
RUST Environment & Infrastructure
15 Brendan Way, Greenville SC 29616
803-234-3016

INTRODUCTION

Billions of dollars are spent each year to cleanup past improper disposal practices and billions of pounds of toxic materials continue to be released annually into streams, air and onto land as evidenced by the annual SARA TRI reports. These billions of pounds represent expensive raw materials, lost productivity, and inefficient processes. Developing a strategy to prevent waste generation of any type in the first place or to minimize waste volume or toxicity is the topic of this paper. The strategy consists of combining the compliance and reporting requirements under existing federal and state hazardous and toxic waste regulations into a materials management program with a cost program which reviews new processes, procedures and materials for their environmental cost.

The combination of a proactive materials management program with a user-friendly method of estimating the environmental cost of new procedures and processes results in an effective pollution prevention strategy.

MATERIALS MANAGEMENT

The first step in gaining control over waste is to gain control over the materials that are used in the processes and procedures. Every facet of the operating process or procedure must be examined and every material in use, no matter how innocuous, must be recorded and managed. Knowledge of all materials in use, whether toxic, hazardous, or benign, is the beginning of an understanding of the chemistry involved. And, for the most part, it is the chemistry and the physics that create the greatest environmental impacts. The use and processing of the raw materials then leads to byproducts generated, products produced, and a better understanding of the risks associated with each.

The easiest way to manage materials in this computer age is with a database management system. Although many systems are available off-the-shelf, they must often be modified for use in specific situations. And other systems are often very cumbersome to use. No matter what system is used, certain basic characteristics must be present to ensure an effective tracking of materials:

1. The raw materials database itself must have the following components:
   - Each raw material must be listed with complete MSDS information coded into the system. This necessarily includes synonyms, components and percents, physical and chemical data, hazard diamond ranking, storage and handling information, disposal information, environmental lists, and health and safety information.
   - Each raw material in use should be coded as to where and why it is used, and how much is used on a daily, monthly or yearly basis. Coding should include the basis for usage, i.e., for cleaning parts, a pounds per part cleaned would be a useful basis for future projections.
   - If the use of certain raw materials is part of a technical order or specification, then specific information relating to the orders should be entered.
   - If byproducts are normally generated when a raw material is in use, then the byproducts and the basis for their generation should be recorded.

2. A waste database must also be created to track any and all known wastestreams, i.e., hazardous waste via manifests, solid waste via landfill reports, wastewater via discharge reports, and air emissions via air permits and compliance testing. A relationship should be established so that linking to the raw materials database is easily achieved.
3. An approval system must be established to monitor any new materials or suppliers to ensure that they are environmentally friendly and can be tracked on the system.
4. A method of monitoring regulations to update the database information on a routine basis must be established.

In developing the database tracking system, it is apparent that the information stored is the first step in completing SARA Title III requirements for both Tier II and Section 313 reports. In addition, the data can also be used in the following traditional compliance situations:

- preparing traditional permit applications and renewals for air and water
- weekly wastewater discharge reports
- air sampling reports
- quarterly hazardous waste reports

- compliance audits
- process surveys and assessments
- accidental release planning
- TSCA reports

In fact, a well-designed materials management system will assist in the preparation of all environmental reports and documentation. More importantly however, it will allow all materials entering a facility to be tracked until their final disposition. A mass balance on all materials in use at a facility should achieve total closure when such a system is designed properly. Accompanying productivity increases and improved materials utilization will ultimately result in significant cost savings.

COST ACCOUNTING

A complete accounting of all aspects of environmental costs is the second part of a successful pollution prevention program. There may be little incentive to reduce the number of waste drums if the cost the waste hauler charges for disposing of one is $100. But if you also consider the cost of recordkeeping, permits, compliance monitoring, and community right-to-know, the $100. cost may double or triple. If you also account for the rapidly rising per drum cost and the money you may have to pay in the future in fines for accidental non-compliance and lawsuits for potential future remediation, the cost may grow to $500., $1000., or more.

Experience shows that traditional cost estimation procedures may understate the treatment and disposal costs. To gain a more accurate picture of total environmental costs and thereby increase the environmental performance of new processes, RUST has developed an environmental costing model. The model is based on EPA's four-tier approach to environmental cost, including usual disposal costs, the hidden costs of compliance, and the costs of liability and public perception. The user inputs the chemicals used, material charges, and conditions of their process. Missing information is filled in by the model using conservative, practical assumptions. Finally, investment, operating cost, and future liability cost is calculated.

A complete accounting of environmental costs from the earliest phases of considering new procedures and processes is therefore even more important for pollution prevention: early on there is much more flexibility in chemistry and process equipment, so the potential for economical waste reduction is far greater than after the plant or the procedure is running. Total waste cost accounting can be difficult in the plant, where presumably you know the efficiency of process equipment and the waste stream quantities and compositions. But in the conceptual phases it may be more difficult: the necessary information may not be readily available early in the research program, and the task of manually estimating total waste cost for multiple process options may be daunting.

The environmental costing model described in this paper has been developed as a tool with which to estimate the present and future costs for process environmental issues at all phases of process development. To overcome the limited amount of process information that is available in the earlier phases, the model takes advantage of whatever data is available and assumes conservative values for missing data. This keeps the model user-friendly through all phases of process development and facilitates making environmental considerations an integral part of initial process selection. How this was accomplished and other details of the model will be covered in the sections to follow.

COST ESTIMATING

The environmental cost estimated by the model is assembled from EPA's four tiers of environmental costs. These tiers are described as:

Tier 0: Usual costs associated with environmental control equipment, installation and engineering.

Tier 1: Hidden costs associated with environmental compliance issues and waste disposal.

Tier 2: Liability costs associated with penalties, fines, future remediation, and mitigation of accidents and spills.

Tier 3: Less tangible costs associated with employee, customer, and regulatory agency relationships.

Costs for the four tiers are estimated based on four types of input:

1. *Chemical-Specific Data* - Chemical and physical characteristics of all chemicals identified in the project, whether raw material, product, by-product, intermediate or waste stream. As each chemical is identified, a unique identifier is used to retrieve all MSDS data for that chemical from a chemicals tracking database. Data extracted for use by the model includes: physical state, boiling point, vapor pressure, specific gravity, solubility, volatility, explosive limits, etc.

   Regulatory information is also retrieved from the materials database using the hazard diamond ranking system for toxicity, fire, and reactivity; and a regulatory indicator which is assigned based on a scan of the MSDS for SARA, RCRA, CAA or CERCLA notes. This MSDS data is displayed to the user to allow for revisions based on new information.

2. *Process-Specific Data* - Unit process selection along with information on the complexity of the unit operation, utility requirements and wash stream information.
3. *Operational Data* - Includes operating schedules, conditions of pressure and temperature (by ranges), production data, and product/by-product separation information.
4. *Project Overview Information* - Includes site location and size, probable year of implementation, equipment dedication, and the potential to see toxicity synergism, toxic material generation, and complex phase behavior.

These four areas of data are organized by process unit operation called process blocks, shown in Figure 1.

To facilitate cost calculations with different levels of process information, input can be made at two levels of detail which are accessed separately. Level I is the base level for the program and is intended to be used in the early chemistry stage of a project when limited or no process specific data is available. Only the annual production volume and the MSDS ID number of the material streams flowing into and out of the process must be specified. All other data entries are set to conservative but realistic defaults which can be overridden if more accurate values are known. The environmental cost calculated by Level I is conservative.

Level II is intended to be used after the material balance and process flow diagram (PFD) development stage is complete. The data input for this level follows the same sequence as the input to Level I but requires detailed information on the process. The cost predicted by Level II will be less conservative and more accurate than Level I. Level II requests additional information on the following issues:

- Selection of a dominant mechanism for transport of contaminants outside plant boundaries
- Known discharges to air, water or land with quantities and/or concentrations
- Suggested air pollution control equipment
- The nature of the wastewater discharge
- Fugitive emission estimates
- Off-specification product generation
- Weighing factors for liability determination based on the EPA risk identification scheme.

Both Levels I and II assume that the new process is being implemented in an existing facility, thus, only incremental costs are calculated. The model does not currently estimate the cost of a new wastewater treatment plant, waste incinerator, or consider a new treatment, storage, and disposal (TSD) operation under RCRA. However the model remains open-ended to allow addition of subsequent levels to consider these factors and further refine cost estimates in the detailed design of the project.

SOFTWARE STRUCTURE

The model is structured into a relational database format. Major design features of this model include:

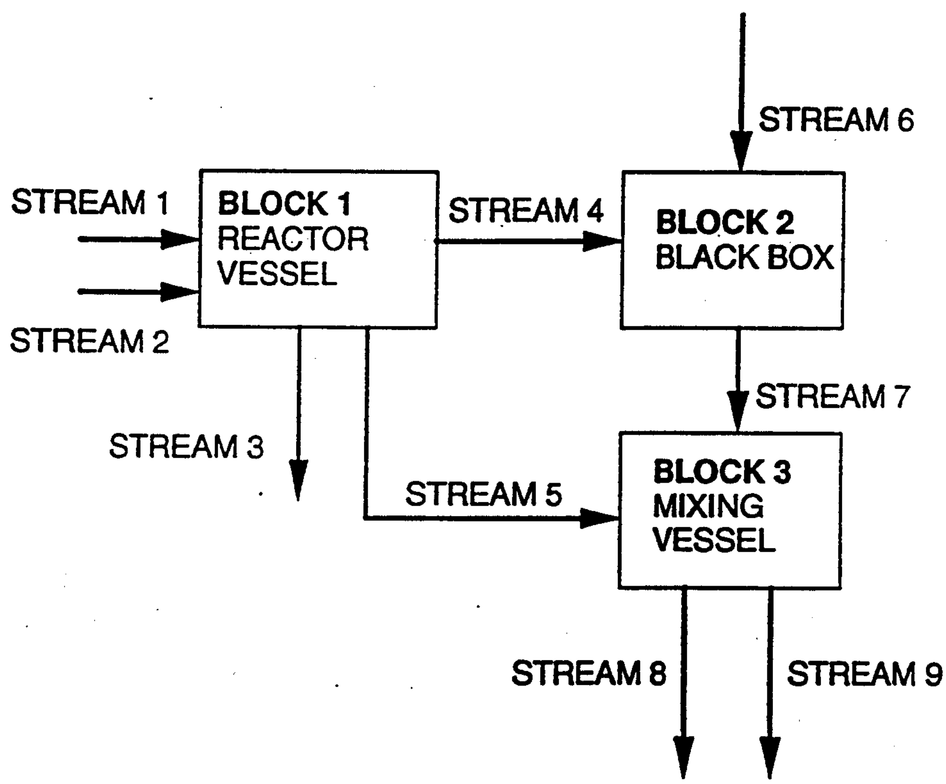
1. Tabular cost parameters which can be changed and updated as needed.
2. Downloading of MSDS information and updating feature for user-specific projects.
3. Flexibility to access either Levels I or II.
4. Expandability to higher levels.

CONCLUSION

The materials management tracking system and the environmental cost model described are the key components of a successful pollution prevention program. The cost model is a development tool; it is meant to be a realistic appraisal of the present and future environmental and waste disposal costs for a project. In early phases of project development, the cost model prompts and inspires process engineers to select and justify process chemistries, operating conditions, and equipment that embody the principles of pollution prevention. As the project progresses, the model identifies environmental cost reduction opportunities. As implementation of the project approaches, the model provides financial analysis with an economic picture of the environmental risk the new process may have.

In implementing the project, the materials tracking database then takes over by tracking usage and disposal information along with continually-updated regulatory information. Cost issues could also be tracked to further refine and enhance the cost model basis.

EXAMPLE OF A PROCESS FLOW DIAGRAM FOR THE ENVIRONMENTAL COST MODEL



This diagram correctly models Block 1 with three input streams and three output streams, Block 2 with two input streams and one output stream, Block 3 with two input streams and two output streams.

FIGURE 1

FLOW-THROUGH AND HANDHELD DEVICES TO PROVIDE ADVANCED LUBRICANT SEGREGATION CAPABILITY FOR PROTOTYPE OIL COLLECTION FACILITIES

Robert E. Kauffman, Larry D. Sqrow, and J. Douglas Wolf
University of Dayton Research Institute
300 College Park
Dayton, OH 45469

Phillip W. Centers, Ph.D.
WL/POSL
Wright Patterson AFB, OH 45433-7103

INTRODUCTION

The Air Force historically has combined used lubricating oils and other fluids (solvents, fuels, etc.) from different sources for recycling and reuse in secondary markets. However, present and future environmental regulations dictate that the Air Force develop waste management programs that segregate the collected used oils and fluids into well-documented stores of known composition. Segregating the collected used oils and fluids will also enable the Air Force to sell the waste oils and fluids to reprocessors increasing the economic and environmental benefits of the developed waste management programs. Since the presence of contaminants in waste oils greatly reduces their value to reclaim/reuse markets, procedures and techniques were needed to classify fluids, to detect contaminated fluids, and to segregate the waste oils and fluids into stores with known compositions.

Therefore, research is being performed to develop used oil management programs capable of segregating used aircraft engine oils (MIL-L-7808 and MIL-L-23699) from contaminated aircraft engine oils and non-aircraft engine lubricants and fluids. The research described herein was performed to identify and develop sensors capable of screening used aircraft engine oils for contaminants such as halogenated and non-halogenated solvents, fuels, aqueous solutions, and automotive engine oils. The developed sensors were then incorporated into flow-through systems to evaluate the sensors' capabilities to detect contaminants and degraded oils in used aircraft engine oils entering waste dumps and 55-gallon drums. Easy to operate handheld devices incorporating the developed sensors were then constructed to segregate incoming used oils and to ensure used oils do not become contaminated during storage.

CONTAMINATION SENSORS

Identification of Analytical Techniques

Introduction

The research project was initiated by collecting and analyzing used aircraft engine oils obtained from waste dumps and maintenance shops located at several Air Force bases and commercial sites. A wide variety of solvents (halogenated and non-halogenated) and jet fuels were detected in the used aircraft oils obtained from waste dumps. The used oils obtained directly from normally operating engines were uncontaminated. However, degradation products were detected in the used oils obtained from abnormally operating aircraft engines. Other possible contaminants include used automotive engine oils, hydraulic fluids, and other non-aircraft engine fluids.

The analytical techniques to be developed into contamination sensors were selected using the following criteria:

- Easy and inexpensive to operate
- Incorporation into flow-through systems
- Reliable, rugged, and rapid
- Inexpensive to construct or purchase
- Miniaturization into handheld devices
- Detects a wide variety of contaminants

Three types of sensors (vapor contaminants, liquid conductivity, and viscosity) were identified for development into used oil screening devices. A fourth type of sensor, a variable, wavelength infrared sensor was also developed for determining the fluid's chemical class.

Vapor Contaminant Sensors

Computer-aided literature searches and contacts with equipment manufacturers identified the following types of sensors to detect volatile contaminants:

- Tin dioxide (SnO_2) vapor sensor
- Halogenated vapor sensor
- Portable gas chromatograph
- Surface acoustic wavelength (SAW) device

The portable gas chromatographs would be useful as a secondary analytical technique to study, and possibly identify, the volatile contaminants detected by the oil screening device. However, the portable gas chromatographs are not suitable for incorporation into an oil segregation system and are more expensive to operate and purchase than SnO_2 sensors. The SAW device and halogenated vapor sensors are specific to certain classes of vapors, and consequently, would not detect a wide range of volatile contaminants.

Therefore, the SnO_2 vapor sensors were judged the best suited for development into vapor contaminant sensors. The SnO_2 vapor sensors meet all the listed criteria and have been used for decades in storage rooms to sense the buildup of organic vapors.

Liquid Conductivity Sensors

Computer-aided literature searches and contacts with equipment manufacturers identified several electrical properties of oils which could be used to evaluate the contamination and degradation levels of used oil samples. Of the identified electrical properties (conductivity, dielectric constant and loss, capacitance, etc.), the sensors used by dielectric and capacitance measurements were judged to be less rugged, less reliable, and harder to modify for incorporation into flow-through systems and handheld devices than the conductivity sensor.

Therefore, the sensors used by conductivity measurements were judged the best suited for development into liquid contamination and degradation sensors. The conductivity measurements are made between two closely spaced, parallel wires of equal length. If necessary, simple modifications (increasing wire length, decreasing the gap between the electrodes) can be made to increase the sensitivity of the conductivity sensors to detect lower concentrations of thermal degradation and contamination in used aircraft engine oils.

Viscosity Sensors

Computer-aided literature searches and contacts with equipment manufacturers identified the following types of viscosity measuring devices:

- Rotating spindle
- Vibrating quartz crystal
- Falling ball
- Vibrating reed
- Flow through a calibrated orifice

The vibrating reed viscometer was judged to be too expensive and impractical for incorporation into the flow-through device. The vibrating quartz crystal viscometer is still in development, is fragile and susceptible to contamination. Since samples containing high levels of particle contamination will be monitored during use, the viscometers based on liquid flow through a calibrated orifice were judged impractical for incorporation into flow-through segregation systems.

Therefore, the rotating spindle viscometer was judged to be the best suited for incorporation into a flow-through segregation system for used aircraft engine oils. A handheld falling ball viscometer was judged to be the best suited for limiting the number of contaminated oils entering the flow-through segregation system.

Variable Wavelength Infrared (IR) Sensors

Initial studies of the collected used oil samples demonstrated that IR spectrophotometry has very limited potential for development into a contamination detector. Therefore, an IR sensor which uses interchangeable optical filters to select the wavelength to be monitored by the detector was developed for chemical class verification (ester for aircraft engine oils, hydrocarbon for jet fuel and automotive engine oils, etc.) of used oils prior to entering the flow-through segregation system.

<u>Evaluation of Selected Analytical Techniques</u>

Solvents and Fluids

To initially evaluate the contamination detection, degradation detection, and chemical classification capabilities of the selected analytical techniques, various types of solvents and fluids were analyzed with the SnO_2 vapor sensor, conductivity liquid contamination sensor, rotating spindle viscometer, and variable wavelength IR sensor. The sensitivities of the sensors to the solvents and fluids were rated as high (H), medium (M), low (L) and not detected (ND) in Table 1.

The results in Table 1 indicate that the SnO_2 vapor contaminant sensor is very sensitive to a wide range of solvents and fluids and is sensitive to below 0.1% (1000 ppm) contamination levels of chlorinated solvents. The contamination level of 1000 ppm is critical since oils containing above 0.1% chlorinated solvents are considered hazardous waste greatly increasing disposal costs.

TABLE 1
SENSITIVITIES OF DEVELOPED SENSORS TO DIFFERENT TYPE SOLVENTS, LIQUIDS, AND LUBRICANTS

	Sensor Type			
Compound *	SnO_2	Conductivity	Viscosity	IR
MIL-L-23699 Oil	ND	ND	H	ND
Automotive Oil	ND	H	M	M
Mineral Oil	ND	ND	M	H
JP-8 Jet Fuel	M	ND	H	H
JP-4 Jet Fuel	H	ND	H	H
Gasoline	H	ND	H	H
Chlorinated Solvents	H	H	H	H
Non-chlorinated Solvents	H	ND	H	H
Organic and Mineral Acids	ND	H	H	ND
Degraded MIL-L-23699 Oil *	ND	H	H	ND
Oil* + 0.1% Trichloroethane	H	ND	ND	ND
Oil* + 1.0% Jet Fuel	H	ND	ND	ND
Oil* + 5.0% Automotive Oil	ND	L	ND	ND

H - High Sensitivity M - Medium Sensitivity L - Low Sensitivity
ND - Not Detected * Baseline Compound was MIL-L-7808

Used Aircraft Engine Oils

To further evaluate the potential of the developed sensors for detecting low levels of contamination and degradation, the used oils collected from the military bases and commercial sites were analyzed with the SnO_2 vapor contaminant sensor, liquid conductivity sensor, and rotating spindle viscometer. The IR sensors are incapable of detecting the contaminants present in the collected used oils, and consequently, were not evaluated. The contaminant ratings (pass/fail) of the SnO_2 vapor contamination, liquid conductivity, and viscosity analyses as well as the gas chromatography/mass spectrometric (GC/MS) analyses are listed in Table 2 for the collected used oils.

The results in Table 2 indicate that the SnO_2 vapor contamination sensor is extremely effective, e.g., vapor contamination ratings by the GC/MS and SnO_2 sensors were identical. The viscosity contamination ratings were only sensitive to the used oil samples with high levels of contamination. The viscosity and conductivity measurements detected the degraded oil obtained from commercial airline site No. 2 (Table 2) which was not detected by the SnO_2 and GC/MS analyses.

TABLE 2
SnO_2 VAPOR SENSOR, CONDUCTIVITY, VISCOSITY AND GAS CHROMATOGRAPH-MASS SPECTROMETRIC (GC/MS) CONTAMINATION RATINGS FOR COLLECTED USED AIRCRAFT ENGINE OIL SAMPLES

		Contamination Rating			
Military Site [a]	Sample No.	GC/MS	Viscosity	Sn/SnO_2	Conductivity
Air Force Base 1	1	Fail	Pass	Fail	Fail
Air Force Base 2	1	Fail	Pass	Fail	Pass
	2	Pass	Pass	Pass	Pass
Air Force Base 3	1	Fail	Fail	Fail	Pass
Army Base 1	1	Fail	Pass	Fail	Pass
Air Force Base 4	1	Fail	Fail	Fail	Pass
	2	Pass	Pass	Pass	Pass
Commercial Site [b]					
Commercial Airline 1	1	Fail	Pass	Fail	Pass
	2	Pass	Pass	Pass	Pass
Commercial Airline 2	1	Pass	Fail	Pass	Fail
Hospital Helicopter	1	Pass	Pass	Pass	Pass

[a] MIL-L-7808 Type Oil [b] MIL-L-23699 Type Oil

FLOW-THROUGH SEGREGATION SYSTEMS

Cylinder Flow-Through Segregation System

To evaluate the concept of a flow-through segregation system for used aircraft engine oils, the SnO_2 vapor contaminant and liquid conductivity sensors were incorporated into a modified 5-gallon aluminum cylinder. Numerous evaluations with used oils containing differing levels of contamination proved that the concept of a flow-through segregation system was possible. The sensors identified (sounded a buzzer) each sample with an unacceptable level of contamination or degradation. For used oils containing high levels (>0.1%) of chlorinated solvent, the buzzer sounded when the first portion of the oil entered the cylinder decreasing the time and effort of the subsequent cleanup.

Continuous Flow-Through Segregation System

Although the cylinder flow-through segregation device accurately detected and segregated the contaminated and degraded used oils, the segregation device was determined to be poorly suited for routine use for the following reasons:

- Used oil limited to cylinder size per testing cycle
- Extensive cylinder cleanout required after contaminated oil detected
- Cylinder drain rate of less than 0.2 gallon/minute
- Viscometer incorporation into cylinder impractical

Therefore, the continuous flow-through segregation device shown in Figure 1 was designed and constructed to correct the deficiencies of the cylinder flow-through system.

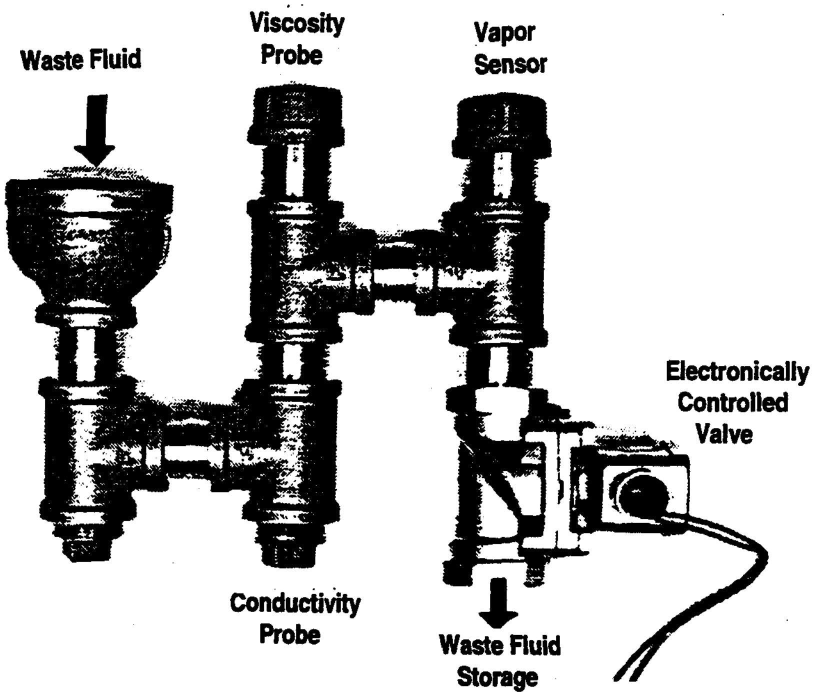


Figure 1 Photograph of Continuous Flow-Through Segregation System.

The continuous flow-through segregation device in Figure 1 was constructed from 2-inch brass piping (size of piping dependent on required drainage rate) fitted with the SnO_2 vapor contaminant and liquid conductivity sensors (fitting for viscometer also available for segregating used oils by viscosity class) and a solenoid valve to control access to the waste dump. The contaminant sensors, solenoid valve, waste dump level sensor, and contamination buzzer are monitored and activated by a programmable microprocessor. A display is used to prompt the user, display sensor readings, output contaminant level (pass/fail), and type of failure (vapor, liquid, viscosity, etc.). The electronically controlled valve connected to the waste dump opening is only closed when contamination is detected by the vapor or liquid sensors. Since the valve is left open, the vapor sensor continuously monitors the stored waste oil for contamination through unmonitored ports. The piping in Figure 1 contains removable plugs to allow drainage of contaminated used oil and to decrease the time and effort required to clean the system after contamination. Limited evaluations of the continuous flow-through segregation system with contaminated oil determined that the microprocessor is able to detect contamination and close the solenoid valve before the contaminated oil enters the waste dump.

Therefore, the initial results indicate that a continuous flow-through segregation system with a design similar to Figure 1 can be constructed which would be economical and well suited for routine use by the Air Force bases to segregate used aircraft engine oils entering waste dumps.

HANDHELD SCREENING DEVICES

Introduction

Handheld devices are needed to screen incoming waste oils for contamination, degradation, chemical type, and viscosity to reduce contamination, and subsequent cleanups, of the flow-through segregation system. The handheld screening devices are also needed to allow used oil reclaimers to verify the waste oils are free of contamination prior to transportation to their facilities. Handheld screening devices based on the SnO_2 and conductivity sensors were developed and evaluated as vapor contamination and liquid conductivity screening devices, respectively. The sensors and a 10 light LED display were encased in small metal boxes and powered by rechargeable battery packs (approximately 8 hours between charges). The vapor contaminant device was calibrated with carbon tetrachloride so that the tenth light represented 1000 ppm chlorine. The liquid conductivity device was calibrated so that the tenth light represented a severely degraded used oil sample (Table 2, Commercial Airline 2).

A prototype of the vapor contaminant sensor was sent to Noble Oil Company (Stanford, NC) for field testing. Personnel from Noble Oil Company obtained good correlation between the results of the handheld SnO_2 screening device with the current wet chemical test (15 minutes test time - color comparator for chlorine content) for detecting chlorinated contamination of collected waste oils.

The commercial handheld viscometer (falling ball) and developed liquid conductivity and IR devices have been successfully evaluated for ease of operation and reliability. Further evaluation of the devices will be performed during future research programs.

SUMMARY

The initial results presented in this paper demonstrate that contaminated and degraded aircraft engine oils can be detected by using a dual sensor combination which incorporates the SnO_2 vapor detector and the liquid conductivity detector. A viscometer and an IR detector can be incorporated into the sensor system to segregate the waste fluids by viscosity grade and chemical class, respectively.

A flow-through segregation system (Figure 1) which incorporates the vapor/conductivity sensor combination was constructed and determined to be well suited for use by Air Force and commercial personnel concerned with waste oil disposal and segregation. Handheld devices based on the developed sensors were constructed for screening incoming waste streams to minimize contamination of the flow-through system and for checking stored waste oils for contamination prior to transportation to reprocessing or reclaiming facilities.

Future research will concentrate on field testing the flow-through and handheld devices at military and commercial sites involved with waste oil disposal and fluid segregation. Used oil management programs involving waste oil reclaimers and reprocessors will also be developed during future programs.

ACKNOWLEDGEMENT

This research was supported by the U.S. Air Force Wright Laboratory, Aero Propulsion and Power Directorate, Wright-Patterson Air Force Base, Ohio under Contract No. F33615-92-C-2218, Task 2 with P.W. Centers serving as Technical Monitor.

SESSION XIV

TO/MIL-SPEC ISSUES/POLLUTION PREVENTION MANAGEMENT

Session Chairpersons:

Brian Ballew, San Antonio - Air Logistics Center
Greg Stanley, HQ USAF/LGMM

PROCESS ORIENTED TECHNICAL ORDER REVIEW

by Laura Maxwell, P.E.
Charles Williams, P.E.
Capt Peter Poon, P.E.
Roby Gregg

SA-ALC/TIESM
450 Quentin Roosevelt Rd
Kelly AFB, TX 78241-6416
(210) 925-7391
FAX (210) 925-4916

*ABSTRACT: This paper will discuss the Process oriented strategy used by San Antonio Air Logistics Center (SA-ALC) to meet Air Force (AF) hazardous materials reduction goals. The primary focus of the AF Ozone Depleting Substance (ODS) program was on technical documents, especially Technical Orders (TOs). The AF approach was to search **all** TOs to identify ODSs and to replace them. However, a different strategy is necessary for the EPA 17 (i.e., targeted chemicals of the EPA's Industrial Toxics Project) and the TRI (i.e., Toxic Release Inventory chemicals targeted under Executive Order 12856) chemicals. The EPA 17 and TRI reduction effort must be **process** oriented. Unlike ODSs, which were totally banned, the goal for the EPA 17 chemicals is a 50% reduction in usage by CY 95 and a 50% reduction in the releases of TRI chemicals by CY 99. Recognizing that difference, SA-ALC/EMP and SA-ALC/TIESM have designated a Process based program to meet these reduction goals in a cost-efficient manner. The program will focus first on identifying the processes that use EPA 17 chemicals and waste streams that contain EPA 17 chemicals. This emphasis will also take care of TRI reduction goals since all 17 EPA substances are also on the TRI list, and few other TRIs generate significant amounts of hazardous releases. Then these processes are prioritized based on a Risk-Quantity criterion. Instead of targeting all EPA 17 processes at the same time, Process Assessment Teams will target the high priority processes. These teams will trace the process back to an authorizing TO and determine whether it is feasible to eliminate the EPA 17 usage. If elimination is not possible, the teams will attempt to make the process more efficient so that less EPA 17 chemicals are required and less waste stream is produced. By using a Process oriented strategy, we will prove that cost and time will be saved because, unlike the AF ODS strategy, **not all** TOs, and other technical documents, must be searched and callouts of EPA 17 and TRI chemicals reduced.*

PROCESS ORIENTED TECHNICAL ORDER REVIEW

By: Laura Maxwell, P.E.
Charles Williams, P.E.
Capt Peter Poon, P.E.
Roby Gregg

SA-ALC/TIESM
450 Quentin Roosevelt Rd
Kelly AFB, TX 78241-6416
(210) 925-7391
FAX (210) 925-4916

Currently, the elimination of all Ozone Depleting Substances (ODSs) continues to be the primary focus of hazardous materials programs across the Air Force. This approach does not discriminate between a 50,000 pound use and a one ounce use. The AF approach required the search, review and revision of **all** technical documents, especially Technical Orders (TOs) which contained ODSs.

A different strategy is necessary for the Environmental Protection Agency's Industrial Toxics Project, known as the EPA 17 for the number of targeted chemicals on the list, and the Toxic Release Inventory chemicals targeted under Executive Order 12856, known as the TRI. Unlike ODSs, which will not be produced by the end of 1995, the *goal* for the EPA 17 chemicals is a 50% reduction in ***usage*** by the end of 1995 and a 50% reduction in the ***releases*** of TRI chemicals by the end of 1999.

Note the terms of the goals: ***usage*** and ***releases***. These terms relate to gravitational units of measurement (GUMs), like ounces, pounds, kilograms or tons. Usage and releases cannot be measured by the number of TOs nor by the number of callouts within these TOs since these technical documents specify *what* and *how* a chemical or compound is to be used for maintenance or overhaul operations, but not *how much*.

A major point in the consideration of meeting both 50% reduction goals is that *these reduction programs are voluntary NOT regulatory*. Not mandated, not regulated, not *required* by the EPA and no penalties, except in public perception if a company or agency does not appear to be doing its best to protect the environment for future generations. This means that the EPA 17 and TRI reduction efforts must be orchestrated smartly and efficiently to maintain operations and minimize costs.

So the goal of 50% reductions in EPA 17 usage and TRI releases cannot be measured through TOs. And this goal is voluntary so that efficiency can be maintained within an agency's operations. This means that only a ***process*** oriented assessment of EPA 17 or TRI reduction efforts can be used to measure progress.

NEW THINKING

The EPA 17, although a relatively "short" list, is nonetheless quite broad in application (see Figure 1). The TRI is a more extensive list comprised of over 300 chemicals so is not shown herein. Several hundred more chemicals are proposed to be added to the TRI list.

Environmental Protection Agency Industrial Toxics Project			
Benzene	Cadmium	Carbon Tetrachloride	Chloroform
Cyanide	Dichloromethane	Lead	Mercury
Methyl Ethyl Ketone	Methyl Isobutyl Ketone	Nickel	Perchloroethylene
Toluene	1,1,1-Trichloroethane	Trichloroethylene	Xylene

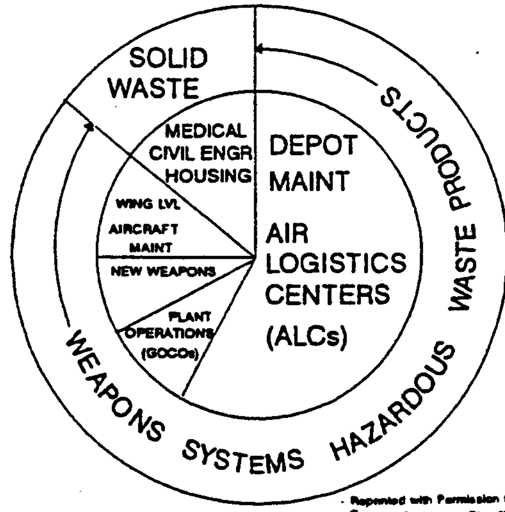
Figure 1. List of EPA 17 Hazardous Substances Subject To 50% Reduction in Usage

All 17 substances on the EPA Industrial Toxics Project list are also on the TRI list. From cleaning to plating and intermediary operations, these chemicals and compounds are pervasive in industrial operations. Managing reductions in 300+ chemicals through technical documentation changes in NOT an efficient method.

Recognizing the difference between a total ban of ODSs and voluntary reduction programs, a team from the San Antonio Air Logistics Center (SA-ALC) Environmental Management Pollution Prevention Division and the SA-ALC Technology & Industrial Support, Materials Engineering Environmental Program designed a **Process based** program to meet these reduction goals in a cost- and time-efficient manner.

Two paradigms were in place with the initial EPA 17 and TRI policies. The first paradigm to avoid was reliance on the number of TO revisions as a measure of effectiveness or progress. TOs were intended to instruct depot and field personnel in the "with what and how's" of a maintenance operation, NOT ***how much*** to apply on a rag or put in a tank.

The second paradigm to hurdle was that the reduction goal is not 50% reduction in usage of *every* EPA 17, but the reduction in TOTAL AGENCY pounds used. This is an important consideration, since the 5 ALC depots (SA-ALC, Oklahoma City ALC, Odgen ALC, Sacramento ALC and Warner Robins ALC) generate over 50% of the hazardous waste within the Air Force (see Figure 2).



- Reprinted with Permission from the Air Force Center for Environmental Excellence Pollution Prevention Div., "Characterizing the Process"

Figure 2. The ALCs Share of Hazardous Waste

It is also important to realize that there are multiple drivers for reductions in hazardous materials besides the EPA 17 and TRI laws. A few of them are the Clean Air Act (CAA), the Clean Water Act (CWA), and the National Emissions Standards for Hazardous Air Pollutants (NESHAPS). These laws affect all field and depot installations. It is reasonable to expect that the current **reduction efforts** in EPA 17 and TRIs as applied to routine maintenance processes **at the** 5 ALCs, in combination with the other environmental laws at all installations, will enable the AF to meet the **TOTAL Air Force** EPA 17 and TRI **reduction goals.** Again, this can be done by focusing on *ALC processes*, without imposing unreasonable EPA 17/TRI- related reporting or restricting operations at field units. The Air Force will be able to meet public expectations without hindering the mission and will be able to transfer new methods and maintenance processes to the field to reduce their hazardous materials usage and releases.

STRATEGIZE

The SA-ALC EPA 17 and TRI Reduction Program will focus first to identify the processes that use EPA 17 chemicals, trace the waste to the source, measure input and output of hazardous materials and contaminated waste, and prioritize which chemicals to target first.

I.D. the Process

Identification of EPA 17-contaminated processes begins categorizing hazardous waste products. All installations are required by federal law - the Resource Conservation and Recovery Act (RCRA) and the Toxic Substance Control Act (TSCA) - to record and report hazardous waste generation. The local Environmental Management (EM) organization reports this data. The hazardous waste can then be traced directly back to the shops where it was generated.

Trace the Source

Traceability of a process is more than just "sampling the water"; it also involves *accountability* of the user. A procedure by which a user identifies and requests authorization for use of a chemical has been installed at SA-ALC. The form, called the "Chemical/Hazardous Material Authorization Request" (SA-ALC Form H-32), is easy to fill out and requires that the user provide a copy of the Material Safety Data Sheet and a direct reference to the TO driving the use. This input is entered into an EM database. Once approved, the *user* is held accountable for correctly using the approved substances. From this reporting and recording step, we know *what chemicals* are used at *which locations* and *what technical documentation* is driving the use. However, we still do not know *how much* is being used.

Measure for Usage

Once approval has been granted to purchase a chemical, the amount delivered is recorded by EM. Thus the total purchases of a particular chemical can be counted (see chart) for each shop. Supplies purchased indicate how much is used over a certain time period. So the *usage* can be measured by amounts purchased (GUM) - baselined for a particular year, and continuously measured for reduction percentages to meet the EPA 17 goal.

PRIORITIZE FOR REDUCTION

We noticed that the EPA 17s currently used at the depots are also the largest, most significant amounts of substances on the TRI list. And since EPA 17s are reductions in ***usage*** and TRIs are reductions in ***releases***, then the TRI goals will be easily met by EPA 17 reduction achievements. Smart use of data already being compiled by the installation Environmental Management (EM) organizations can ease meeting **both** EPA 17 and TRI goals.

Now that the who, what and where of all hazardous chemicals is known, which chemical(s) are attacked first to reach the EPA 17 and TRI reduction goals? All 300+ cannot be worked simultaneously. Priorities can be difficult to set since all reduction targets can be classified into two categories: Politically Favorable and Ethically Sensible. These two categories are not mutually exclusive although often treated as opposites. Priorities and plans can be set with both categories of targets in mind.

Politically Favorable targets are those reductions that can be accomplished in the shortest amount of time with the greatest amount of gain (reduction). They are measured by GUMs and are easily tracked by EM data. Ethically Sensible targets are more difficult to achieve since total elimination of the chemical and process are preferred above reducing the amount of chemical used. Ethically Sensible targets are measured by RISK reduction - an elusive number at best. Only a few target chemicals can be eliminated, but more often the total amount of a given chemical used can be easily reduced by simply improving the process and improving efficiency.

Also, a fact noted during the identification phase, **very few TOs** are driving the majority of hazardous materials used. This means that NOT ALL TOs need to be searched, reviewed and revised. Only the relatively few requiring the larger quantities of materials purchased. Significant monetary savings in digitization, review, substitution engineering and publication costs can be achieved by careful prioritization of TOs, instead of all-out TO-clean-up warfare.

Reduction Methods

One of the first considerations for reducing EPA 17 chemical usage is Maximum Achievable Control Technologies (MACT). Many installations and industries have facilities that could greatly benefit from more efficient, less costly and safer off-the-shelf equipment upgrades or new advanced technology-based systems. Installing new equipment allows the user to continue the authorized process and still reduce quantities of hazardous materials required to perform the same job. This type of initiative **does not** require a TO change and meets Politically Favorable targets quickly and efficiently. No new health or safety hazards are introduced and personnel protective equipment remains the same.

Other considerations are those changes that **do** affect TOs. The entire process must be assessed by a technical team at this point. What exactly does the process entail? What procedures are *authorized* (i.e., traceability to which TOs)? What are the *requirements* for each component undergoing this process? And how can these requirements be met without use of this chemical? This is the Ethically Sensible side of prioritization. Our team is made up of Environmental Management engineers, Materials Engineering personnel and the cognizant engineers, together with shop floor personnel. Our process assessment will detail each of the above criteria for a few targeted chemicals and form a reduction/replacement strategy.

We must remember that a great deal of effort could be expended in eliminating or reducing Chemical Z to meet Ethically Sensible goals, with little to no impact on the total EPA 17 poundage. The reduction goals lend themselves to full utilization of MACT first (Politically Favorable), then accomplish follow-up work on Ethically Sensible targets.

Replacement strategies are full topics on their own, but a few of the evaluation requirements are: process in use (i.e. cleaning, plating, etc.), materials in process (which solvent or solvents), materials of components being processed (aluminum, steel, cadmium-plated, etc.), materials of existing equipment, availability of possible substitutions, materials compatibility, testing, availability of specifications (government or industry), qualification and control of substitution chemical or process, revision of TOs, and distributing the changes with proper training to the field units and depots so that all installations can reduce hazardous chemical usage and releases.

CONCLUSION

By using a ***Process oriented*** strategy, EPA17 usage and TRI release reduction goals can easily be met. This strategy expends a minimum amount of time and effort to meet *pounds* related goals *without* searching, reviewing and changing <u>all</u> TO call-outs of hazardous materials. This allows us to meet our goals smartly and quickly without impairing our mission or our support to our customers.

REPELLETIZING SPENT PLASTIC MEDIA FROM DEPAINTING PROCESS

by

Alan O. Rockswold//SM-ALC/EMP
5050 Dudley Blvd., Suite 3//McClellan AFB,CA
(916) 643-3341x351//DSN 633-3341x351

THE PROBLEM

Paint and other coatings must be removed from aircraft, vans and ground equipment to allow inspection and maintenance of the equipment. Methylene chloride was a common material used for paint removal, but its use has been reduced because of environmental considerations. The use of methylene chloride based paint removers requires large amounts of rinse water and generates large amounts of contaminated waste water.

Methylene chloride based paint removers have been replaced with plastic media blasting, which eliminates the waste water problem. However, the plastic media blast (PMB) process generates tons of contaminated spent bead dust, which must be disposed as hazardous material due to heavy metal contamination

THE PMB PROCESS

Plastic media beads (PMB) are used in high pressure nozzles to remove paint from surfaces. The process is similar to sand blasting process, but it is less abrasive than sand. Beads impact on the coated surfaces and scrub away coatings. During the process, beads are eroded away and reduced in size. The beads, which drop to the floor, are collected and recycled through a two stage sieve and then to the depaint nozzles feed tank.

In the first stage, chips and other debris are discarded. In the second stage, useable beads are separated and are reused. The dust which passes through the second sieve is too small to be effective in removing coatings and must be discarded. It must be disposed of as hazardous waste since it contains heavy metals from the pigments in the coatings and also chromium from the corrosion protection coating. Although the amount of heavy metals is relatively low, the spent beads will not pass the leach extraction test because particles are very small and the metals are easily extracted.

POTENTIAL SOLUTIONS

Incineration of spent media has been investigated, but has presented difficulty in that the material tends to stick together making handling and clean burning difficult. Further, all incineration processes generate air emissions which are difficult to control and require hard-to-obtain air permits.

Separation of spent PMB using air flotation has not been successful since apparent densities are virtually equal. This method appears to be not feasible.

Separation by use of liquids with carefully controlled densities has provided some separation potential, but in most cases has resulted in large amounts of liquid to handle and eventually dispose of. In addition, the PMB must now be separated from the liquid. Although this method of separation will work, it is messy and not a satisfactory solution.

Thermoplastics can be re-melted in plastic extrusion machines and can be reformed. Type V plastic media is considered to be thermoplastic and can be re-melted. Unfortunately, at the plastic softening point, considerable degradation occurs and the plastic tends to regress back to the monomer. It becomes sticky and is no longer suitable for use as plastic media for coatings removal.

THE SUBJECT SOLUTION

McClellan AFB decided to further investigate the feasibility of re-melting and reformulating plastic media beads using some type of plasticizer so lower melt temperatures could be used. A contract solicitation was offered and Battelle, of Columbus, Ohio was awarded a contract to investigate the reformulation of PMB into useful beads for re-use in removing coatings. Battelle has determined that the PMB can be reformulated into usable beads by using a solvent plasticizer in the extrusion process. The solvent is recaptured and recycled through the process.

This paper describes the process that has been developed and the current status of progress toward its implementation at McClellan AFB.

PROCESS DEVELOPMENT

Battelle was chosen in part because of their experience in the plastics and process industries and in part because they had plastics processing equipment suitable for the proposed process available at their Columbus facility. They also have extensive laboratory and polymer test equipment available.

Initial tests at Battelle centered around demonstrating the feasibility of the process using new, unused beads. They quickly determined it was necessary to use some sort of plasticizer to assist in softening and plasticizing the polymer so it could be pumped, mixed and extruded from a plastics extruder. Several plasticizers were considered but each had some deficiencies. The plasticizer finally selected is relatively non-toxic, is not a smog precursor, works well in the process and was assessed as having the best balance of properties. It is also the cheapest to use in the long run. Unfortunately, it is a flammable solvent, so the entire system was designed to operate as an explosion proof system. Solvent recovery is provided.

The next hurdle was to develop a method of reducing the polymer strands extruded from the extruder into the right size range. It was necessary to quickly cool the strands so they could be chopped into pellets. In the first tests, water quench was used, but was replaced with dry ice, which worked better. The resulting pellets(approx. 1/8"d x 3/16"l) needed to be reduced to the proper size range for use. A hammermill type grinder was tried. Due to the residual solvent, the grinder tended to smear the polymer and did not make suitable size beads. Before grinding was retried, the pellets were heated to remove the residual solvent. When the material was cooled again, it could be ground to a suitable size range.

At this point, Battelle demonstrated that the process was possible. It was now necessary to optimize the process. A better cooling system than mixing with dry ice was desired. Liquid nitrogen was tested and found to be suitable for initial cooling. It was also determined that with new, sharper grinder blades it was not necessary to use dry ice for reducing the pellets to the proper size range for beads.

The next thing to check out was the suitability of reformulated beads for removing paint coatings from test panels under standard conditions. Standard test panels were prepared using standard test coatings similar to coatings used by the Air Force on aircraft and other equipment. These coatings were bead blasted under standard conditions. Stripping rates were measured and found to be equal to, or greater than rates with new, unused beads. Aggressiveness to the substrate metal and bead attrition rates were equal to, or less than that of new beads.

After checking with California air pollution authorities, we agreed that a solvent recovery range of 95.5% or higher was acceptable. The proposed project at that time recovered only about 90% of the solvent. The solvent recovery system was redesigned to capture more than 95.5% solvent by using super cooled chillers.

Another minor improvement we agreed to was to replace proposed bucket elevators with screw conveyers to minimize chances of small metallic parts getting into the machinery, especially the extruder.

CURRENT STATUS

An acceptable process has been demonstrated. Suitable equipment has been ordered for installation at McClellan AFB. Delivery of essential major equipment is scheduled for early September and equipment installation is scheduled to start on 1 September. Site facility modifications are in process and are scheduled for completion by 1 Sep 94. Once the installation of the equipment is completed, Battelle will initially operate the equipment to complete the test trials, to optimize the operating procedures, train McClellan personnel, prove the process and the equipment, and determine the optimum number of paint/depaint cycles.

FINAL DISPOSITION OF SPENT PMB

As spent PMB is recycled, a portion of the material (about 20%) will be diverted from the process to limit the buildup of heavy metal contaminants. These pellets will be formed into useful end-use products. Some potential uses include filler for faux-marble counter tops, partitions or doors; moldings, fence posts, parking lot bumpers, pallets and planter boxes. By developing a final useful product, disposal of spent PMB as hazardous waste can be eliminated. At McClellan AFB, that equates to elimination of about 200 tons per year.

It is estimated this project will pay for development costs, equipment costs and operating costs in 3.1 years. Liability risk assessment in using the final products is considered to be equivalent to the risk of alternative disposal such as in a landfill.

SUMMARY

A process to recycle spent plastic bead media from depainting Air Force aircraft, communication vans and other equipment has been demonstrated in semi-commercial equipment. The process will be installed and operated at McClellan AFB in late 1994. Final disposition of the bead media will be into useful end-use items. It is expected the process will be profitable

Science Applications International Corporation
An Employee-Owned Company

Ozone Depleting Chemical (ODC) and EPA-17 Chemical Elimination From Technical Orders

Mr. Charles Williams
SA-ALC/EMP
Kelly AFB, TX 78241-5000
Phone (210) 925 3100 ext. 331

Mr. Alfred E. Eudy
Science Applications International Corporation (SAIC)
4242 Woodcock
San Antonio, TX 78228
Phone (210) 731-2200

BACKGROUND

In 1992, the SA-ALC EMP and TIESM organizations formulated a strategy for complying with Air Force objectives to eliminate Ozone Depleting Chemicals (ODCs) requirements from Technical Orders (TOs), Military Specifications (MIL-SPECs) and Military Standards (MIL-STDs). SAIC provided engineering support needed to implement critical portions of the strategies. Separate programs for Hazardous Material (HAZMAT) TO Identification and Preparation, Digitization and Screening for ODC references, Chemical and Process Substitution, as well as Printing and Publication resulted from this effort.

On 23 Dec 93, the Deputy Assistant Secretary of Air Force Acquisition directed a comprehensive acquisition pollution prevention policy. One of the primary objectives of this policy was designed to eliminate the use of ODCs and hazardous materials. This policy also requires that the acquisition community initiate procedures for required changes to technical orders and MILSPECs, and to make the necessary investments to physically implement the changes in acquisition programs in support for Single Managers (SMs) to implement pollution prevention policies to reduce ODC and HAZMAT use and release in the environment to as near zero as feasible.

Of the 43,000 TOs maintained by SA-ALC, over 1800 were eventually identified as TOs requiring the use of ODCs and other chemicals/materials targeted by the EPA for reduction. We anticipate that by 31 Dec 94, process changes will have been initiated to eliminate 20,000 HAZMAT chemical references from these TOs including all ODC requirements (except for those requirements needed for Liquid Oxygen) . During the start up of this pollution prevention program, numerous problems were encountered, including: identifying possible substitutes, identifying which TOs contain targeted chemicals and materials, pricing a contract when most factors upon which a price would be based were unknown, developing a Statement of Work (SOW) to describe the process, handling an interagency digitization contract, coordinating with all team members to ensure team personnel successfully communicate acceptable substitutions, developing a database system for efficiently identifying substitute chemicals and processes, and establishing a priority for processing of TO changes.

CHEMICAL AND PROCESS SUBSTITUTION

Technical Orders (TOs) were found to contain a wide range of stringent technical requirements for using hazardous chemicals. The requirements to use these chemicals are driven by performance standards and other considerations such as toxicity, availability, and the operational environment. Specific TO callouts of targeted chemicals, such as Ozone depleting Chemicals (ODCs) and others targeted under the EPA's Industrial Toxics Program (EPA-17), impede chemical and process substitution. Therefore, TOs must be screened and reviewed to identify opportunities where toxic substances can be reduced or eliminated, less toxic substances substituted, or procedures modified to reduce pollution.

The Kelly AFB and SAIC Environmental Team has developed streamlined, automated procedures to find, validate, and substitute less hazardous alternatives for targeted chemical substances. Kelly AFB has been evaluating substitutes for several years with the intent to make TO substitutions. The team's approach to providing engineering support to eliminate those targeted chemicals and processes requires various engineering and administrative procedures.

TO Identification and Preparation

The customer, Kelly AFB, identifies TOs for processing based on their knowledge of the requirements of the TO for use of hazardous chemicals.

Digitization and Automated Screening

Each TO is reviewed to ensure completeness and all changes are posted prior to digitization. The TOs are digitized using optical scanners, optical character readers, and "tagged" using a system of "modified" Standard Generalized Markup Language (SGML) software. After review, the digitized and tagged TO is processed against Air Force-developed Tech Order Review Program (TORP) software. TORP generates a Chemical Process List (CPL) which pin-points the location of each targeted chemical.

Chemical and Process Substitution

TOs are selected for chemical and process substitution based specifically on ODC callouts. Once a TO is selected, both ODCs and EPA-17 chemicals are processed to identify possible substitutions. Initial work involves administrative procedures designed to examine the assigned TOs for completeness, to ensure each TO has a corresponding CPL that correctly pinpoints chemical targets, to establish a tracking system for each technical order and to estimate the number of callouts for targeted chemicals.

After initial processing, chemical and process substitution begins with reviewing and verifying the CPL produced by TORP, and identifying performance requirements for each targeted chemical on the CPL. Information from each verified target is loaded in an SAIC-developed data base which compares each targeted chemical with various alternatives. Each alternative is compared to similar applications and processes used in previously processed TOs.

In many instances, substitute alternatives are drawn from a list of "approved" alternatives which have been cleared by Kelly. The list of permissible substitutes is a "living" data-base, constantly updated as new, better alternatives are identified and approved. In other instances, we must perform research on chemicals and chemical mixtures by examining chemical and physical properties of suspected targets to identify chemical constituents. Manufactures' chemical trade names such as "Chlorothene" and "Chloroethane" may require additional research to identify targeted chemicals and acceptable substitutes. Therefore, the chemical data base is being constantly updated with new chemical names and MILSPEC numbers as chemical targets and mixtures are identified which are found to contain targeted materials.

The most important lesson to be learned in chemical and process substitutions is that alternatives ***cannot*** be used as simple, drop-in replacements. An array of alternatives must be considered, and each substitution must be based on applicability of the replacement chemical to the immediate and follow-on processes, meeting required performance standards, the availability of the replacement chemical, and the expected working environment where the chemical will be used. All of those considerations are extremely important in identifying acceptable substitutes In some instances, substitutions cannot be made. This must be realized and accepted.

Other important lessons learned in reviewing TOs is that each TO must be additionally screened manually due to incorrect MILSPECs associated with targeted chemicals, incorrect spellings of targeted chemicals which allow the chemical to "escape" identification and pinpointing its location through TORP, reference to a targeted "solvent" or "chemical" by a number in the consumable materials listing rather than identifying the target, and procedures requiring duplicated processes. Also, many of the TOs list cleaning procedures that are "cut and pasted" from other TOs; therefore, the errors associated with paragraph numbering, MILSPEC numbers and spellings are transposed into other TOs. All lessons learned from working previous TOs are incorporated into the data base daily.

The process is finalized with a series of deliveries that includes a new Chemical Process List which pinpoints the exact location and application of each targeted chemical, a Form 252 (TO Change Request Form) with the recommended chemical deletion and recommended alternative, and for some chemicals with no substitute, a listing showing a recommendation of "no substitute available" without performing additional testing. The Form 252 flows into the existing TO change system and eliminates confusion when making a large number of changes.

PROGRAM ACCOMPLISHMENTS

The success of this program is unprecedented. First of all, the Chemical Dictionary used in TORP contains more than 11,000 targets listed by military specification, trade name or chemical name. Not all the chemicals are hazardous, but Kelly AFB felt that all chemicals should be identified. Therefore, this large data base not only pinpoints the location of the possible combinations of targets identified as possible ODCs (225) and EPA-17 (775) chemicals, but also provides a listing and the locations of other chemicals which may require future tracking.

The most striking benefit of the expanded Chemical Dictionary was recognized immediately by our ability to substitute toluene and xylene based coatings such as polyurethane paints, enamel paints, lacquers and primers with water-based or less volatile alternative coatings. Another advantage of this expanded dictionary was illustrated by our ability to pinpoint and substitute solvents such as PS-661, P-D-680 Type I and Type II, and EPA-17 targeted solvents such as Trichloroethylene, Perchloroethylene, Toluene, Xylene and Methyl Ethyl Ketone. In many of the applications, we were able to make direct substitutes with aqueous based cleaners.

As a part of the substitution process, we also performed a process review where targeted chemicals (ODCs and EPA-17) are used. During this review, we identified several process and application errors in many of the Technical Orders. Examples of some of the errors identified include requirements for using P-D-680 to clean electrical parts or as a precoating and surface cleaner prior to applying primers and paints. In other cases, we found incorrect spellings and MILSPECs which were not compatible with the listed targeted chemicals. When application and previous substitution errors are identified, we provide recommended process and chemical substitutes to correct the technical order on a Form 252 (TO Change Request Form) with appropriate deletions and proposed alternatives.

Initial estimates for this work effort projected approximately five chemical targets per TO with a goal of finding acceptable substitutes for three targets per TO. Due to the process and expanded data base developed by the SAIC, SA-ALC/EMP, and SA-ALC/TIESM Environmental Team, we are reviewing an average of 50 targeted callouts per TO for substitution. Of those, approximately 25 callouts are identified as "WARNINGS", "CAUTIONS" and "STATEMENTS" which will be changed by the TO manager, and approximately 25 (5 ODCs and 20 EPA-17) callouts are chemicals or processes requiring the use of targeted chemicals and consideration for elimination or substitution.

As of 18 July 94, we have completed work on 448 TOs and we have a 95% success rate in completely eliminating all references to ODCs and drastically reducing the use of EPA-17 chemicals in each of the completed TOs. Limited applications of ODCs cannot be substituted when used as fire suppression agents on some aircraft and near liquid oxygen.

We have an in-house developed software data base with approved rationales for substituting or eliminating chemicals listed in 315 Military Specifications.. Due to the expanded data base, we have made great strides in reducing the use of chemical mixtures that contain not only ODCs, but also EPA-17 and other targeted chemicals by finding substitutes for chlorinated hydrocarbon solvents, P-D-680, chromated primers, some cadmium plating requirements, and solvent-based paints and thinners.

This program is a prime example of the success that may be achieved in support of the Air Force's Pollution Prevention Program by building a strong and committed team. Programs like this one can be used as a prototype to show the benefits of the Air Force and industry working together to produce a comprehensive pollution prevention program.

Robert S. Pace, Joseph A. Mulloney, Jr., Barry L. Rubin
EA Engineering, Science, and Technology, Inc.
11019 McCormick Road
Hunt Valley, Maryland 21031

DEVELOPMENT OF A NATIONAL LEVEL POLLUTION PREVENTION PROGRAM

Introduction

EA Engineering, Science and Technology, Inc. (EA), is supporting the Air National Guard Readiness Center and over 150 Air National Guard (ANG) units nationwide in development and execution of a nationwide Pollution Prevention Program. This support is being provided through a basic ordering agreement between EA and Armstrong Laboratories at Brooks, AFB. The program includes several Pollution Prevention (P2) support areas:

- Preparation of a generic Pollution Prevention Plan which includes a P2 Opportunity Assessment, Pollution Prevention Management Plan, and a P2 Technologies Information Database.
- Preparation of air emissions inventories at over thirty installations to assist in air emissions baseline reporting as well as helping meet the Clean Air Act Amendments of 1990.
- Preparation of Hazardous Waste Minimization Plans for several bases.
- Preparation of Stormwater Pollution Prevention Plans and Spill Prevention and Response Plans.
- Updating AF Form 2761s using the Air Force HM/P2 Program at twenty locations to facilitate compilation of industrial toxics and ozone depleting chemical inventories.

The purpose of this paper is to discuss the Command-wide approach taken to prepare a Pollution Prevention Plan for all ANG installations. This approach is useful for multi-facility organizations characterized by common facilities and processes. Other multi-media environmental management issues related to Executive Order 12856 (EPCRA and P2), the Clean Water Act, the Resource Conservation and Recovery Act, and the Clean Air Act Amendments can also be addressed using this approach.

Approach

The Pollution Prevention Plan consists of a generic Opportunity Assessment (OA) and Pollution Prevention Management Plan (PPMP). During early scoping of the project, it was determined that available resources could be more effectively applied by preparing a generic document applicable to all ANG bases rather than preparing separate documents for each of the 150 ANG installations. Standardized industrial shop survey procedures were established to implement opportunity assessments at fifteen representative ANG bases identified by the ANG Readiness Center. These bases also exhibited a representative cross section of aircraft by type and number and base missions . Geographically Separated Units (GSUs) were also surveyed. Figure 1 illustrates the model approach used to evaluate important activities and processes which use hazardous materials or generate waste and pollutant streams. By using this model at each location, hazardous material inputs and pollutant outputs were identified and summarized for significant waste generating sub-activities within each industrial shop. Standardized lists and record-keeping tables for typical hazardous materials and wastes associated with each industrial shop are provided in the OA to allow ANG personnel to track these components at the shop level. Shop level record-keeping facilitates identification of process oriented solutions and enhances performance monitoring.

Record-keeping Issues

Accurate and consistent recording of pollutant stream quantities and costs is essential for focusing resources on high priority streams and for performance monitoring. Figure 2 illustrates a hazardous waste profile for the baseline year (1993) for a selected ANG base. Annual hazardous waste disposal quantities are disaggregated by component waste streams and expressed in terms of percent of total weight and total disposal cost. Figure 2 suggests that the focus for a P2 strategy for this base would be parts cleaning, paint related materials, and fuel spill clean-up streams assuming the criteria for measurement is disposal reduction by weight. While ANG and AF P2 metric guidelines are based on weight reduction, in this example, commensurate reduction in the cost of waste disposal would not be possible because of the differing unit costs associated with the component waste streams. For example, while parts cleaning accounted for 33.2 percent of the total waste stream by weight, it represents less than 16 percent by cost. Conversely, expires shelf life materials represent about 4 percent of the total waste stream for the base, but over 16 percent by cost. These and similar relationships among other component wastes streams suggest that detailed records of waste stream quantities and costs are critical for making resource allocation decisions depending upon the P2 reduction goals and objectives.

Figure 3 further identifies the impact of measuring one time events on P2 data reporting. A one time event is defined as an individual situation or activity which results in the generation of wastes in a non-repetitive manner (this does not include repetitive events which may occur every few years such as cleaning out oil-water separators). The figure demonstrates that removing one time events can have dramatic effects on baseline quantities, particularly in terms of weight, and that by using standard measuring criteria for the baseline year and all subsequent years, an installation can have more reliable and consistent data for performance monitoring. Baseline waste tracking records should only count routine and annual contributions to waste loads. Other elements of the waste stream that must be paid for, should be kept track of, but not included in P2 reporting associated with reduction goals (i.e., manifested non-hazardous wastes).

Solutions

Four major waste groups were identified from the survey sample: waste oil and fuels, solvent wastes, paint and paint-related wastes, and miscellaneous wastes. The component streams to each waste group were further identified and the following information tabulated for each: primary industrial shop source, alternative P2 solutions, P2 method (source reduction, recycle, treatment) and the ANG P2 reduction goals which could be satisfied by implementation of these solutions (hazardous waste, municipal solid waste, industrial toxic program chemicals, affirmative procurement, and ozone depleting chemicals.

Each of the P2 solutions was entered into a ANG P2 Database (P2Tech). P2Tech contains ANG-specific pollution prevention technology information. The purpose of the database is to provide ANG Environmental Coordinators and Base Environmental Engineers with information to help them formulate P2 solutions for their base. P2Tech is cross-referenced in the ANG Pollution Prevention Plan. The database is accessed using FOXPRO version 2.6 which has been provided to each Environmental Coordinator by the ANG Readiness Center. A User's Guide, diskette, and hard-copy version of P2Tech was provided to each base representative and demonstrated at the ANG 1994 Environmental Management Training session. P2Tech consists of the following categories of information and analyses:

- Technology description
- P2 Method (i.e., source reduction, recycling)
- Primary applicable shops
- P2 Target Goals/Benefits
- Constraints
- Cost Analysis (including cost savings, return on investment)
- Vendors and case studies

Pollution Prevention Management Plan (PPMP)

A generic PPMP was developed for the ANG that is adapted from the Air Force PPMP prototype developed by HQUSAF/CEV. The PPMP represents the implementation plan for an overall base-level P2 program using the opportunities identified in the OA and the technologies provided by P2Tech. The PPMP includes a *Process* subsection which provides the framework for development of the steps necessary to implement the program and outlines organizational responsibilities for plan development and plan evaluation. The *Program* section presents the recommended solutions to meet ANG goals and the costs and financial justification for making these recommendations. The *Execution* section of the Plan identifies the actions required to implement each action identified in the *Program* section. The generic PPMP was provided to all ANG bases on computer diskette to allow each base to tailor the plan to meet their specific requirements.

The approach summarized in this paper involves a combination of survey sampling to accomplish a national-level Opportunity Assessment, preparation and dissemination of a technologies database to facilitate communication of P2 solutions, and a standardized and modifiable PPMP. This approach represents a cost-effective method for development and implementation of a Pollution Prevention Program across large, multi-facility government organizations.

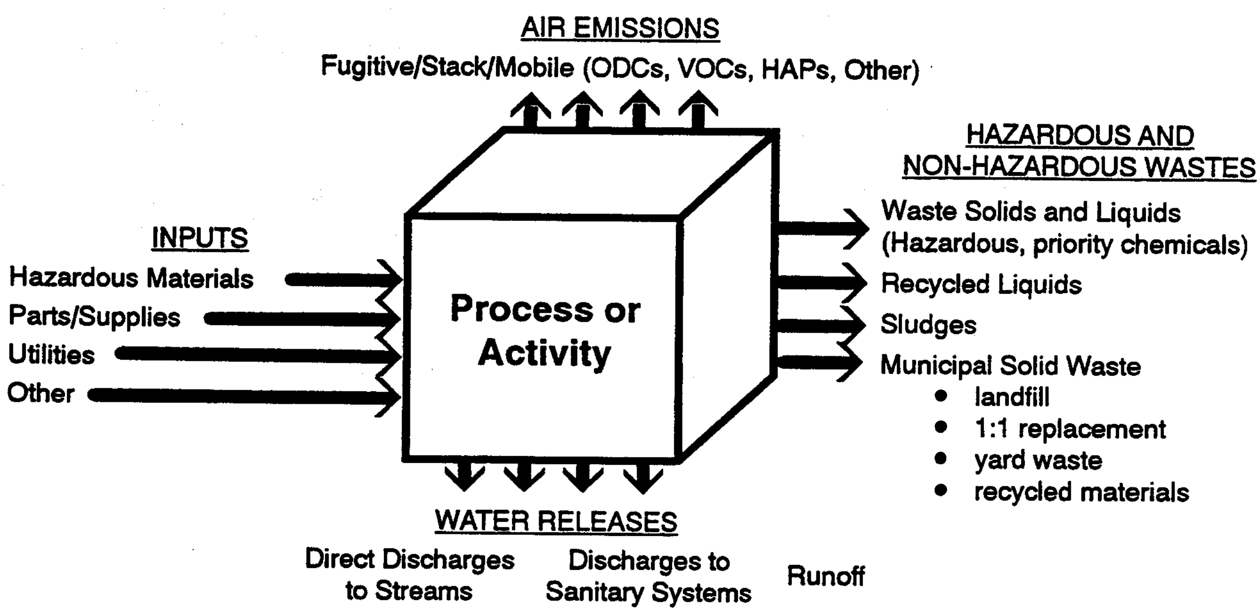


Figure 1. Opportunity assessment model.

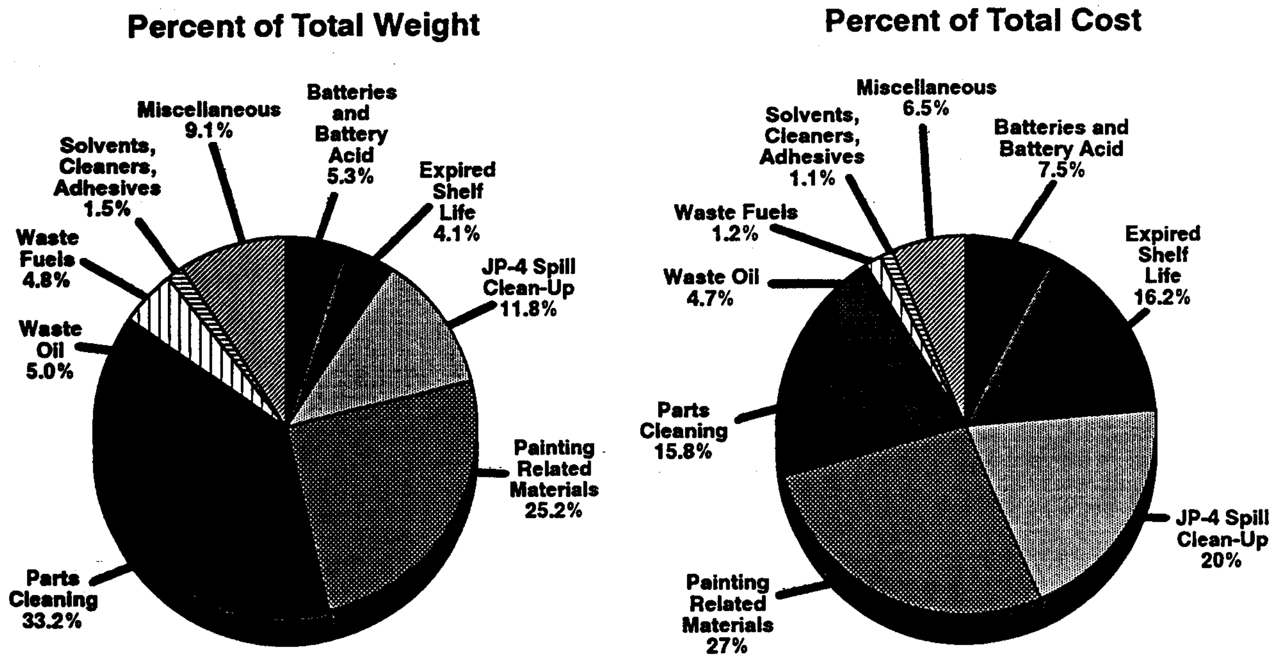


Figure 2. Waste quantity vs. disposal cost—sample ANG base.

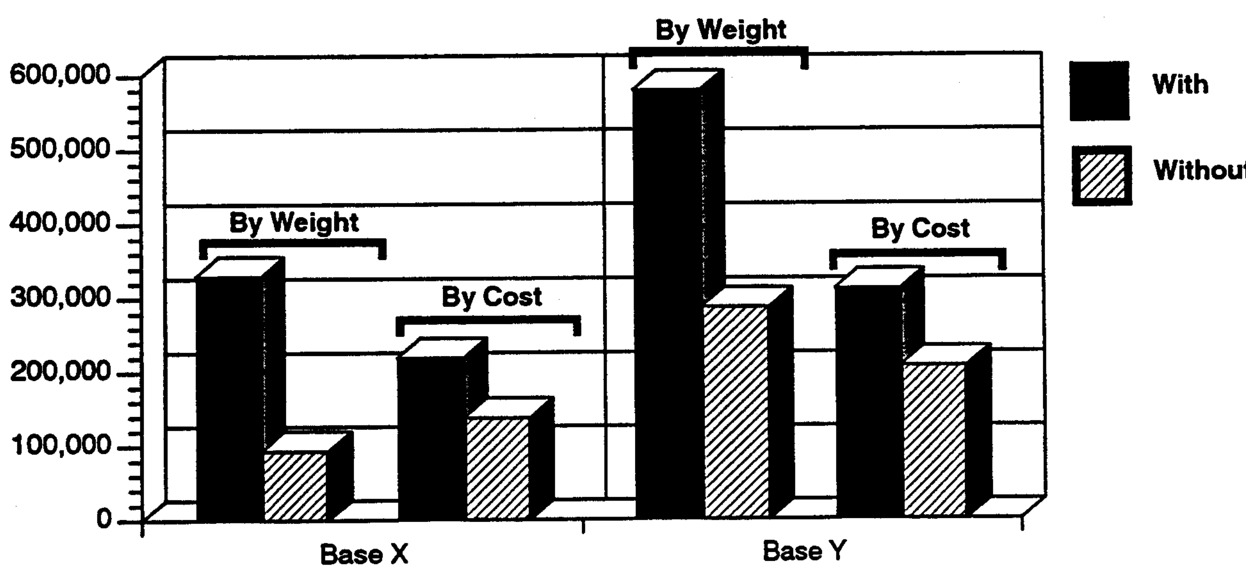


Figure 3. Impact of counting one-time events.

SESSION XV

POLLUTION PREVENTION IN STRIPPING PROCESSES

Session Chairpersons:
Lt Frank Titus, HQ USAFE/CEV
Major Steven Hoarn, HQ ACC/CEV

ENVIRONMENTALLY ACCEPTABLE CHEMICAL AIRCRAFT PAINT STRIPPERS

OKLAHOMA AIR LOGISTIC CENTER

by

Robin Lee Stearns
OC-ALC/EMV
7701 2nd Street, Suite 204
Tinker AFB, OK 73145-9100
(405) 736-5102, DSN 336-5102

ABSTRACT: Oklahoma City Air Logistics Center is currently using an environmentally acceptable alternative paint stripper, benzyl alcohol, instead of the more harmful methylene chloride and phenol based materials. This new material is used on C/KC-135 and B-52 aircraft. he use of this material as an aircraft paint and rubber remover has reduced the chemical usage by over 50% and water usage by approximately 25%. The new process is much more efficient for certain processes and results in a minimum of hazardous waste. The new stripper removes polysulfide primer (MIL-P-87112) in less than one hour, while a dwell time of 18+ hours is required to remove polyurethane topcoat (MIL-P-83286). Another benefit of the new stripper is a significantly reduced health hazard. The benzyl alcohol can be found in perfumes, baby lotion, and deodorants. There is an important environmental benefit due to the reduction of the air toxic methylene chloride, included in the Clean Air Act Amendment of 1990. Included in the presentation are corrosion data, implementation strategies, production impacts, and orker response

INTRODUCTION

Oklahoma City Air Logistics Center currently strips paint from the KC-135, E-3, and B-52, with a future requirement to strip the B-1. Historically, methylene chloride (dichloromethane, DCM) paint removers have been utilized, and have amounted to over 300 tons per year of DCM emitted. An environmentally acceptable chemical alternative has been used for the past two years in the removal of polysulfide-primed coatings. The chemical used is Benzyl Alcohol, a relatively benign chemical commonly found in perfumes, baby lotions, and deodorants. The two removers studied at OC-ALC in 1992 were SR-125A, manufactured by Eldorado Chemical, San Antonio TX, and CB-1058, manufactured by McGean-Rohco, Inc., Cleveland OH. In 1993, an OC-ALC Purchase Description was written for a competitive procurement process. On July 30, 1993, an addition into Air Force Technical Order 1-1-8 was made to include benzyl alcohol-based paint strippers for aircraft paint stripping. In 1994, a new, improved Eldorado product, SR-145, won the OC-ALC annual contract per the Purchase Description.

To implement a new chemical paint remover, several steps were taken at OC-ALC to qualify the material for use on Air Force weapon systems. Corrosion is the main concern for any material applied to aircraft. The ALC has a great concern about the Production performance of the material. Additionally, The material must pass environmental and health standards. To pass all of these requirements, and integrated approach was taken at OC-ALC for the qualification and implementation of the Benzyl Alcohol based paint remover.

CORROSION

The qualification of Benzyl Alcohol paint remover began with a baseline of the requirements for the DCM-based chemical remover. Specifically, OC-ALC relied on an immersion corrosion test, a sandwich corrosion test, and a hydrogen embrittlement test. The immersion corrosion test is in accordance with ASTM F483, with the limits illustrated in Table I, and results shown in Table II.

TABLE I
IMMERSION CORROSION TEST REQUIREMENTS

METAL	SPECIFICATION	SURFACE TREATMENT	WEIGHT CHANGE (mg)
ALUMINUM	QQ-A-250/1 (H-24 CONDITION)	AS RECEIVED (1)	+ 0.3
ALUMINUM	QQ-A-250/4 (T3 TEMPER)	AS RECEIVED (1)	+ 0.3
MAGNESIUM	QQ-M-44 AZ31B-H24	MIL-M-3171, TYPE 1 (2)	+ 1.5
MAGNESIUM	QQ-M-44 (AZ31B-H24)	MIL-M-3171, TYPE III (2)	+ 1.5
STEEL	MIL-S-7952	AS RECEIVED (1)	+ 1.0
STEEL	MIL-S-7952	CADMIUM PLATED PER QQ-P-416, TYPE II, CLASS II (2)	+ 0.14 mg/cm2

(1) Remove surface dirt, oil, and contaminants with toluene. Clean and polish with acetone wet pumice (SSS-0-821, Grade FFFF), rinse with methyl alcohol (O-M-232) and air dry.

(2) Remove surface dirt with acetone and air dry.

TABLE II
IMMERSION CORROSION RESULTS

MATERIAL	SUBSTRATE	AVERAGE (mg)	ALLOWED (mg)
SR-125A	2024 Al	-0.35	+ 0.3 *
SR-125A	Mg Type I	-1.6	+1.5 *
SR-125A	Bare Steel	-0.9	+1.0
SR-145	2024 Al	0.2	Bare Steel
SR-145	1100 Al	0.1	+0.3
SR-145	Mg Type I	1.5	+1.5
SR-145	Mg Type III	0.1	+1.5
SR-145	Bare Steel	0.3	+1.0
SR-145	Cd Plated Steel	0.14 mg/cm^2	+0.14 mg/cm^2
CB-1058	2025 Al	-0.3	+0.3
CB-1058	Mg Type I	-0.8	+1.5
CB-1058	Bare Steel	-0.55	+1.0
Phenol	2024 Al	-0.3	+0.3
Phenol	Mg Type I	-3.7	+1.5
Phenol	Bare Steel	-0.8	+1.0

* Excess weight loss represents less than 0.0001 in/yr material loss, waiver for use

Sandwich corrosion is a test of dissimilar metals commonly found on aircraft at OC-ALC. The test consists of coupling different metals with fasteners as shown in Table III. These assembled couples are placed in glass jars, covered with remover, and conditioned for 72 hours at 100 degrees F, then removed and immediately suspended vertically in a suitable desiccator for 72 hours. Prior to test, the desiccator shall have been cleaned and the lower portion filled with distilled water, then tightly closed and conditioned at 77 +2 degrees F. During test, the desiccator shall be kept closed and the temperature maintained at 77 +2 degrees F.

TABLE III
DISSIMILAR METAL COUPLES

Couple Number 1	Aluminum (AZ) QQ-A-250/1 (H-24 Condition) coupled with Magnesium QQ-M-44 (AZ31B-H24), with MIL-M-3171, Type I Surface Treatment
Couple Number 2	Aluminum QQ-A-250/4 (T3 Temper) coupled with Magnesium QQ-M-44 (AZ31B-H24), with MIL-M-3171, Type III Surface Treatment

ASSEMBLY HARDWARE:
SCREWS: M535206-6-232
WASHERS: AN960-6, Cadmium Plated per QQ-P-416 Type I, Class I
NUTS: MS20341-6S

Prior to assembly, clean metal surfaces as detailed in Table I (2).

Both couples passed the sandwich corrosion tests. Photos are shown in Figures 1 and 2.

Hydrogen embrittlement is an important consideration for an aircraft stripper due to the use of high strength steels used in some components. The pH of the material is set at a range of 8.0 - 11.0. An additional indicative test is ASTM F519, Type 1c. Both the Eldorado SR-125A and SR-145, as well as the McGean-Rohco CB-1058 passed the hydrogen embrittlement test.

PRODUCTION CONSIDERATIONS

Benzyl Alcohol based strippers are recognized as "Environmentally Friendly" because of their low vapor pressure (<0.1 mm Hg @ 86 deg F) and absence from an EPA lists available to the author at the time of writing. Additionally, no OSHA hazardous chemicals are listed on the Material Safety Data Sheets (MSDSs), see Attachments 1 and 2. At OC-ALC, the Bioenvironmental engineers have been conservative, and still require the air-supplied respirators due to precautionary reasons. It is understood that at this time, the benzyl alcohol-based strippers are less hazardous to human health than the conventional phenol-DCM-based strippers.

Dwell time of these strippers is significantly increased. The total topcoat buckling will take from 10 to 18+ hours, depending on temperature for the SR-125A material. The SR-145 material requires a dwell time of 6 to 8 hours, thus improving the Production process. Once buckled, the topcoat must be removed with a squeegee, due to congealing of paint chips upon contact with water. A subsequent application of benzyl alcohol stripper onto the remaining polysulfide primer requires only a 1 hour dwell time, after which, the coating may again be squeegeed for complete removal. The aircraft is then totally rinsed.

The complete coating removal for a KC-135 requires approximately 25 barrels of DCM-based stripper. The same task using benzyl alcohol uses 12 barrels of the SR-145 material. The adoption of the benzyl alcohol stripping for the KC-135 aircraft at Oklahoma City has resulted in an elimination of 80 tons per year of DCM emissions. Additional pollution prevention benefits are a reduction of approximately 70,000 gallons of water per aircraft due to the decreased rinsing required when using the benzyl alcohol stripper.

CONCLUSIONS

The use of benzyl alcohol-based paint strippers has significantly reduced the amount of methylene chloride emissions due to aircraft paint stripping. Although benzyl alcohol is only applicable to polysulfide-primed aircraft, its use has contributed to a more positive attitude regarding environmentally acceptable aircraft paint stripping. The research performed by Eldorado in the environmentally acceptable aircraft paint strippers continues for such coatings systems involving TT-P-2760 (Koroflex ®), and epoxy primers, throughout the chemical stripper industry.

Optimization and Prototyping of Medium Pressure Water (MPW) Depaint Process

OKLAHOMA CITY AIR LOGISTICS CENTER

by

John Stropki
Battelle, Columbus
505 King Avenue
Columbus, OH 43201-2693
(614) 424-5414

Robin Lee Stearns
OC-ALC/EMV
7701 2nd Street, Suite 220
Tinker AFB, OK 73145-9100
(405) 734-7071, DSN 884-7071

Abstract: Current methods for cleaning and removing paint from aircraft involve the use of chemical strippers such as methylene chloride. Due to environmental concerns/impacts, chemical strippers will be banned in the near future. alternatives to chemical strippers must be fount to maintain the current levels of reliability and maintainability (R&M) and/or improve the R&M aspects of cleaning and removing paint.

Several independent Air Force investigations have been completed on a modified medium pressure water cleaning/depainting process. The process is capable of effectively and economically removing various contaminants and protective coating systems from metallic and non-metallic structures while preserving or improving current levels of R&M. To ensure that the modified MPW is suitable for aircraft applications, the Air Force needed to further develop the technique for full scale aircraft and components.

The results of a program funded by Oklahoma City Air Logistics Command (OC-ALC/EMV) to evaluate the cleaning/stripping efficiency of a medium pressure water jet are described in the paper.

INTRODUCTION

This research program was designed to evaluate the potential of a paint stripping process that utilizes a medium pressure water jet as a viable alternative to the current practice of paint stripping and cleaning of aircraft with hazardous chemicals. The means of determining the viability of this environmentally safer blast process was predicated on establishing a set of process parameters at which paint stripping was accomplished at an economically sound rate, while minimizing any possible substrate damage.

A complete evaluation of the Aqua Miser® medium pressure water (MPW) blasting process and four candidate nozzles was conducted through three discrete tasks. Task I concentrated on (1) establishing depaint efficiency and (2) characterizing any potential substrate damage as a result of stripping with the MPW process. Tasks 2 and 3 included a field-level demonstration and evaluation of the Aqua Miser system on aircraft component parts and partial aircraft airframes, respectively.

A description of the technical activities and results obtained from each of the three tasks is provided in the following text.

TECHNICAL APPROACH

A summary of several OC-ALC requirements which are scheduled to be satisfied throughout the next 18 months includes:

(1) MINI-LARPS (Large Aircraft Robotic Paint Stripping Facility)

- Installed and operational in Fall, 1994
- Use confined to depainting aircraft and component parts

(2) LARPS Facility

- Installed and operational in Spring, 1995
- "Full-scale" depainting of KC-135 and B-1 aircraft

(3) MPW Process

- Use confined to either touch-up or backup to LARPS on KC-135 and B-1 aircraft
- Use on B-52 and E-3 aircraft which cannot be depainted by LARPS because of facility limitations

- Full or partial depainting/cleaning of aircraft components.

Detailed descriptions of the various tasks conducted as a part of this study are provided in the following text.

Task No. 1. Optimization Testing of MPW Process

Task activities were divided into the following four subtasks: (1) Production Rate Assessment,

(2) Qualitative Damage Assessment, (3) Spot Weld Integrity Assessment, and (4) Structural Vibration Stress Test. All four subtasks concentrated on determining the process parameters that produce the most efficient paint stripping rate with minimal blast imparted damage to common aluminum aircraft alloys. Production rates obtained during all optimization testing were determined by calculating the rate at which paint is removed from test panels with only water. Potential blast damage was determined by (1) measuring any deformation which developed on the surfaces of small test coupons (arc height samples) after the paint removal operation, (2) characterizing the integrity of spot welds, and (3) measuring the stresses imposed on aluminum test panels that are configured to be representative of actual aircraft structures.

Production Rate Assessment

The type and dimensions of materials that were used to perform all optimization testing of the Aqua Miser water-only process with four (dual orifice, rotating head, fan, and LARPS) nozzles that were evaluated include:

- AL2024-T3 alclad - 0.032 inch by 24 inches by 24 inches.

Individual panels were coated with several "in-service" coating systems which included: polysulfide primer/polyurethane topcoat, Koroflex primer/polyurethane topcoat, self priming topcoat (SPT), solvent-based epoxy/polyurethane topcoat, and water-borne epoxy/polyurethane topcoat. The dry film thicknesses of most coatings ranged between 0.002 and 0.003 inches. Panels were cured for seven days in a controlled laboratory environment that was maintained at 72 degrees F and 50 percent relative humidity. All panels were then artificially aged in an oven at 210 degrees F for 96 hours.

The process used for all optimization testing included a Government-furnished Model E25 Aqua Miser bicarbonate of soda stripping (BOSS) Blasting System that was manufactured by Carolina Equipment and Supply Company. By design, this electric unit is rated at 3.2 GPM @ 15,000 psi and capable of being adapted for use with the four different types of nozzles that were evaluated.

Optimization of the MPW process for the cleaning of component parts included a controlled metering of BOSS media into the water blast stream. A screw auger-driven media feed system was used to precisely control a flow rate of approximately 7 ounces of media per hour. This particular media feed rate was selected from testing that was recently completed at Warner Robbins Air Logistics Center (WR-

ALC). A more detailed optimization of blasting parameters for partial airframe depainting will concentrate on blasting airframe structures with only medium pressure water. No BOSS media is planned to be used on (1) samples used to assess the efficiency and damage of the MPW process, and (2) the designated sections of aircraft (KC/C-135 and B-52) that are scheduled for partial depainting.

Control of the paint removal process on all test panels used for process optimization was achieved with a computer-controlled table assembly that was available at Tinker AFB. The horizontal axis of the table was capable of achieving speeds up to 4.0 inches per second and traveling approximately 24.0 inches in both directions. Individual test panels were mounted to the table and were positioned at a minimum distance of 2 inches and at a 60-degree angle from the blast nozzle.

Qualitative Damage Assessment

The type and dimensions of the Almen coupons used to determine the potential blast-induced damage to thin aluminum airframe materials included:

- A12024-T3 bare - 0.032 inch by 0.75 inch by 3 inches.

The 3-inch dimension of all coupons was oriented in the sheet rolling direction. In addition, all Almen coupons were sheared from painted panels. Blasting of individual coupons was on the common face of the original panel.

Panels from the individual Almen coupons were painted and aged in accordance with the previously described procedures.

The protocol used to develop arc height data (blast-induced coupons deformation) included a quasisaturation blasting of the Almen coupons. Individual coupons were not repainted between the initial depainting cycle and after the subsequent four blast cycles. This form of testing represents a "worst-case" situation that may occur from either excessive dwell time during paint removal operations or the equivalent of an expected depainting cycle of Air Force aircraft.

The test fixture was mounted to ensure that the blast stream traversed the coupons perpendicular to the rolling direction of the Type 2024-T3 aluminum alloy. This alignment permitted full coverage of the test coupons with one pass of the blast stream. Final Δh measurements were made from Almen coupons that are blasted with the traversing direction perpendicular to the roll direction of the coupons. This was done to ensure that the Δh measurements were consistent with the procedures established by Battelle during previous Air Force paint removal programs.

Complete optimization of four (rotating, dual orifice, fan, and LARPS) blast nozzles and the MPW process was based on (1) maximum strip rates obtained for the epoxy/polyurethane coating system that was applied to aluminum test panels, and (2) the Almen coupons delta are height produced at stripping parameters established by OC-ALC/TIESM and Battelle. Process variables included standoff distance, impingement angle, nozzle pressure, and traverse rate. An analyses of all data established the efficiency of the various blast nozzles. Subsequent testing and efficiency evaluations of the MPW process (without BOSS media) included only one nozzle. This nozzle was selected for continued evaluation as a result of superior paint removal performance.

Spot Weld Eddy Current Inspection Testing

Test panels for the spot weld integrity tests were prepared using two panel configurations: flat and 2inch radius bend. Bends applied to the appropriate panels were applied prior to spot welding. Panels were constructed from the following materials and thicknesses:

- A12024-T3 alclad, 0.032 inch
- A12024-T3 alclad, 0.080 inch
- A17075-T6 alclad, 0.032 inch
- A17075-T6 alclad, 0.080 inch.

Fabrication and testing protocol for the various sets of metal test panels was in accordance with the OC-ALC LARPS Qualification Plan (paragraph 4.2.19).

The procedures used to conduct all spot weld eddy current inspections are as follows:

- Preparation of two (flat and 2-inch radius bend) panels for each of the four materials per LARPS Qualification Plan (paragraph 4.2.19).

- Establish baseline measurements by nondestructively eddy current inspecting every spot weld per T.O. IC-135-36.

- Blast panels with each of the four nozzles and optimized blast parameters that were obtained from testing performed in Subtasks I and 2. Two stripping cycles per panel.

- Nondestructively inspect every spot weld on stripped panels per T.O. IC-135-36.

- Compare all baseline measurements with post-stripping measurements to determine the location and frequency of broken spot welds.

The spot welding of all test panels was performed at OC-ALC. Additionally, all pre- and poststripping eddy current inspection testing was conducted by OC-ALC.

Structural Vibration Testing

A simulated aircraft fuselage section or test box was constructed to perform several stress tests during this subtask. The approximate dimensions of the box are 9 inches by 21 inches. As was discussed with OC-ALC/TIESM and OC-ALC/LAPEP personnel, the frame of the box was constructed from aluminum angles that are spaced to simulate the dimensions between ribs and stringers on an aircraft. Two different 8 inch by 8 inch test panels were independently evaluated on the frame. One panel was fabricated from 0.032-inch Type 7075-T6 bare aluminum sheet, and the second panel from 0.032-inch Type 2024-T3 bare aluminum sheet. Panels were secured to the angles with 0.0125-inch threaded fasteners, which were evenly spaced around the perimeter of the panel being evaluated. The strategic placement of several strain gages and an accelerometer onto the underside surfaces of the test panels permitted a recording of all stress and vibration measurements.

The intent of this test was to measure the induced strains and frequencies generated by the MPW process on a simulated aircraft fuselage section and assess the potential for fatigue damage.

Construction of the test box included the mechanical fastening of a single test panel to the aluminum frame. No sealant was used between the test panels and frame. Six strain gages were instrumented along the internal surfaces of each test panel. All components were secured and sealed to ensure maximum protection from potential water damage.

Stresses introduced onto the test panel as a result of the MPW process were measured by the strain gages at several intervals throughout the blasting process. Various combinations in nozzle stand-off distance, traverse rate, and blast jet rotational rate were investigated. The pressure of the water blast stream was maintained at approximately 15,000 psi. Testing did not include BOSS media.

Task No. 2. Prototyping of MPW Process With BOSS Media on Aircraft Component Parts

Activities performed during this task concentrated on depainting aircraft component parts at Tinker AFB. Process parameters established for MPW and MPW plus BOSS media blasting of the standard polyurethane coating system during testing conducted at WR-ALC and OC-ALC were used. All blasting operations were performed by OC-ALC personnel in Building 2122. This facility represented a production environment, therefore, was equipped with the power, air, water, and drainage requirements to complete this task. A summary of the activities performed, as well as the protocol for conducting this task, is provided in the following text.

Battelle cleaned and/or depainted four (4) engine cowling parts that were selected and removed from B-52 aircraft. All components were painted and heavily soiled with carbon residues and oil contaminants. Components had a metallurgical composition of either A12024 and A17075 and were classified Maintenance Items Subject to Repair (MISTR) parts that are authorized by OC-ALC to depaint with plastic media beads (PMB).

The Model E25 Aqua Miser unit used during the water-only optimization phase of Task I was used for blasting all painted component parts. However, a controlled rate of BOSS media was introduced into the blast stream to increase depaint efficiency. Process efficiency was maximized by using the results of controlled testing that was performed on standard epoxy/polyurethane test panels that were depainted during Task I and at WR-ALC. The standard two-handed fan nozzle was the only nozzle that was to be used with the BOSS media. Additional testing with the LARPS mini-nozzle is also scheduled for depainting "select" airframe components.

Additional activities performed as part of this task included: (1) on-site technical assistance and/or training of OC-ALC production personnel responsible for operating and maintaining the MPW system, (2) measuring and documenting operational parameters which included safety and healthrelated hazards, and (3) an identification of all costs (shop floor time, man-hours, consumables, and equipment amortization) associated with the efficient operation of the BOSS process. Process efficiency was determined by the production-level strip rates that were obtained at the initiation of this task.

Task No. 3. Prototyping of MPW Process

on Partial Airframe Sections

Activities performed during this task focused on depainting Air Force designated airframe sections on large aircraft (KC/C-135 and B-52) that are maintained at Tinker AFB. Integration and testing of the optimized MPW process was conducted in conjunction with OC-ALC production personnel. Optimal blasting parameters established for a single nozzle that was selected during Task I was used in the testing conducted during this task.

On-site assistance was provided during the actual blasting operations that were performed by OC-ALC production personnel in a designated section of Building 2122 at Tinker AFB. Numerous aircraft depainting operations are performed in this facility; therefore, the basic (air, water, and electrical) requirements of the MPW system were available.

A summary of the activities that were performed, as well as the protocol for conducting this task, is provided in the following text.

Testing performed during this task was limited to the various aluminum (Al2024, A17075 and A17079) airframe structures that were depainted with the MPW process. OC-ALC/LAPEP stated that all depainting was to be performed on select areas (approximately 100 square feet) of structures on E-3 or B-52 aircraft. Possible areas included:

- top/bottom sides of wing
- fuselage (2 areas)
- vertical stabilizer
- engine nacelle.

OC-ALC personnel will provide Battelle with a mapping of the various coating systems applied to the structures that are to be depainted. The majority of airframe structures are painted with the standard epoxy/polyurethane coating system; hence, prototyping is to include a complete removal of this coating. <u>No</u> observable process-induced substrate damage are anticipated for these structures. Areas adjacent to the depainted structures were to be masked by OC-ALC personnel prior to testing.

Selective stripping of any non-standard coating systems that are on airframe structures are also scheduled to be investigated during this task. This stripping process involves the removal of only the outermost (topcoat) protective coating from the airframe structure. If proper techniques are used the primer on the structure will remain intact after being blasted with the medium pressure water.

The efficiency of the MPW process is to be assessed by (1) determining the production strip rates for the various structures, and (2) visually characterizing the condition of the depainted structures.

All stripping parameters selected as a result of the testing performed during Task I are to be used to depaint approximately 1,000 square feet of select airframe structures. Carolina Equipment and Supply personnel were responsible for providing all services related to equipment set-up and the training of production personnel. On-site technical direction to OC-ALC production personnel was also provided to ensure that the optimized stripping parameters are maintained from structure to structure. This process summarized any problems that may develop in the production environment as a result of hardware limitations.

An additional aspect of this task will be to work closely with production personnel at Tinker to measure and document a final set of depainting parameters that maximizes the efficiency and safety of the MPW process.

RESULTS

The results obtained from a limited amount of optimization and prototype testing that has been performed on each of the three tasks confirms that the water-only blasting process is capable of meeting the depaint production requirements of OC-ALC. Process capabilities that have been successfully demonstrated during Task I testing include (1) selective (topcoat only) and, (2) full depaint of "in-service" coating systems that are on OC-ALC aircraft. To date, all testing has been conducted on painted test panels with water-only blasting parameters. No bicarbonate-of-soda media was used on partial airframe test panels or sections of aircraft.

Optimization Testing

A total of four MPW blast nozzles were evaluated on 0.032-inch A12024-T3 alclad/bare panels. Included in the test matrix were panels coated with five different paint systems. A set of optimized blast parameters were obtained for each nozzle/coating system combination.

Results indicate that the highest production depaint rates and least damage on coated panels were obtained for the one-jet "hammerhead" or rotating nozzle and modified LARPS nozzles. Acceptance criteria for both nozzles were based on the quality of the surface finish for full and selective depainting with the MPW process.

The production rates and damage (Almen arc heights) measured for the various nozzles (selective and full depaint) are provided in Figures 1 and 2. As shown, no one nozzle will efficiently depaint all "in-service" coating systems. The highest selective depaint rates (1.1 to 2.3 ft^2/min) were obtained for nozzles on the polysulfide/polyurethane coating system. Conversely, the LARPS, fan, and one-jet nozzles were the only nozzles capable of completely depainting all coating systems at an efficient (0.5 ft^2/min) or acceptable rate. Disadvantages associated with the LARPS and fan nozzles, and related depaint parameters are the small standoff distances, narrow "footprints" and residues that remain on the surfaces of the aluminum panels coated with the Koroflex and polysulfide primers. These residues require a chemical clean-up (thinned version of SR-125A) prior to repaint processing. This clean-up is also required for the epoxy/polyurethane and Koroflex/polyurethane coatings that are removed with the one-jet or "hammerhead" rotating nozzle.

All depaint parameters obtained for the LARPS and one-jet nozzles are to be used for component parts and partial airframe prototyping activities. Production rates on the "aged"

Koroflex/polyurethane coating system of E-3 or B-52 aircraft are scheduled to be obtained and compared to rates measured during laboratory testing. An assessment of the quality of the surface finish of the depainted airframe sections also will be performed and used to verify the production efficiency of the MPW-process. Final acceptance of the process will be based on the results obtained from the stress and spot-weld tests.

Stress and Spot-Weld Testing

To date, no results are available for these two tests as all testing has not yet been completed. Limited depainting of spot-weld panels has been performed and no damage or cracking has been measured for the examined spot welds. Testing included 2-pass processing with the dual-orifice nozzle on both flat and curved panels. Additional testing with each of the remaining three nozzles is required before a final set of results are provided to OA-ALC/LAP personnel.

Component Parts and Partial Airframe Prototyping

All prototyping activities are scheduled for completion during July, 1994. This particular task was intentionally delayed until the results of the stress and spot-weld tests are available. If the results of these tests indicate that the MPW process is a viable production tool, then the aircraft prototyping activities will be completed.

Preliminary cleaning and depainting of coating systems applied to the internal surfaces of B-52 engine cowlings have been completed. The results of these exercises have confirmed that the MPW process is capable of efficiently cleaning "baked on" carbon residues from the components. A post-blast examination of the depainted surfaces indicates that the process is acceptable and capable of providing a quick clean-up of these components. Additional cleaning and depainting of component parts is scheduled at OC-ALC. The results of these depaint exercises will be reviewed for input into the final report that is scheduled for issuance during September, 1994.

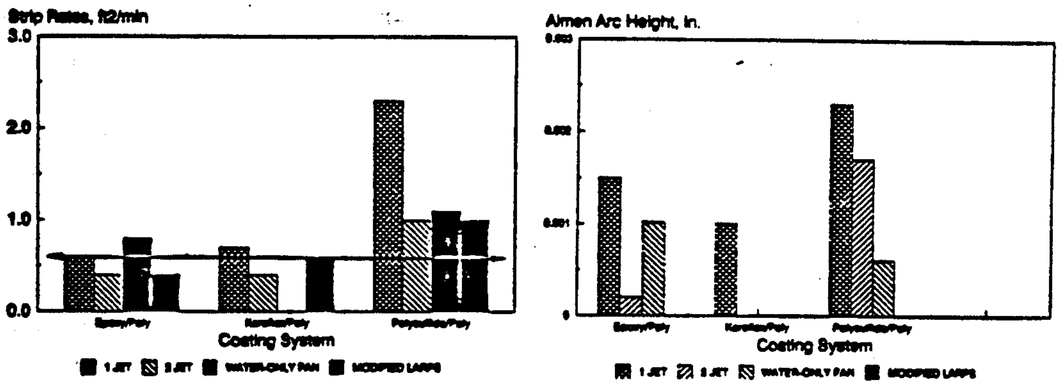


Figure 1. "Best" Selective Strip Processes

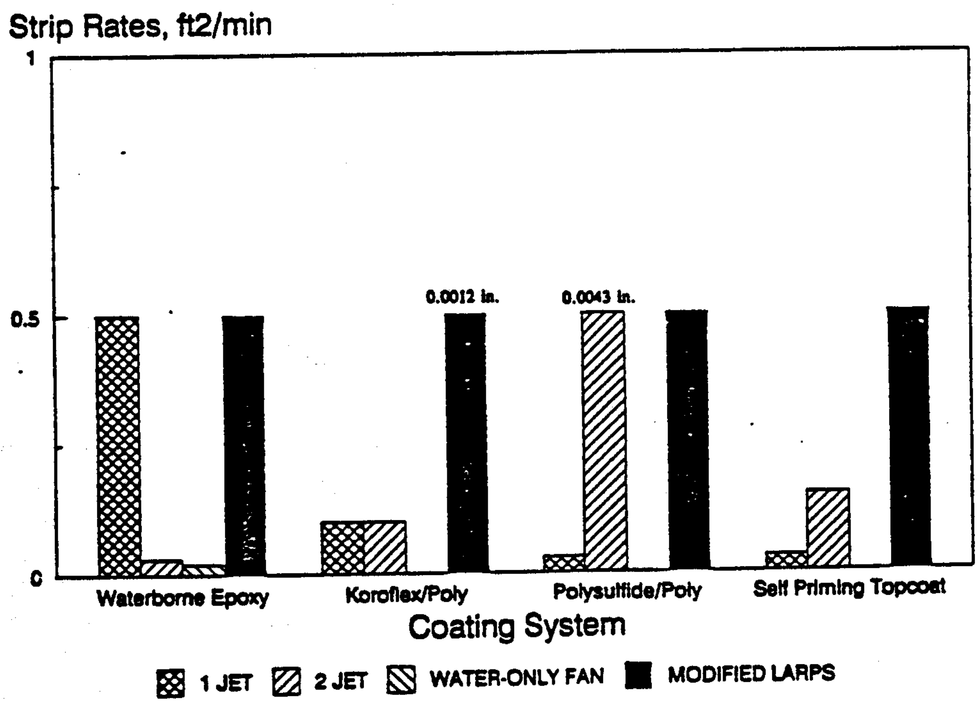


Figure 2. "Best" Full Strip Processes

EVALUATION OF PROPYLENE CARBONATE IN AIR LOGISTICS CENTER (ALC) DEPAINTING OPERATIONS

Angela Burckhalter
OC-ALC/EMV
7701 2nd Street, Suite 220
Tinker AFB OK 73145-9100
(405) 734-7071, DSN 884-7071

Ann Marie Hooper
Foster Wheeler USA
Clinton, NJ 08809
(908) 730-4616

Carlos Nazario
OC-ALC/LIPEB
Building 3108, Suite 2H27
Tinker AFB OK 73145-3030
(405) 736-7246, DSN 336-7246

Johnny Springer, Jr. & Kenneth R. Stone
United States Environmental Protection Agency
Pollution Prevention Research Branch
26 W. Martin Luther King Boulevard
Cincinnati, OH 45268
(513) 569-7542

Abstract: This report summarizes a study which evaluated a solvent blend containing propylene carbonate as a potential replacement for methyl ethyl ketone (MEK) in aircraft radome depainting operations. This study is supported by the U.S. Environmental Protection Agency's (EPA) Risk Reduction Engineering Laboratory through the Waste Reduction Evaluation at Federal Sites (WREAFS) Program. The study was conducted at the Oklahoma City Air Logistics Center (OC-ALC) at Tinker Air Force Base (TAFB). TAFB currently uses MEK to depaint B-52 and KC-135 aircraft radomes in a ventilated booth. Because MEK is highly volatile, many gallons vaporize into the atmosphere during each depainting session. Therefore, EPA is supporting studies to identify effective nonvolatile, less toxic substitutes for MEK.

The solvent blend tested, PC Blend 2, was provided by Texaco Chemical Company and contained 25% propylene carbonate (PC), 50% n-methylpyrrolidone (NMP), and 25% dibasic ester (DBE). This solvent blend was compared with MEK during testing. The tests measured paint removal time and

efficiency, paint adhesion, flexural properties, weight change of the substrate after paint removal, and hardness of unpainted substrate test panels.

Test results revealed that PC Blend 2 performed favorably in comparison with MEK in removing paint from the fiberglass/epoxy (F/E) test panels with successful paint adhesion results. A preliminary economic analysis estimated that TAFB would save over $30,000 in their first year of operation by replacing MEK with PC Blend 2. PC Blend 2 should continue to be evaluated as a substitute in the TAFB radome depainting operation. Additional qualification testing, if required by the Air Force, and a full-scale demonstration project are recommended before implementation.

INTRODUCTION

This project is supported by the U.S. Environmental Protection Agency's (EPA) Risk Reduction Engineering Laboratory (RREL) through the Waste Reduction Evaluation at Federal Sites (WREAFS) Program. The program provides technical assistance and support to Federal facilities in conducting Waste Minimization Opportunity Assessments (WMOAs) and pollution prevention research. This project also focuses on EPA's 33/50 Voluntary Reduction Program, which plans to reduce generation of 17 hazardous substances; 33% by the end of 1992 and 50% by the end of 1995. One of the 17 chemicals, methyl ethyl ketone (MEK), is a solvent used for depainting aircraft radomes at the Oklahoma City Air Logistics Center (OC-ALC) at Tinker Air Force Base (TAFB).

TAFB removes paint from radomes on KC-135, EC-135, B-52, B-1, and E3A aircraft. In a large ventilated booth an MEK shower loosens the paint. The MEK attacks the primer through scribed breaks in the topcoat. According to operators, the paint starts to bubble after 30 minutes of continuous showering. As the primer dissolves, the topcoat is flushed away form the radome by the MEK shower. Topcoat residue is filtered from the MEK. The solvent then flows to a sump for recycle back to the spray header. The operation typically takes 1.5 to 3 hours. According to TAFB, a large percentage of the MEK is lost to the atmosphere through the booth exhaust system. After the MEK shower, any remaining paint residues are removed by hand sanding. Topcoat chips are captured in a sump and disposed as hazardous waste. In 1991, 719 pounds of topcoat chips were disposed, and an estimated 8,250 gallons of MEK evaporated to the atmosphere.

From previous research and background documents, RREL has identified propylene carbonate (PC) as a possible alternative to MEK. To date, PC had not been performance-tested as a substitute for MEK in radome depainting operations. EPA sponsored this proof-of-concept study to evaluate PC's performance as a substitute for MEK in the depainting operation. Texaco Chemical Company provided PC Blend 2, which contains 25% PC, 50% NMP, and 25% DBE.

RESULTS AND DISCUSSION

Using PC Blend 2 and MEK, EPA's contractor for this study, Foster Wheeler, simulated the depainting procedure to determine the time and removal efficiency for spray operations, which is representative of the actual depainting operation. TAFB selected hardness, flexural properties, paint adhesion, and weight change tests to analyze the solvent's effects on the substrate.

Simulated Depainting Procedure

The simulated depainting procedure was utilized for both PC Blend 2 and MEK, each in a separate, identical unit. The apparatus consisted of a parts washer fitted with a 1/4 inch diameter spray nozzle. The parts washer flow rate was approximately 7 L/min. Both units were modified with a 0.07 hp orbital magnetic drive centrifugal pump, because the original pumps seal material was incompatible with both MEK and PC. The nozzle sprayed 2 inch square test panels made of fiberglass/epoxy (F/E) honey comb cut from a condemned B-52 radome.

The times required for the solvents to bubble and totally remove the paint were recorded, and a qualitative judgment of paint removal was recorded at various time intervals. After bubbling, the paint was removed by hand or with a blunt-edged wooden spatula.

Removal times for paint adhesion test panels are provided in Table 1.

TABLE 1. PAINT REMOVAL TIMES

	Paint removal time (minutes)	
	PC Blend 2	MEK
Run 1	45	30
Run 2	21	29
Run 3	25	25
Run 4	25	25

Hardness

Hardness tests were performed in accordance with ASTM Test Method D 2583-87 to test for potential embrittlement of the substrate by the solvent. Eight 2 inch square test panels were cut from an unpainted F/E prepreg sheet used for another project at TAFB. These tests determined indentation hardness with a Barcol Impressor. Indentations were made on the specimens and the hardness measured. In accordance with ASTM D 2583, 20 measurements were made on each test panel, 10 before and 10 after contact with the solvent. The panels were sprayed with solvent in the depainting simulation unit for 2 hours, and gently wiped dry with a paper towel.

Average hardness results are summarized in Table 2. The test objective was a Barcol hardness of 55 or greater. As indicated in Table 2, hardness measurements met this objective and did not change significantly after exposure to solvent. Measurements ranged form 75 to 85 Barcol hardness units, with an overall average of 80.4. These results show that MEK and PC Blend 2 do not chemically embrittle the substrate.

TABLE 2. AVERAGE HARDNESS READINGS

	PC Blend 2		MEK	
	Before	After	Before	After
Run 1	80.0	82.6	81.4	81.4
Run 2	79.7	79.7	79.6	81.8
Run 3	80.4	80.7	80.0	80.5
Run 4	79.8	79.4	78.9	79.6

Flexural Properties Test

The flexural properties test was performed in two parts. The first part measured flexural properties of the test panels in accordance with ASTM Test Method D 790-91, Test Method I, Procedure A. Sixteen test panels were prepared from an F/E prepreg sheet provided by TAFB and cut to test specifications. Six test panels were tested in the as-received condition, five panels each were conditioned by exposure in the MEK and PC Blend 2 depainting simulators for 2 hours. After drying 1 hour, the solvent-exposed panels were subjected to load in a tensile machine until breakage of outer fibers occurred.

Results of the flexural properties test showed that 12 panels failed at approximately 72,000 psi loading and four test panels had lower flexural strength, failing at a loading of approximately 52,000 psi. These four panels failed with a straight break across the test panel rather than by the zigzag pattern exhibited with the stronger panels. Further examination revealed that the four panels were cut from a weaker section of the F/E prepreg sheet. Comparison of individual test results of the 12 stronger test panels and the four weaker ones showed that flexural strength was unaffected by exposure to either solvent.

During the second part of the test, the failed test panels were examined with a scanning electron microscope (SEM) to determine if the solvents damaged the interface of the F/E and laminate structure. For SEM examination, the panels were cut into 1 inch squares with the failure break in the center of the square. The squares were then mounted on an aluminum stud using carbon dag, which provides a conductive bond between the stud and the panel. The squares were then sputtered with gold in a vacuum chamber to reduce charging the microscope. The surface was examined at 30X, 300X, and 1200X magnification; the cross section was examined at 1200X magnification to observe any fiber/matrix interface separation. Microphotographs were taken at each magnification to document the conditions observed. Squares of test panels not exposed to any solvent were also examined by the SEM to obtain a baseline comparison.

Figures 1 through 3 represent microphotographs taken of an unexposed, MEK exposed, and PC Blend 2 exposed panel. These figures indicate no damage was done by either solvent to the fiber matrix interface or to the fibers. If damage occurred, the microphotographs would have shown noticeable gaps where the fibers interface the matrix. Also, individual fibers appear to be intact, indicating the solvent did not attack the resin binding the fibers.

Paint Adhesion

Paint adhesion testing was performed in accordance with ASTM Test Method D 3359-92a, Method A using F/E with honeycomb test panels. After paint removal in the depainting simulation unit, test panels were repainted by TAFB personnel with the rain erosion coatings applied to B-52 radomes. The same 10 to 12 mil thickness of coating and painting procedure used for actual radomes was applied to these test panels. For the adhesion tests, two incisions were made in the panels down to the substrate layer. A pressure sensitive tape was then applied to the intersection of the cuts for a period of 90 seconds (+ or - 30 seconds). The tape was 1 inch wide PermaCel 99TM. After tape removal, the X-cut area was visually inspected. Adhesion is rated according to a scale of 0A (removal beyond area of X-cut) to 5A (no peeling or removal).

The paint adhesion ratings were 5A for each test panel. This rating indicates no peeling or removal of paint by the pressure sensitive tape occurred, suggesting complete paint adhesion after the depainting/repainting cycle for both MEK and PC Blend 2.

Weight Change Test

The weight change test, developed by TAFB, determines if damage occurs to the substrate material. Four clean, unpainted F/E prepreg test panel were weighed before and after immersion in the solvent. A weight loss indicates that the solvent has attacked the substrate. A weight gain reveals that the solvent is absorbed through microcracks in the substrate. The test panels were immersed in the solvent for four hours. After immersion, the panels we gently wiped by hand and dried in a 150 degree oven for 1 hour.

A parallel experiment was also conducted on standard 2.5 inch square 316 stainless steel (SS) plates to validate the drying procedure. The 316 SS is inert and not affected by either solvent. A weight gain indicates the presence of solvent residue on the surface.

Table 3 presents the results of the weight change test. The test panels exposed to both PC Blend 2 and MEK showed weight loss, indicating slight substrate damage; this was considered to be negligible by TAFB. The parallel experiment with 316 SS standards confirmed that the solvent residue had evaporated from the surface of the test panels.

TABLE 3. WEIGHT CHANGE TEST RESULTS

	Weight change (grams)	
	PC Blend 2	MEK
Run 1	-0.011	-0.008
Run 2	-0.009	-0.006
Run 3	-0.020	-0.013
Run 4	-0.025	-0.009

CONCLUSIONS AND FURTHER EVALUATIONS

The evaluation test results indicate that PC Blend 2 is a potentially viable replacement for MEK. PC Blend 2 removed 100% of the paint in about the same time as MEK and required slightly more scraping for total removal. PC Blend 2 and MEK do not embrittle the F/E substrate, do not affect flexural properties of the F/E substrate, and do not impact paint adhesion. Examination by SEM indicated no significant damage to the fibers or the fiber matrix interface. .

PC Blend 2 and MEK panels exhibited a small weight loss after immersion for 4 hours. PC Blend 2 showed possible damage to the top resin layer of the F/E substrate. The impact of this possible damage will be evaluated in Phase II of this project.

A preliminary cost analysis estimated a $30,085 savings by substituting PC Blend 2 for MEK in TAFB's radome depainting operation.

In Phase II of this study, the EPA RREL will evaluate PC Blend 2 in an Life Cycle Assessment, Analysis and Design (LCA) approach that investigates the energy and environmental impacts of the product on the substrate of a radome as well as the engineering design of the system in which it is used. Phase II will evaluate a full scale test, using operational radomes, and conducting sampling and analyses to determine environmental impacts and any variation in performance. Repetitive de-painting and painting exercise will be performed to determine the long term viability of the PC Blend.

Additionally, the LCA research will evaluate potential adverse effects of the solvent on the substrate, and possible reformulation of the solvent blend to eliminate or reduce any identified damage.

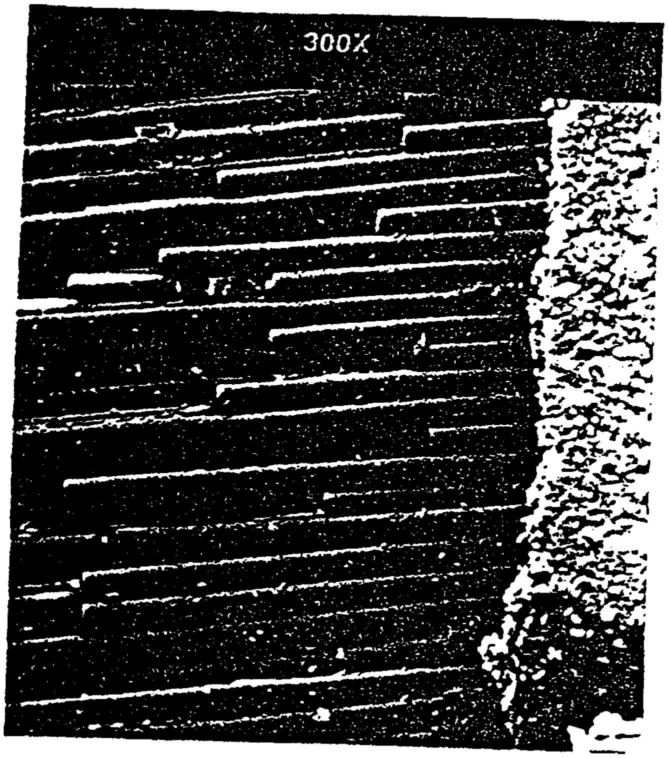


Figure 1. Microphotograph of Unexposed Specimen at 300X

Figure 2. Microphotograph of MEK Exposed Specimen at 300X

Figure 3. Microphotograph of PC Blend 2 Exposed Specimen at 300X

SESSION XVI

OZONE DEPLETING CHEMICALS

Session Chairpersons:
Lt Col. Gil Wendt, HQ AFMC/EN
Captain Bill Kolakowski, HQ USAF/CEVV

Database for Identifying Ozone-Depleting Substances in Military Items

P. Michael Luthi
Dynamac Corporation
Rockville, Maryland
2275 Research Boulevard
Rockville, MD 20850-3268
(301) 417-9800

Abstract
On April 21, 1993, President Clinton signed Executive Order (E.O.) 12843 requiring federal agencies to comply with provisions of the Clean Air Act Amendments of 1990 regarding procurement and use of substances that cause stratospheric ozone depletion. Additionally, the Department of Defense (DoD) Fiscal Act of 1993 requires that DoD contracts calling for the use of products containing ozone-depleting substances (ODSs) be reviewed and revised to specify ozone-safe substitutes.

Dynamac Corporation developed the Hazardous Materials DataBase (HMDB) to assist DoD installations in complying with E.O. 12843 and the DoD Fiscal Act of 1993. This database is designed specifically to identify and report ODSs from among DoD-procured items known to contain hazardous substances. HMDB contains information on approximately 90,000 National Stock Numbers (NSNs) and includes NSNs that also contain Emergency Planning and Community Right-to-Know Act (EPCRA) Section 313 chemicals and extremely hazardous substances. HMDB allows queries on all data elements and thus allows users to identify reformulations or substitutes for a product. The database also is capable of identifying ODSs and hazardous substances from Military Specifications (MILSPECs), manufacturers' products, or manufacturers providing parts to DoD through their procurement system.

Difficulty has been encountered in identifying and tracking ODS-containing products used by DoD because regulations and guidance have not addressed practices unique to DoD facilities (such as the handling of local purchases with locally assigned NSNs or part numbers). Consequently, research efforts have included reviewing local procurement papers and locally developed databases to update HMDB. As part of this update process, Dynamac has contacted numerous manufacturers to determine if non-hazardous reformulations of their products are available or in development.

The U.S. Air Force developed policies to implement E.O. 12843 and DoD Fiscal Act of 1993, and has suspended actions on a number of procurements pending resolution of their ODS compliance. Dynamac has supported Air Force ODS-related compliance efforts by developing and implementing HMDB to determine ODS presence in specified product lists. In addition to other tasks, Dynamc has reviewed MILSPECs related to these procurements, documented which products contain ODSs, identified all ODS components, and determined ozone-safe replacements.

Background
Although the effects of projected emission levels on stratospheric ozone depletion have not been precisely quantified, data show that policymakers must act to identify ozone-safe substitutes. Hammitt [1] states:

> *Because of pervasive uncertainty about the likely extent of future ozone depletion, its relationship to the quantity of potential ozone depleters emitted, its effect on the biosphere, and the appropriate valuation of these consequences, it is not currently possible to choose the level of emission-limiting regulations that will maximize welfare by optimally balancing costs of environmental damage against those of emission control. Policymakers must act in the face of this uncertainty.*

Executive Order 12843 requires that federal agencies (1) implement cost-effective programs to minimize the procurement of materials and substances that contribute to depletion of stratospheric ozone; and (2) give preference to the procurement of alternative chemicals, products, and manufacturing processes that reduce overall risks to human health and the environment by lessening ozone depletion in the upper atmosphere. E.O. 12853 also requires that federal agencies shall, to the extent practicable:

- Conform their procurement regulations and practices to the policies and requirements of Title VI of the Clean Air Act Amendments, which deal with stratospheric ozone protection
- Maximize the use of safe alternatives to ODSs
- Evaluate present and future ODS use, which should include assessing existing and future needs and plans for recycling
- Revise procurement practices and implement cost-effective programs (1) to modify both specifications and contracts that require ODS use; and (2) to substitute non-ozone-depleting substances to the extent economically practicable
- Exercise leadership, develop exemplary practices, and disseminate information on successful efforts in phasing out ODSs

The DoD Fiscal Act of 1993 prompted the Air Force to institute aggressive ODS reduction and management policies beginning January 1, 1993. These policies state:

- Purchase of newly produced Halons is prohibited as of June 1, 1993, unless a waiver is approved
- Acquisition of facility air conditioning and refrigeration systems requiring ozone-depleting is prohibited starting January 1, 1993
- Procurement of commercial vehicles with ODS air conditioners is prohibited starting June 1, 1993
- Purchase of newly produced ozone-depleting refrigerants is prohibited as of June 1993
- Effective April 1, 1994, the purchase of ozone-depleting solvents and equipment/systems/products requiring the solvents for maintenance and/or operation is prohibited
- No contract awarded after June 1, 1993, shall include a requirement to use ozone-depleting substances or any requirement that can be met only through the use of these substance without a consent order

Hazardous Materials Database

Dynamac Corporation developed for the Air Force a hazardous materials information search and retrieval system designed specifically to identify and report the presence of ODSs from within a large data set of DoD procurement items known to contain hazardous materials. This system, the Hazardous Materials DataBase or HMDB, is a PC-based, relational database employing the user-friendly Windows environment. HMDB encompasses detailed Material Safety Data Sheet (MSDS) data and other information from a wide variety of databases and other sources. HMDB provides DoD with essential procurement, use, and EPCRA reporting information for Tier II inventories and Form R reporting, which are required under E.O. 12856; ODS identification and elimination; EPA 17 reduction; and other pollution prevention goals. It provides immediate access to hazardous materials associated with more than 4,500 MILSPECs, 87,000 NSNs, 99,000 part numbers, 17,000 manufacturers' products, 24,000 manufacturers, and 7,000 CAS Numbers. The system can segregate items associated with ODSs from any given set of NSNs, MILSPECs, part numbers, item names, or manufacturers providing parts to DoD through their procurement system.

HMDB allows users to conduct queries on all data elements, thus enabling users to identify reformulations or substitute products. The system also generates tailored reports and summaries, including the following representative samples:

- All MILSPECs and corresponding NSNs, manufacturers, part numbers, and chemical percentages, and the presence or absence of specific chemical constituents

- All MILSPECs and corresponding NSNs identified as containing a specified chemical constituent from a class or group of hazardous chemicals

- All MILSPECs and corresponding NSNs identified as "free from" containing a specified chemical constituent from a class or group of hazardous chemicals

Dynamac Corporation also performs the following services:

- Contacts manufacturers who provide products containing specific ODSs to determine if non-hazardous reformulations of their products are available or being developed

- Provides an analysis of potentially available, non-hazardous substitutes

- Prepares impact assessments

In addition to identifying items containing hazardous and/or toxic chemicals, HMDB can also determine the storage and usage amounts of hazardous materials to ascertain which chemicals meet EPCRA reporting requirements. The HMDB system provides additional critical data sources for supplementary information. These sources, used as a relational link between the installation's hazardous NSNs, include:

- Hazardous material information pertaining to each NSN (e.g., part information, ingredients, chemical concentrations, weights, manufacturer information)

- Supply information about each NSN (e.g., current inventory, amounts used, quantities ordered)

- SARA Title III chemicals and their hazardous classifications, Reportable Quantities (RQs), and Threshold Planning Quantities (TPQs)

- Validation tables

HMDB Features
Currently, HMDB allows for viewing, searching, and printing of existing hazardous material data. Figure 1, *Hazardous Materials Data Flow*, illustrates HMDB data flow. HMDB uses monthly supply data to track current on-hand quantities, requisitioning objectives, and quantities ordered. These data elements are mandatory and necessary for calculations that determine total amounts acquired, in relevant units of measure, for each hazardous material.

Data Retrieval
HMDB displays general information, such as ingredient and percentage data, for individual NSN records. Standard movement is allowed to each NSN on the screen. A browse listing allows simultaneous display of all records. Data on the current screen may be printed out at any time.

Searching
The HMDB search feature allows the user to enter an NSN to be searched. If the system finds the NSN, the product is considered to contain hazardous materials; the chemical constituents, percentages, and classifications are listed on the screen. If the NSN is not found, a message indicates that it is presumed not to be hazardous.

Figure 1

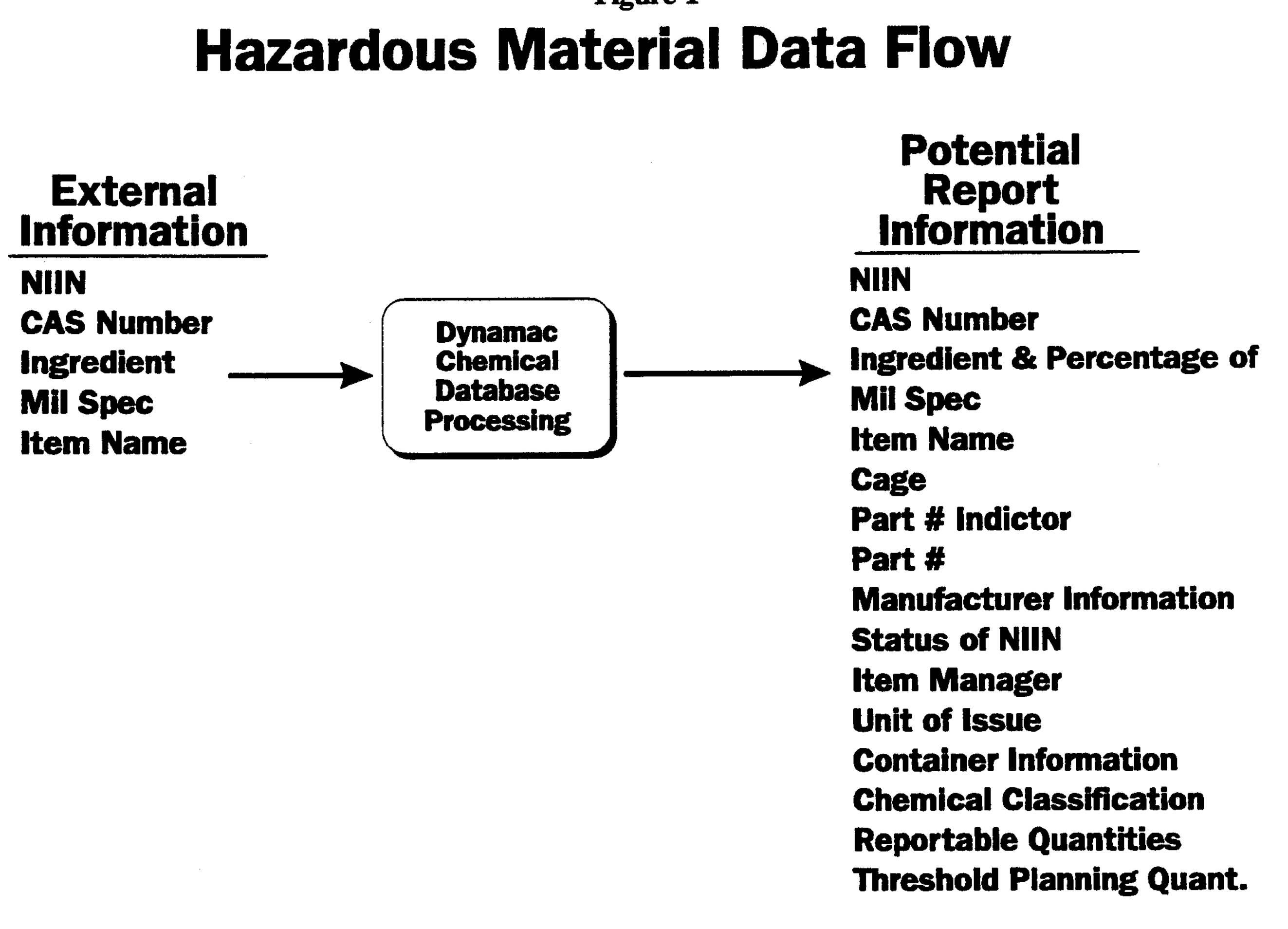


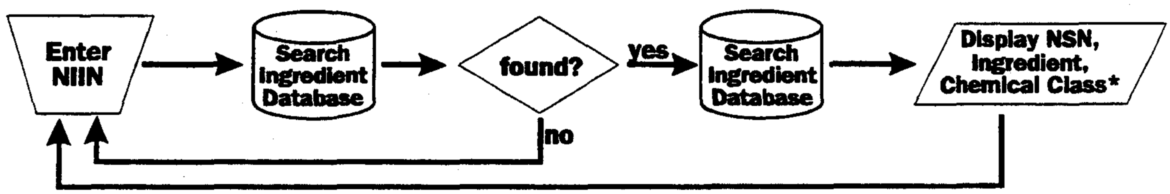
Figure 2, *Search Method for Hazardous Chemicals*, depicts the HMDB search feature.

Reports
Numerous reports are included to display information, in a summary format, as an overview of an installation's current hazardous materials status. Existing standard reports available in the system include:

- Listing of NSNs with hazardous constituents and their chemical classifications
- Listing of all hazardous chemicals applicable to the installation by specified chemical classification (e.g., ODS, 313, Extremely Hazardous Substance (EHS))
- Listing of each 313 chemical in use at the installation along with the total quantity of that chemical
- Breakdown of hazardous chemicals by Department of Defense Activity Address Code (DODAAC) or equivalent provider
- Listing of partial information to be applied to the EPA Form R Report for each chemical that meets the reporting requirements
- Listing of all EHS chemicals meeting Tier I/Tier II reporting requirements

Figure 2

Search Method for Hazardous Chemicals



*** NSN: 6810-00-476-5612**

NIIN	Ingredient	Chemical Class
1	Methyl chloroform	ODS/313/CERCLA/OSHA/CAAA/CARB
	Nitromethane	OSHA
2	Diethylene Dioxide	313/CERCLA/OSHA/CAAA/CARB
	Methyl Chloroform	ODS/313/CERCLA/OSHA/CAAA/CARB

Legend
ODS: Ozone Depleting Substances
313: Toxic Chemical 313
CERCLA: CERCLA Chemical
OSHA: OSHA Chemical
CAAA: Clean Air Act Chemical
CARB: California Clean Air Chemical

Keeping HMDB Current
The system accepts monthly data pertaining to the quantities of hazardous NSNs through routine extractions performed by various logistic systems databases. The data are imported through an automated feature that accepts a standardized file format and structure to update HMDB as it relates to the current EPCRA chemical status.

Future Additions
Additional features planned for HMDB include:

- Routines to export data to other applications
- Hazardous material and waste tracking systems
- User options for filtering and tailoring HMDB data outputs
- Customized report generator to satisfy all user reporting needs
- Electronic validation table and hazardous material updates based on availability
- Provision of current status of DoD's goal of reducing toxic chemical use by 50 percent by the year 1999, based on a 1994 baseline

Special Studies
Urgency related to the Air Force's policy of reduced reliance on ODSs prompted the Air Force to task Dynamac with development of the HMDB. This database system was designed and implemented on a fast-track schedule--completion within 30 days of task assignment. Using HMDB, Dynamac conducted several special studies for the Air Force. Tracking purchase requests allowed Dynamac to identify growth patterns in specific categories.

For example, Dynamac conducted a special study to review all NSNs identified by the U.S. Air Force as containing ODSs. As a result of this special study, 25 percent of these NSNs were found to include products that did not containing ODSs, which meant that immediate purchase of these items was possible. The research performed on ODSs, NSNs free of ODSs, and ODS substitutes for products is crossfed throughout the Air Force. Additionally, through coordination with the General Services Administration, the information from the NSN review is being updated to include products that GSA has identified as ODS-free substitutes.

The results of three studies are summarized below.

In a study completed for the U.S. Air Force, San Antonio Air Logistics Center/TIESM (SA-ALC/TIESM), 68 MILSPECs were researched for the presence of ODSs. The 68 MILSPECs equated to:

- 677 National Stock Numbers
  - — 609 NSNs were identified as ODS free
  - — 68 NSNs contained ODSs

- 1,595 separate products
  - — 1,430 products were identified as ODS free
  - — 165 products were identified as containing at least one ODS

- 252 manufacturers

In a second study done for SA-ALC:

- 798 National Stock Numbers
  - — 310 NSNs were identified as ODS free
  - — 488 NSNs contained ODSs

- 1,888 separate products
  - — 83 products identified as ODS free
  - — 1,805 products were identified as containing at least one ODS

- 506 manufacturers

For Malstrom Air Force Base, HMDB was used to research 786 new NSNs to determine the toxic chemicals present in each product and their category (ODS, EHS, 313, etc.).

Conclusion

HMDB is a relational database that takes logistics data and breaks out the NSNs into their hazardous components. This system also can calculate storage and usage data by entire installation, individual activity, chemical class, and other variables.

HMDB is an important analysis tool that accepts logistics input from various sources, analyzes that input, and then provides output in the form of management reports and data as required to meet various reporting requirements.

Endnotes

1. Hammit, J. K. Timing Regulations to Prevent Stratospheric Ozone Depletion. Rand Report R-3495-JMO/RC, April 1987.

SESSION XVII

AUTOMATED SYSTEMS

<u>*Session Chairpersons*</u>*:*

James Hsu, Dynamac Corporation
Neil Sylvestre, MITRE Corporation

<u>P2 DECISION-MAKING AND THE ROLE OF PC-BASED DECISION SUPPORT TOOLS</u>

Paul D. Norcross, Natural Design Systems
Post Office Box # 325
Dalton, Mass. 01227
413-339-8630

Dennis M. Vaughan, SYSCON Corporation
1735 Jefferson Davis Highway
Arlington, Va. 22202
703-415-3390

Introduction

Identification and quantification of waste steams and their costs are an essential part of any P2 program. Material process flow models are critical to effective cost-benefit analysis and compliance with future P2 regulations.

Computer generated flow modeling carries additional benefits as well. It can speed up the time it takes to map plant processes, and can ultimately be linked directly with existing environmental reporting software to automate report generation. Because reports must be updated, generally on an annual basis, a software-driven system becomes an excellent time saver. Further, it helps reduce reliance on outside consultants.

The purpose of this article is to explore the benefits and conceptual background for ongoing program design and development work at SYSCON. A manually generated manufacturing process will be examined, and the benefit of an interactive computer-based tool will be discussed at critical stages in the modeling process.

Getting Started: Gathering Information

Charting a manufacturing process requires detailed knowledge of each manufacturing task. Charting this same process from an environmental point of view requires the addition of detailed chemical data, raw material quantities, waste stream identification and fate information. It must all be coupled with production volumes not only for each product line, but more specifically for each production unit within the product line.

Assembling this data is a sizable undertaking, but computer-based systems can help. Purchasing information, either downloaded or scanned from documents, can be loaded in semi-automated fashion, as can Material Safety Data Sheets (MSDS). They can also be loaded manually. Particular fields such as chemical common name, manufacturer, chemical abstract numbers (CAS), and percent-by-volume data can be extracted.

Flowcharting the Process

After the plant's chemical inventory is loaded, the software can "interview" the plant manager or production foreman through the flow charting process. What operation occurs first? What are its raw material inputs? What are it's outputs? Where do these outputs go? Each of these questions can be answered directly from knowledgeable plant personnel, often assisted by pop-up menu information from the previously loaded data. These pop-ups can also be customized to suit the individual manufacturing process.

In this fashion, the process modeling tool would guide the user in the creation of a precedence network for the complete manufacturing process. For example, assume that welding, grinding, and painting represent particular production units and that welding must be performed before grinding, followed by painting. This precedence information is used to generate a flow chart in much the same fashion as construction management software generates PERT charts.

For more complex manufacturing processes composed of many more production units, a process flow diagram is an especially useful tool to identify, track, and tally what the manufacturer does at each step in the process. This is crucial to determining strategies necessary to optimize production flow, material costs, as well as the waste stream.

From an environmental utility standpoint, production must be normalized from one year to the next. For example, if in one year a manufacturer generates 15,000 gallons of waste phosphoric acid cleaning solution, and in a subsequent year he generates only 10,000 gallons, it would appear usage efficiency had improved. However, if the 15,000 gallons stemmed from a production of 5,000 widgets while the 10,000 emanated from a production volume of only 2,500, then obviously efficiency of raw material usage has actually fallen. A process flow model quickly reveals these trends if the data is properly calibrated to production information.

Manufacturing plants vary widely in production methods. This software is designed to handle batch processing, continuous, and job-shop manufacturing because the software is process oriented, not black-box oriented. Production cells can also be accommodated.

Using the Model

The information generated thus far satisfies the most difficult portion of the P2 planning process--identifying the exact nature of the process and the specific fate of all materials. At this point, with accurate data input, the process is sufficiently characterized to constitute the material balance requirement of a P2 plan. Parameters can now be adjusted to test their impact.

Assume that a new hazardous waste contractor's disposal prices are attractive. The plant manager wants to determine the financial impact of switching firms. The environmental fate database portion of the software can be accessed, service prices adjusted, and net annual disposal costs calculated for either the affected process or the entire plant.

Alternatively, assume that a cleaning alternative to phosphoric acid has been found that promises to be an acceptable substitute. It features less toxic constituents at an affordable cost. Running the model again enables rapid evaluation of the impact. Similarly, any parameter of the system can be challenged to produce "what if" information. Thus, establishing 2 year and 5 year toxic use reduction goals is easily projected, and their impact more fully identifiable before the required plan is submitted to the governing environmental agency.

Final Reporting

Although the primary focus of the software if on in-plant process characterization for pollution prevention planning, environmental reporting burdens are considerably simplified by having completed the flowcharting process. Because the information is in a database, extraction into report format is relatively easy, particularly with existing dedicated reporting programs.

Pollution Prevention Techniques

New requirements of programs like the Clean Air Act and the Clean Water Act have created dangerous territory for inattentive manufacturers. The advantage of a good P2 program is that it graphically quantifies all pollution sources, thus reducing the potential for surprises. It also goes a long way to identify and address OSHA chemical safety hazards in the workplace. Finally, it typically results in lower raw material costs, and dramatic improvements in plant efficiency at moderate cost, because the construction of the plan, and what actions it will require is entirely up to the facility.

It is important to note which actions constitute creditable pollution prevention techniques under the EPA's Waste Minimization guidelines. The approved techniques are:

- **Input Substitution** - "replacing a toxic or hazardous substance or raw material used in a production unit with a non-toxic or less toxic substance."

- **Product Reformulation** - "substituting for an existing end-product an end-product which is non-toxic or less toxic upon use, release, or disposal."

- **Production Unit Redesign** - "developing and using production units of a different design than those currently used."

- **Production Unit Modernization** - "upgrading or replacing existing production unit equipment and methods with other equipment and methods based upon the same production unit."

- **Improved Operations and Maintenance** - "modifying or adding to existing equipment or methods including, but not limited to, such techniques as improved housekeeping practices, system adjustments, product and process inspections, or production unit control equipment methods."

- **Recycling and Reuse** - "when achieved by using equipment or methods which become an integral part of the production unit of concern, including but not limited to filtration and other closed loop methods."

Based on practical experience, the most common method for minimizing pollution from a reportable chemical is the first on the above list -- input substitution. For example, often a less toxic, citrus-based cleaner can be found to fully replace chlorinated degreasers. The second most frequently employed pollution prevention technique is production unit modernization. An example of this might be adding a new welding fume extraction system to reduce the proliferation of chromium and nickel dust from stainless steel welding operations. The dust is captured for metals recycling, and OSHA air quality issues are positively impacted.

At a division of Beloit Corporation, a Fortune 200 manufacturer of heavy machinery for the pulp and paper industry, one of the first targets for pollution prevention was the machine coolants. Beloit uses scores of large machining tools throughout the plant. Machine coolants typically become contaminated with petroleum lube and hydraulic oils which are also used to run the machines. The organics break down, causing the 60 or more gallons of coolant to become rancid in a matter of a few weeks. Recycling using filtration, and the addition of hazardous biocide agents only delays the ultimate requirement to dispose of the thousands of gallons of coolant annually.

In this case, a new coolant was found which did not break down. A simple switch resulted in saving over $88,000 annually in coolant disposal and purchase costs. It eliminated a worker health and safety issue due to its lower toxicity, and provided a completely unexpected side benefit -- the new coolant's higher lubricity resulted in a 20% longer cutting tool life ($55,000), and about double the cutting speed.

In another section of the same plant, 1,1,1 Trichloroethane was used to manually degrease old papermill equipment being readied for repair. It took as much as 16 to 24 hours of labor to pre-clean the machinery prior to the commencement of rebuilding operations. A search for suitable closed-loop washing technology resulted in the purchase of a machine to handle up to 10 ton loads, and fully wash the equipment in less than 30 minutes in a fully closed-loop cycle. Payback on this unit was so rapid, a second machine was purchased for additional applications in the plant. As a result, the Trichlor was fully eliminated from the facility.

PC-Based Decision Support Tools

The process of identifying and evaluating pollution prevention choices is one which can be greatly facilitated by the aid of various PC-based decision support tools. By using the computer to help model the manufacturing process, the decision set structure is maintained in a manner which will support subsequent evaluation and optimization. A "rapid prototype" of such a decision aid is described as part of the presentation of this paper. Windows-compatible screen options are presented and discussed, and the attendees are invited to imagine the flexibility in pollution prevention decision-making which would be provided by such a tool.

SESSION XVIII

POLLUTION PREVENTION IN VEHICLE MAINTENANCE

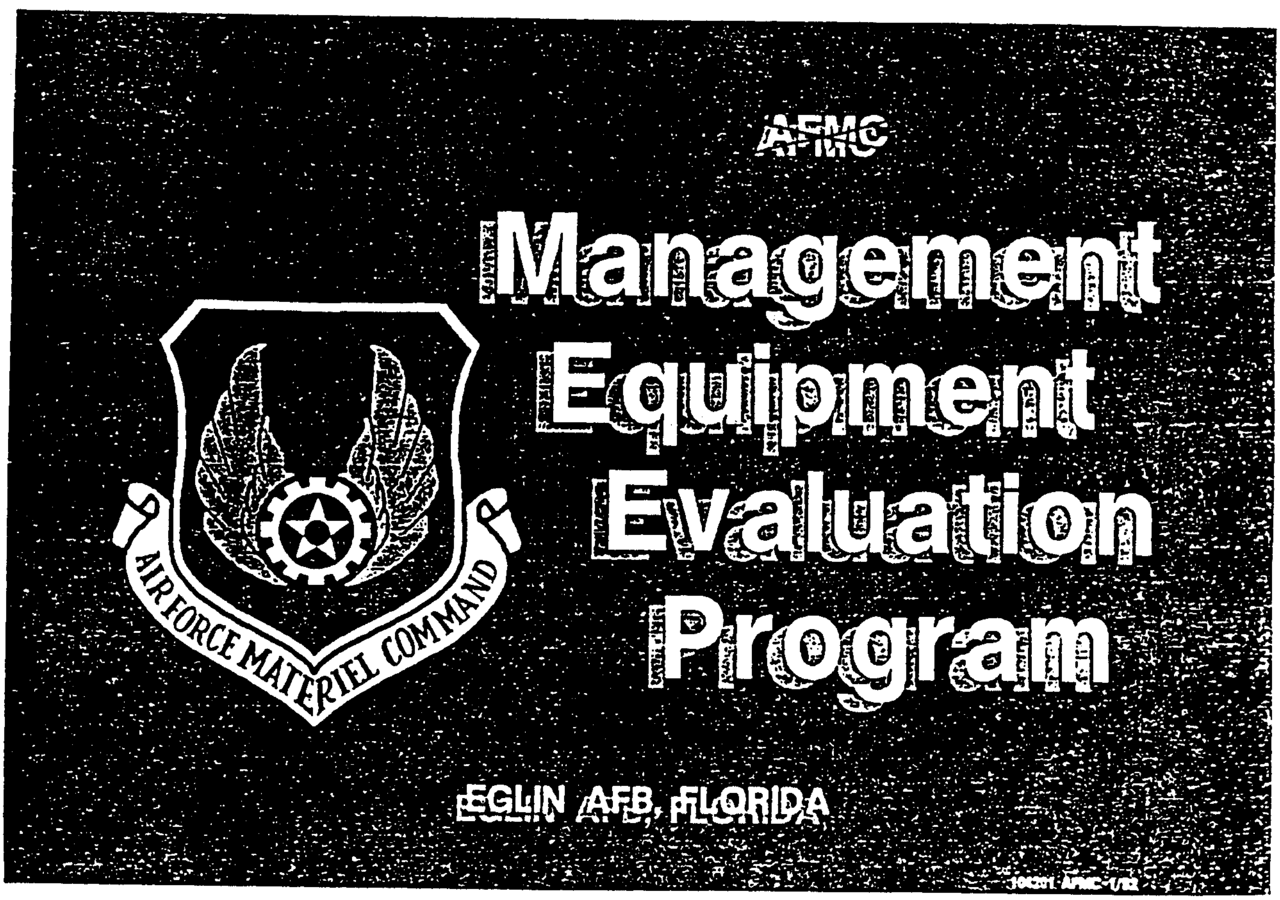
Session Chairpersons:
CMSgt Gary Richards, MEEP
Nancy Carper, HQ AFCEE/EP

MANAGEMENT EQUIPMENT EVALUATION PROGRAM

Jake Detweiler
615 SMSQ/LGTV - Eglin AFB, FL

(SLIDE 1)

WOULDN'T IT BE A GREAT DEAL FOR CONSUMERS IF THEY COULD TAKE HOME A PRODUCT - A CAR, WASHING MACHINE, LAWN MOWER, ECT - USE IT FOR A CERTAIN PERIOD OF TIME, BUT BUYING IT ONLY AFTER BEING SURE IT WAS WHAT THEY WANTED? THAT IS BASICALLY WHAT AIR FORCE MEEP DOES.



(SLIDE 2)

MANAGEMENT & EQUIPMENT EVALUATION PROGRAM (MEEP)

OVERVIEW: *THE MEEP IS AN AIR FORCE EVALUATION PROGRAM DESIGNED TO ENHANCE TRANSPORTATION AND CIVIL ENGINEERING MANAGEMENT BY IDENTIFYING MORE EFFECTIVE AND ECONOMICAL MANAGEMENT EQUIPMENT OR PRACTICES. THIS IS ACCOMPLISHED IN THE BEST POSSIBLE ARENA - THE FIELD, WITH CONTROLLED TESTING PERFORMED BY POTENTIAL USERS OF A PRODUCT. THE PROGRAM IS GOVERNED BY AIR FORCE INSTRUCTION 24-305.*

OVERVIEW

- **AIR FORCE PROGRAM**
  - **ENHANCES TRANSPORTATION MANAGEMENT**
  - **ENHANCES CIVIL ENGINEERING MANAGEMENT**
  - **EVALUATIONS ACCOMPLISHED IN THE FIELD**

104292 AFMC 1/92

(SLIDE 3)

MANAGEMENT: *THE AIR FORCE TRANSPORTATION DIRECTOR IS THE PROGRAM EXECUTIVE AGENT AND THE VEHICLES, EQUIPMENT, AND FACILITIES DIVISION ACTS ON BEHALF OF THE EXECUTIVE AGENT. MANAGEMENT OF THIS PROGRAM WAS FOR YEARS ACCOMPLISHED BY A FUNCTION UNDER THE VEHICLE MANAGEMENT DIVISION AT ROBINS AFB GA. THIS RESPONSIBILITY WAS OFFICIALLY TRANSFERRED BY THE AIR FORCE TO AIR FORCE SYSTEMS COMMAND IN JUNE 1987. SUBSEQUENTLY, DUE TO THE AIR FORCE LOGISTICS COMMAND MERGE, MANAGEMENT WAS PLACED UNDER THE NEW (COMBINED) AIR FORCE MATERIALS COMMAND TRANSPORTATION DIRECTORATE AND RELOCATED TO EGLIN AFB IN THE FLORIDA PANHANDLE.*

MANAGEMENT RESPONSIBILITY

- MANAGEMENT OF THE PROGRAM ORIGINALLY ACCOMPLISHED BY MMVV AT ROBINS AFB GA
- MANAGEMENT RESPONSIBILITY TRANSFERRED TO HQ AFSC/LGT IN JUNE 1987
- WITH THE AFLC/AFSC MERGE IN JULY 1992, MANAGEMENT RESPONSIBILITY NOW RESTS WITH HQ AFMC/LGT

104203 AFMC-1 92

(SLIDE 4)

PROJECT MONITORS: PROJECT MONITORING IS PRIMARILY PERFORMED BY FOUR FIELD MEEP ACTIVITIES LOCATED AT EGLIN AFB FL UNDER HQ AFMC, LANGLEY AFB VA UNDER THE HQ ACC, RANDOLPH AFB TX UNDER HQ AETC AND AT ELMENDORF AFB AK UNDER HQ PACAF.

PROJECT MONITORS

- PROJECT MONITORING PERFORMED BY FOUR MAJCOM FIELD ACTIVITIES LOCATED AT:
  - EGLIN AFB (HQ AFMC)
  - LANGLEY AFB (HQ ACC)
  - RANDOLPH AFB (HQ AETC)
  - ELMENDORF AFB (II AF/HQ PACAF)

104204 AFMC-1 92

(SLIDE 5)

OBJECTIVES: *This program enhances vehicle management by improving management plans, practices and procedures in areas such as:*

- *FACILITY LAYOUT*
- *EQUIPMENT CRITERIA*
- *INSPECTION NEEDS AND QUALITY CONTROL*
- *COST CONTROLS*
- *PERSONNEL TESTING AND TRAINING*
- *SHOP PROCEDURES*
- *SERVICEABILITY STANDARDS*
- *Standardization, Reliability, Maintainability and Survivability of vehicles and equipment. In addition, items for fleet use, and other new products are tested for serviceability, maintainability and usability. Areas are compared and recommendations are made concerning cost effectiveness, productivity, policy and procedures in vehicle maintenance concepts which are used by industry to improve maintenance. Further, vehicles, shop equipment, economy or efficiency in vehicle transportation are taken under study. However management plans for civil engineering activities are not evaluated under this program.*

OBJECTIVES

- **ENHANCE VEHICLE MAINTENANCE PLANS, PRACTICES AND PROCEDURES**
- **ENHANCE CIVIL ENGINEERING PRACTICES AND PROCEDURES**

104205 AFMC-1/92

(SLIDE 6)

PROGRAM FEATURES: MEEP is a unique function permitted to cut through "Red Tape" in planning, conducting and implementing the results of projects. Some features of this program which point out its utility value are:

- *Functions as a primary point of contact between the Air Force and private industry in respect to evaluation of transportation and civil engineering equipment, vehicles, tools, and related products. MEEP operates under the "try before you buy" concept. Product tests are performed at field level, by potential users, to determine if it will improve performance, economy or efficiency over items already in use.*

- *Provides "real world" field testing results for Air Staff's, Major Command's, Air Logistic Center's, Equipment/Material managers and other interested government parties. Testing gives a valid documented basis for adopting more effective items or rejecting unsuitable ones, usually also saving money.*

- *Shares and exchanges information with other military, federal and civil government agencies, foreign and domestic. This process helps to reduce unnecessary duplicate testing.*

PROGRAM FEATURES

- CUTS THROUGH RED TAPE
- PRIMARY POC BETWEEN AIR FORCE & INDUSTRY
- PROVIDE "REAL WORLD" FIELD TESTING
  - SHARES AND EXCHANGES INFORMATION
    - MILITARY
    - FEDERAL GOVERNMENT
    - CIVIL GOVERNMENT

104206 AFMC-1 92

(SLIDE 7)

PROCEDURES:

- *MEEP evaluations are performed after a multi-faceted selection process has taken place. Personnel from management and the various program monitor locations attend industrial trade shows and screen manufacturer's brochures and trade magazines for information on new or improved products.*

- *Air Force transportation and/or civil engineer functions are solicited to provide information about potential test items.*

- *Manufacturer representatives are encouraged to either send information to any of the MEEP functions or to contact a monitor to make an appointment for product presentation.*

- *Once a product has been approved for testing, the Air Force accepts vehicles, equipment, tools, or products from industry under a no cost to the government bailment agreement contract. The item is then issued to base units for field testing during the evaluation period. As many as five bases may test a product at the same time, which helps ensure the concept is thoroughly evaluated in different environments.*

- *The MEEP monitoring office, or offices, responsible for tracking the project ensure the items receive maximum utilization throughout the test period. During the evaluation phase, which ranges from six months to up to two years, information is collected to provide a data base for post test analysis.*

RESULTS: At the conclusion of the project test phase, the item is returned to the manufacturer or in many cases purchased by the testing unit. Test result data is thoroughly examined and all evaluation information is formed into a detailed report by the MEEP activity(s) responsible for performing the test.

- *Reports are forwarded to the program management office (MEEPMO) where they are analyzed for feasibility of Air Force procurement.*

- *Based on report data and recommendations form MEEP evaluating activities, if a product is acceptable and eligible for stock number assignment, formal paperwork is submitted. Otherwise, if desired, bases must procure the products using established local purchase procedures.*

- *When all required action has been completed, a final report is processes to the manufacturer/dealer informing them of test results. Similar reports are sent to all MAJCOM Headquarters and other agencies with vehicle/equipment responsibilities. In addition, semi-annual status reports are published providing current information on all MEEP projects. These reports explain good and bad points of a product. To help managers decide whether the item fits a need at their location.*

PROCEDURES

- MULTI-FACETED SELECTION PROCESS
  - INDUSTRIAL TRADE SHOWS
  - MANUFACTURERS' BROCHURES
  - TRADE MAGAZINES
- BAILMENT AGREEMENT
  - NO COST
- PROJECT TRACKING AND REPORTING

104207 AFMC-1/92

(SLIDE 8)

BENEFITS TO THE GOVERNMENT: *BY TESTING VEHICLES AND EQUIPMENT IN THE AREA OF POTENTIAL USE PRIOR TO SPENDING PRECIOUS TAX DOLLARS FOR PURCHASE, THE AIR FORCE IS ASSURED THAT THE PRODUCT BEING BOUGHT IS NEEDED, MAYBE MORE COST EFFECTIVE, PROBABLY EASY TO USE, AND IS IN FACT USEFUL IN THE SHOP WHERE IT WILL BE USED. IF THE PRODUCT DEMONSTRATES TO BE BETTER THAN A VEHICLE OR PIECE OF EQUIPMENT ALREADY IN THE INVENTORY, THEN THE PRODUCT TYPE IS OFTEN CHOSEN TO REPLACE OLDER, LESS ADVANTAGEOUS ITEM.*

BENEFITS TO INDUSTRY: *MANUFACTURERS ARE RELIEVED OF THE NEED TO PROVE THE ATTRIBUTES OF THEIR PRODUCT. ADVANTAGES AND/OR DISADVANTAGES ARE PROVEN BY THE TESTING UNIT(S) WHO REPRESENT THE ULTIMATE USER.*

- *MEEP TEST RESULT REPORTS OFTEN PROVIDE READY ACCESS TO FEDERAL AND/OR NATIONAL STOCK NUMBER ASSIGNMENT AND HELP MANUFACTURERS OBTAIN GSA CONTRACTS.*

BENEFITS

- GOVERNMENT
  - COST EFFECTIVE
  - IMPROVES QUALITY
  - EASE OF USE
- INDUSTRY
  - NEED NOT PROVE ATTRIBUTES
  - ACCESS PROVIDED TO NSN ASSIGNMENT

104208 AFMC-1/92

(SLIDE 9)

MANPOWER: THERE ARE PRESENTLY THREE CIVILIAN AND ONE MILITARY POSITIONS AUTHORIZED FOR THE MEEP MANAGEMENT OFFICE (MEEPMO) FUNCTION.

- FIELD MEEP ACTIVITIES ARE AUTHORIZED 5 SPACES AT EGLIN AFB, 6 AT RANDOLPH AFB, AND 8 POSITIONS AT LANGLEY AFB. 11 AF/LGTV HAS ONE PERSON PERFORMING MEEP DUTIES PART TIME.

- IN ADDITION, HEADQUARTERS AIR FORCE CIVIL ENGINEER SERVICES AGENCY (HQ AFCESA) HAS TWO INDIVIDUALS THAT COORDINATE ALL BCE TYPE PROJECTS WITH MEEPMO. TO ASSIST THEM IN THEIR MEEP DUTIES HQ AFCESA HAS DESIGNATED MONITORS IN MAJCOM CIVIL ENGINEER DIRECTORATES. PLUS AFCESA IS FINAL AUTHORITY FOR ALL POST EVALUATION ACTION FOR THOSE PRODUCTS.

MANPOWER

- MANAGEMENT STAFFING
  - MEEPMO - FOUR ~~FIVE~~ POSITIONS
    - THREE CIVILIANS
    - ONE ~~TWO~~ MILITARY
- FIELD ACTIVITY STAFFING
  - EGLIN AFB - 5 POSITIONS
  - LANGLEY AFB - 8 POSITIONS
  - RANDOLPH AFB - 6 ~~5~~ POSITIONS
  - ELMENDORF AFB - 1 POSITION
- HQ AFCESA
  - 2 MEEP COORDINATORS
    - EACH MAJCOM - 1 CE PROJECT MONITOR

104209 AFMC-I 92

(SLIDE 10)

PROJECT BREAKDOWN BY ACTIVITY: *THIS SLIDE SHOWS QUANTITY OF ACTIVE PROJECTS CHARGED TO EACH MEEP ACTIVITY. (NOTE: A PRODUCT IS OFTEN BEING TESTED BY MORE THAN ONE ACTIVITY, SO OVERALL TOTALS WILL NOT BE THE SAME AS ON THE CURRENT PROJECTS CHART).*

FIELD MEEP ACTIVITIES

EGLIN AFB FL (AFMC)
NUMBER OF PROJECTS ____________

LANGLEY AFB VA (ACC)
NUMBER OF PROJECTS ____________

RANDOLPH AFB TX (AETC)
NUMBER OF PROJECTS ____________

ELMENDORF AFB AK (II AF/PACAF)
NUMBER OF PROJECTS ____________

104210 AFMC-1.92

(SLIDE 11)

CURRENT PROJECTS: AS OF 26 AUGUST THERE WERE ___ PROJECTS EITHER ACTIVELY BEING PURSUED, IN THE EVALUATION PHASE, OR UNDER REVIEW FOR CATALOGING AND STOCK NUMBER ASSIGNMENT. THIS IS BROKEN DOWN TO __ TRANSPORTATION PROJECTS, __ CIVIL ENGINEER, __ ENVIRONMENTAL RELATED, AND __ THAT ARE CATEGORIZED AS "OTHER" THAT COULD BE OF BENEFIT TO SEVERAL ORGANIZATIONS, INCLUDING FLIGHT LINE FUNCTIONS. TOTAL RETAIL VALUE OF ALL ACTIVE PROJECTS IS ABOUT _._ MILLION DOLLARS.

CURRENT PROJECTS

TOTAL ACTIVE PROJECTS	________
• TRANSPORTATION	________
• CIVIL ENGINEER	________
• ENVIRONMENTAL	________
• OTHER	________
TOTAL DOLLAR VALUE	________

104211 AFMC-1 92

(SLIDE 12 & 13)

ENVIRONMENTALLY RELATED MEEP PROJECTS: *THE NEXT TWO SLIDES SHOW ALL OF THE MEEP PROJECTS THAT HAVE ENVIRONMENTAL OVERTONES, AS OF AUGUST 1994. IF YOU SEE ANYTHING YOU WOULD LIKE TO HAVE MORE INFORMATION ABOUT, WE HAVE A FORM FOR YOU TO FILL OUT WITH THE PROJECT NUMBER, AND YOUR NAME, ADDRESS AND PHONE NUMBER. YOU CAN ALSO STOP BY OUR BOOTH IN THE EXHIBIT AREA WHERE MORE DATA MAY BE AVAILABLE. IF NOT PRODUCT DATA WILL THEN BE FURNISHED TO YOU AS SOON AS POSSIBLE.*

(SLIDE 12)

CURRENT ENVIRONMENTALLY RELATED
MEEP PROJECTS (AS OF 5/21/93)

TRANSPORTATION

PROJECT NR	PROJECT TITLE	VENDOR*
EV91-02	SOLAR POWER BATTERY CONDITIONER/CHARGER	*
EV91-66	BODY SHOP MASTER WORK STATION	*
EV91-72	DIESEL ENGINE FUEL INJECTOR CLEANER SYS	*
EV91-87	GASOLINE ENGINE PORT INJECTOR CLEANER	*
EV91-94	DIESEL EXHAUST SMOKE ANALYZER METER	
EV92-07	DIESEL FUEL BY-PASS FILTER SYS	*
EV92-12	BY-PASS OIL FILTRATION SYS	*
EV92-17	DUSTLESS SANDER	*
EV92-57	OIL/FUEL FILTER RECYCLING CENTER	*
EV92-68/	HYDRAULIC FLUID BY-PASS FILTER	*
EV92-69	AUTOMATIC TRANSMISSION FLUID FILTER	*
EV92-71	THERMO OIL BATTERY	
EV92-73	DIESEL ENGINE FUEL FILTER HEATER	
EV92-74	PARTS WASHER W/FILTER	*
EV92-98	FUEL SYSTEM MAGNETIZER	
EV92-101	BATTERY POWERED TOW TRACTOR	
EV92-104	FOAM PACKAGING SYS	
ET93-02	CLEAN AIR VALVE	
ET93-04	ANTIFREEZE RECYCLING SYS	*
ET93-13	VEHICLE CHASSIS DYNAMOMETER	
ET93-24	PAINT THINNER/SOLVENT RECYCLER	

(SLIDE 13)

CIVIL ENGINEER

EC92-82	WASTE PETROLEUM PRODUCT FURNACE	
EC93-40	HAZ MAT VIDEO TRAINING	

OTHER AREAS

EO92-21	DRUM CRUSHER/COMPACTOR	
EO92-86	AQUEOUS CLEANING SOLUTION RECYCLER	*

CLOSED ENVIRNOMENTALLY RELATED MEEP PROJECTS (AS OF 05/24/93)

TRANSPORTATION

EH89-30A	HV/LP VEHICLE PAINTING SYS	*
EH89-30B	HV/LP VEHICLE PAINTING SYS, W/TURBINE	
EV90-53	OIL FILTER CRUSHER	
EV91-13	MOBILE A/C REFRIGERANT RECYCLER/RECHARGER	*
EV91-56	GAS ENG FUEL INJECTOR CLEANING SYS	*
EV91-56A	GAS/DIESEL INJ/CARB INT CLEANER SYS	
EV92-55	WATERFALL PAINT WASTE DISPOSAL MACHINE	*

CIVIL ENGINEER

EC90-78	AIR CURTAIN SMOKE DESTRUCTOR	

OTHER AREAS

* INDICATES A MANUFACTURER OR REPRESENTITIVE IS SCHEDULED TO HAVE A BOOTH AT THE EXHIBITION.

Pollution Prevention for Vehicle Maintenance Operations within 30th Transportation Squadron at Vandenberg AFB, CA

Carolyn Howk, Joe Walters, Sgt. Samuel Underwood
Engineering-Science
199 S. Los Robles, Suite 400
Pasadena, California 91107
(818) 585-6075

Vandenberg Air Force Base (VAFB) is one of two national launch facilities operated by Air Force Space Command (AFSPC) which provides spacelift and intercontinental ballistic missile (ICBM) launch operations. Military, civil, and commercial satellites are launched into orbit, and Peacekeeper and Minuteman ICBMs are maintained and tested at VAFB.

VAFB occupies 98,400 acres in an environmentally-sensitive area along the south-central coast of California. The base is located approximately 140 miles west-northwest of Los Angeles and 55 miles northwest of Santa Barbara. VAFB is a small, self-supporting, city with large residential and industrial areas, fire department, police department, theater, restaurants, housing, library, medical clinic, and chapel. The majority of the base activities occur within its ten-square mile cantonment area, with the remaining activities generally dispersed along the 35 miles of coastline at various launch facilities

As part of AFSPC's program for conducting Pollution Prevention (P2) Opportunity Assessments, Engineering-Science (ES) recently completed a 1993 initial survey for significant industrial processes for VAFB. One of the units investigated was the 30th Transportation Squadron.

The P2 study done by ES reviewed hazardous material usage, waste releases, and pertinent process information for industrial-type activities at the vehicle maintenance facility. The primary focus of process hazardous material usage was on the U.S. Environmental Protection Agency (EPA) 17 industrial toxic project chemicals and ozone depleting compounds (ODCs). A data collection team interviewed the appropriate base personnel and collected material usage and waste generation information. In addition, general process information in the form of process flow diagrams was collected. The material and waste generation information was recorded using electronic clip boards which downloaded the information directly to a database. Information from the material safety data sheets (MSDS) was also input into the database. At this point the data was sorted and the weights of the air emissions, hazardous material, hazardous waste, wastewater, ODC, and EPA 17 chemicals was calculated. A list of target chemicals used by the 30th Transportation Squadron was also extracted from the database.

Information from a total of 17 industrial-type processes was analyzed (See Table 1). Petroleum-based fluid changes as well as painting, industrial, and solvent operations makeup the industrial-type processes of 30th Transportation. In order to reduce the pollution generated at the maintenance facility, a point system was used to rate hazardous conditions of each process, and all processes were prioritized for evaluation of source reduction opportunities. These opportunities are being evaluated in the second phase of the study.

Table 1
30th Transportation Squadron Process Distribution

Process Code	Process Description	Building Location
TPAB01	Abrasive Blasting	10711
TPFC01	Fluid Change	10711
TPFC02	Antifreeze Change	10711
TPFC03	Fluid Change	10713
TPFC04	Antifreeze Change	10713
TPFC05	Fluid Change	1800
TPFC06	Antifreeze Change	1800
TPIO01	Tire Change Operations	10711
TPIO02	Air Conditioning Recharge	10711
TPIO03	Brake Cleaning	10711
TPPO01	Vehicle Painting and Repair	10711
TPSK01	Parts Cleaning Using a Safety Kleen Unit	10711
TPSK02	Immersion Cleaning Using a Safety Kleen Unit	10711
TPSK03	Immersion Cleaning Using a Safety Kleen Unit	10713
TPSK04	Parts Cleaning Using a Safety Kleen Unit	10713
TPSK05	Parts Cleaning Using a Safety Kleen Unit	1800
TPSO01	Carburetor Cleaning	10711

However, P2 within the 30th Transportation Squadron is not something new. In August, 1993, the 30th Transportation Squadron relocated from an old maintenance facility to a new facility at VAFB. This new facility incorporated many of the latest design features for P2.

The maintenance bays are wide to allow the workers ample room to work on the vehicles. This type of access will enables workers to see where leaks are occurring quickly and more easily. A dedicated bay with a work pit gives the workers easy access to the undercarriage of vehicles.

A centralized material dispensing and hazardous waste collection points were also installed in the new facility. This limits the area where spills can occur during material transfer, so that material waste and the use of rags and absorbents is minimized. With centralized dispensing from 55-gallon containers, workers are also less likely to open new containers just because they can not find an open can.

An aboveground storage tank (AST) was installed for the storage of waste oil. Having the waste oil stored above ground, minimizes the possibility of soil and groundwater contamination. Leaks are easily detectable and repairable. Because waste oil was previously stored in 55-gallon drums, the labeling, handling, and record keeping requirements have been reduced. The potential for spills and leaks from multiple was oil drums has also been reduced.

A new abrasive blast unit was purchased for the 30th Transportation Squadron. This unit is used to removed paint, corrosion, grease and oil, and other substances from small automotive parts such as heads, valves, pistons, valve covers, and battery box trays. This unit uses supplied air. A vacuum is created in the blasting box to keep the dust down inside to improve visibility. Particles of up to 5 microns are filtered from the air stream on the effluent end of the unit.

A new paint booth was constructed within the building. This paint booth is sized so that anything from small parts to light trucks can be painted in the booth, and all of the painting is done there. Particulates and volatile organic compounds (VOCs) from the painting process are drawn through the exhaust dry filters. The influent air is also dry filtered before entering the booth.

A recycle unit for waste antifreeze is currently under procurement. The antifreeze will be recycled on site using this new unit, which will reduce the amount of new antifreeze procured and the waste antifreeze manifested off site.

Numerous good housekeeping practices have been instituted to maintain the facility in good condition. The floors are cleaned weekly using a biodegradable cleaner. The maintenance bays are continually inspected for spills, safety violations, and other potential hazards.

Engineering-Science is currently evaluating other source reduction alternatives for potential future implementation within the 30th Transportation Squadron. These options include such practices as using synthetic oil, fluid quality testing, and additional applications of biodegradable cleaners. However, the organization has already taken major steps toward spill reduction, hazardous material usage, waste generation, and air emissions.

The Application of Pulse Technology for the Purpose of Extending Battery Life

Mr. Mark Witt
Specialized Products Company
3131 Premier Drive
Irving, Texas 75063
(214) 550-1923

Introduction to Pulse Technology

When engineers at the Stennis Space Center evaluated a crude solar device, with a small circuit board attached to it in August 1990, they discovered that "The pulsed power will prevent sulfate accumulation on battery plates maintaining peak performance". From this report and subsequent patent numbers 4,871,959; 5,063,341; 5,084,664 and 5,276,393 that were assigned to the circuit, a group of products was developed that with three years of verifiable military evaluations will revolutionize the lead-acid battery industry as it is known today.

The main purpose of Pulse Technology is to prevent crystallization of the electrolyte. In cases where crystallization has taken place in the battery plates, the technology is effective in dissolving the crystal and permitting the individual molecule to free itself from the crystal formation and become a free molecule again. The process is accomplished by causing the individual molecules of the crystal formation to take on energy as a direct result of the pulsing action. This is accomplished with a dc pulse that strictly controls the rise time, pulse width and resonant frequency. The pulse required to accomplish this effect must be fast enough in rise time to trigger a wave of at least 2 to 10 MHz at a pulse width of less than .3 micro seconds. The pulse frequency is not critical to the process but will run anywhere from 2 kHz to 20 kHz, depending on loading and power supply voltage used.

All elements have a magnetic moment at a resonant frequency. The resonant frequency of sulfur is 3.26 MHz. When this frequency is induced into the crystal formation of sulfur, individual molecules of the crystal will accept this energy and be excited to a higher energy level state, thus breaking the bonds of the crystal structure. As a result, the individual molecules of sulfur are freed from the crystal and are now ready to be charged and return to solution to form an active electrolyte again. This process requires very low energy input to the battery, primarily because each molecule is being energized individually sufficient enough to dissolve and liquefy the sulfur crystals.

The dc current of wattage value of the pulse is sufficient only to take care of the normal internal discharge to the battery. Pulse Technology products were not designed to recharge a battery. When a battery needs charging, it will require a charger be placed in parallel so that the positive pulse modulates the dc charging current.

Why Batteries Fail

Lead acid batteries work on a principal of energy being transferred from the sulfur molecules to the lead plates. Theoretically, when sulfur molecules reach a specific low level of energy, they release from the lead plates and dissolve back into a liquid state. They are then ready to accept a recharge. In practice, however, some of the sulfur molecules reach such a low level of energy that they do not return to the solution but remain attached to the plates and eventually become crystallized. When sulfur reaches its lowest energy state, it becomes a crystal which then grows as other sulfur molecules are accumulated. Because the energy level of the individual sulfur molecule is at a very low state and attracts other low energy sulfur molecules, the crystal forms and becomes tightly bound as one unit. In this form, it is no longer effective as an electroyte, and the battery loses its ability to function. The extent of accumulation and hardness of the crystal formation is a product of time, state of charge in the battery and usage cycle of the stored energy. A battery in this condition is considered bad and is usually discarded.

Benefits of Pulse Technology

The principal benefit of Pulse Technology is to keep batteries free of sulfur build-up, thereby allowing a battery to function continually at 100% efficiency. A battery with clean plates that allows an unobstructed transfer of energy will accept a full charge and release all its stored energy. At the same time, it is estimated that more than 80% of discarded batteries are only clogged by sulfur crystallization of the electrolyte. Therefore, continual use of Pulse Technology will accomplish three things not available prior to this invention: 1) Dramatically extend the useful life of a battery by avoiding or reversing accumulation of sulfur crystals; 2) Improve the efficiency of a battery by allowing 100% capacity of operation; and 3) With solar-powered units, maintain the battery by replacing the charge lost due to unavoidable normal internal discharge.

Economic Considerations for the Military

It is hard to imagine in this world of technological breakthroughs that we are still using a battery which has not changed in basic design since its invention almost 90 years ago. As a society, our reliance on the lead-acid battery has caused many individuals and companies to look for a better alternative with limited success. Although the lead-acid battery is not excessively expensive, its cost goes up dramatically when you include disposal cost and labor hours. The Air Force reported in the Consolidated Status Report, 16 June-15 December 1993, "In conclusion, the Solargizer worked by removing sulfation from the battery plates as the manufacturer claimed. Extensive use of the Solargizer could result in significant savings. It is unknown exactly how long a battery will last with the Solargizer connected, but it is estimated at least eight to 10 years of life can be added". Proper application of Pulse Technology products like the Solargizer in the military could result in a significant reduction in batteries purchased and billions of dollars saved over the next decade.

Environmental Impact of Pulse Technology

Many experts predict the lead-acid battery will be the primary source of battery power for the next 10 to 20 years. After the tire, the battery is the most expensive and difficult product to dispose of safely. Yet over 80% of discarded batteries have nothing more than a curable sulfation problem. Imagine the contamination that prematurely dumping battery lead and sulfuric acid across the nation can cause. Then realize what difference the innovation of Pulse Technology can make. The simple fact that the Air Force, Army and Navy at different times and locations have taken condemned discarded batteries that were verified as not capable of accepting a charge, returned them to as new condition and put them back into service is an excellent reason to investigate the possibility of using Pulse Technology products to solve your battery problems.

SESSION XIX

LEAD BASED PAINT ISSUES

Session Chairpersons:

Jerris Harris, HQ AFCEE/EP

David Galson, Galson Corporation

Summary Findings of Lead Based Paint Surveys at Four Air Force Bases

David Galson, PE
Galson Corporation
5733 Grisborne Avenue
Oakland, CA 94611

Tel:(510) 339-3550 /800-950-0506
FAX (510) 339-3552
Email: dgalson@AOL.com

During 1993, Galson Corporation completed surveys for lead-based paint (LBP) in Military Family Housing (MFH) at four Air Force Bases: Goodfellow, Sheppard, Columbus, and Keesler. The smallest survey (at Goodfellow) involved surveying 10 units distributed among 11 architectural styles. The largest survey (at Keesler) involved the survey of 880 units distributed among 26 architectural styles.

	No. of Unit Types	No. of Units
– Goodfellow:	11	100
– Sheppard:	13	386
– Columbus:	16	350
– Keesler:	26	880

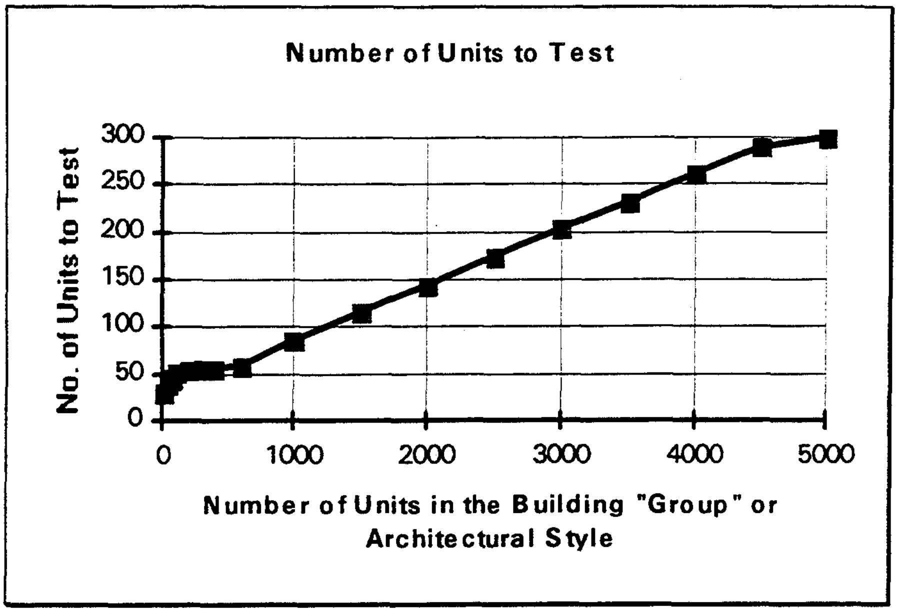
X-Ray Fluorescence (XRF) spectrum analyzers manufactured by the Scitec Corporation were used throughout the four surveys, and no bulk samples were collected.

Painted materials were quantified and prioritized based on the lead content and physical condition. Summary statistical reports were generated that listed the number and percentage of observations which fell into each of 5 priorities for each painted component within each architectural style (or building type).

Summary of Scope of Work

- **Identify LBP materials to reduce health risks**
- **Provide Tools and Information to better manage LBP**
- **Full XRF Survey of Statistically Representative Units**
- **Provide survey database**
- **Provide Lead Management Plan**
- **Provide Electronic Management Tool**

The number of units to test from each building type or architectural style were determined according to HUD guidelines. Asummary of these guidelines appears ion the chart below.



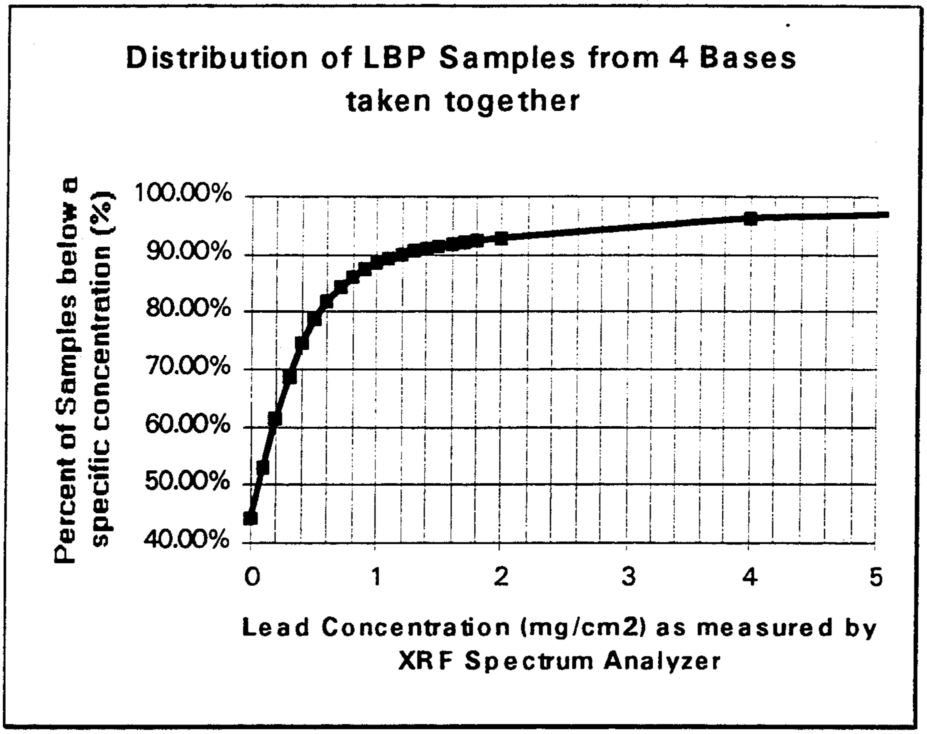
The findings of the survey were submitted in three formats including a written report with printed statistical summaries, electronic data with a PC-compatible integrated query and maintenance system, and CAD drawings showing the space names, floor plan layouts, color coded sample locations, and lead content.

Through the use of master, or prototypical, buildings, data entry and quality control (QC efforts were reduced because similar elements from one building to the next were simply copied. Only unique and distinctly different observations required keyboard entry efforts. Coded analyzer results were checked on -site then downloaded directly to the database management system. In this way, manual data entry of lead measurements was not required.

Once the field and analyzer data for a building were completely entered and quality checks were passed, the data were transferred to a skeleton copy of the building floor plan in CAD format. Sample tags were automatically placed in the proper locations on the drawing using custom software.

A total of 134,724 XRF samples were collected representing 108,886 observed materials. Roughly 24% of all observed materials needed more than one XRF sample collected. Of the observed materials approximately 10% were found to have lead concentrations above the action level of 1.4 mg/cm2. Roughly 1% of the observations were found to be above the action limit, and were chipping, cracking, and peeling.

With a low/inconclusive limit of 0.8 mg/cm2 and action limit of 1.4 mg/cm2, roughly 5% of the samples collected were classified as inconclusive and will require additional testing with an alternative method.

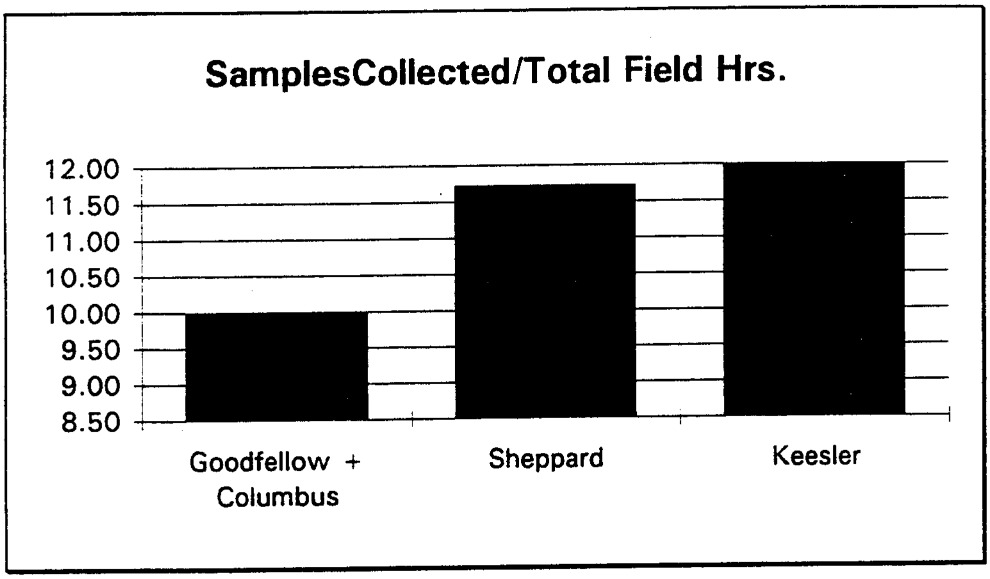


The PC software submitted with each survey permits facility managers and technicians to easily review survey findings for a specific building, or for a building of similar architectural style or painting history. Additional bulk or XRF samples can be added to the database, and changes to material conditions can be easily recorded.

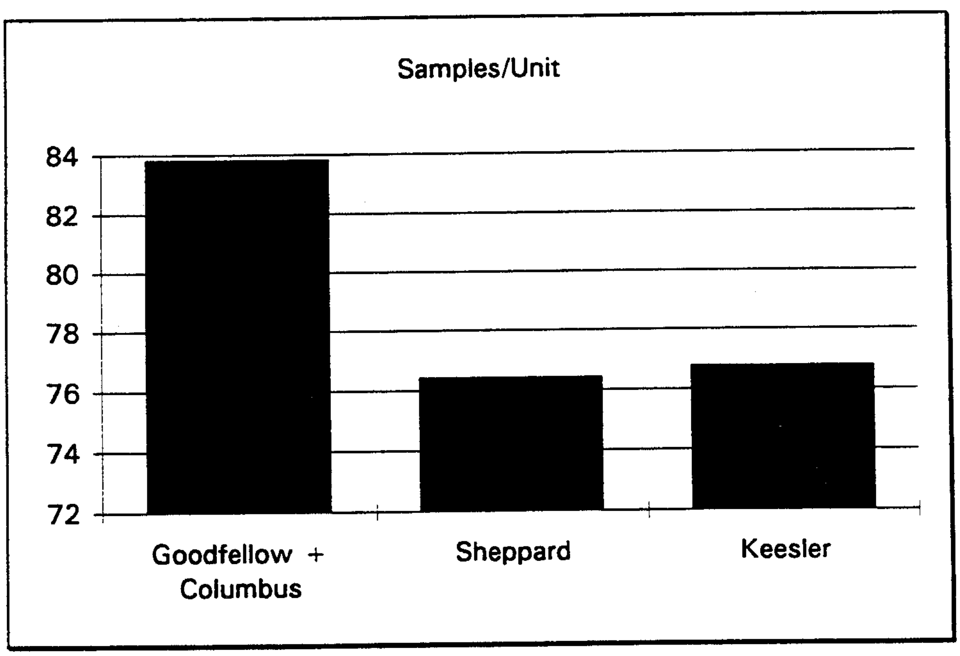
Survey data (stored in .dbf format) and survey drawings (stored in .dwg format) are fully documented so that they can be imported into other environmental management programs as they become available.

Planned releases of the software will allow users to determine cost estimates for various abatement alternatives. Abatement projects will be recorded in the program keeping the database created during this project up-to-date.

Productuivity for the projects was tracked using a number of different statistics. One ratio tracked was the samples collected per total field hours. This performance is displayed in the chart below:



Funding issues for the projects relate not just to productivity, but also to the difficulty or diversity of the building stock being surveyed. The following chart shows the variation possible between different faciltities.



These variations, along with the cooperation of the facility personnel to assit in accessing the housing units have the biggest impact in the effort required to complete these types of projects.

Proper Characterization of Lead Based Paint Contaminated Debris

Major Daniel R. Turek, USAF, BSC, CIH
21st MDG/SGPB 625 West Ent Ave
Peterson AFB, CO 80914-2840
DSN: 834-7721 COMM: 719-556-7721 FAX: -8370

Introduction

Environmental regulations as promulgated by the Resource Conservation and Recovery Act (RCRA) and fortified by the Federal Facilities Compliance Act (FFCA) currently require the characterization of lead containing wastes to determine proper disposal criteria. The base has the responsibility to ensure that all Lead-based paint (LBP) abatement wastes and construction debris are disposed of properly. The Bioenvironmental Engineer (BEE) has a significant role in determining the fate of such waste. This presentation will provide guidance and lessons learned to installation Bioenvironmental Engineers or Environmental Managers on legislative requirements, waste stream characterization, Toxicity Characteristic Leaching Procedure (TCLP) testing, sampling procedures, and waste disposal technical requirements.

Regulatory Requirements: Resource Conservation and Recovery Act

In 1976 Congress passed RCRA which was designed to track and regulate hazardous wastes from the time they were manufactured to final disposal. The U.S. Environmental Protection Agency (EPA) continuously develops RCRA regulations and publishes them annually in the Code of Federal Regulations (CFR). RCRA distinguishes between solid waste and hazardous waste. Solid waste is a very broad term covering all solid and liquid forms, and some gaseous forms, of household trash, discarded industrial materials, sludge from waste treatment plants, and so forth. Hazardous waste is solid waste that may substantially pose a threat to human health or the environment when improperly handled.

Hazardous wastes are regulated differently than non-hazardous wastes. Solid wastes (non-hazardous) are regulated under Subtitle D of RCRA, and are subject to minimum technical standards for landfills. Subtitle C of RCRA, on the other hand, regulates hazardous waste through a "cradle-to-grave" system to ensure proper management from generation through ultimate disposal. RCRA sets forth requirements to assure that the disposal of hazardous waste is effective and permanent to the extent of no escape of hazardous materials to the environment. LBP abatement projects produce potentially large quantities of solid waste which may be hazardous waste. Such wastes must be considered under Subtitle C of RCRA because of possible lead content. Lead is considered to be a threat to human health and the environment if uncontrolled, treated, or disposed of improperly. Disposal restrictions are solely based on the possibility that the lead content in such wastes may leach if placed in a sanitary landfill. Specific laboratory tests required under RCRA are designed to measure this potential. Presently, Federal EPA has no special exclusions or provisions governing the disposal of construction debris coated with LBP.

State and Local Laws and Regulations

States regulate solid (non-hazardous) waste, and many run their own hazardous waste programs with U.S. EPA approval under RCRA. RCRA encourages states to assume some of the Federal responsibilities for operating their own Regional EPA approved hazardous waste management programs. In general, state laws and standards are required to be equivalent to or more stringent than Federal hazardous waste standards. There are some variations from state to state, and certain states have enacted very stringent hazardous waste and air quality requirements. For instance, EPA Region I currently plays the lead role in research and development of LBP waste management. States in this region have more detailed standards and consequently more guidance in implementing these standards than other states. *At the local level, it is imperative that the BEE, as well as other key players on the installation, (i.e. Environmental Management/Flight) coordinate their hazardous waste activities (especially sampling and disposal requirements) regarding LBP waste with the appropriate state, county and local agencies <u>before disposal/demolition actions</u> are undertaken.*

Anticipated Waste Streams

The LBP abatement actions generally will produce specific waste types. In general, any activity that concentrates LBP has the potential to create a hazardous waste. Typically, the polyethylene used in abatement and personal protective suits will be non-hazardous waste as long as they are decontaminated with a high efficiency particulate air (HEPA) filtered vacuum. Removed substrate components that contain LBP can be either hazardous or non-hazardous waste. This section will discuss various abatement activities and the anticipated quantity and type of waste associated with each activity. BES must identify the wastestreams resulting from the abatement activities and include them in the installation's Waste Analysis Plan. Though these general guidelines state that certain decontaminating procedures will render some wastes non-hazardous, remember that BES must comply with *<u>local</u>* regulations on the need for TCLP testing.

<u>Paint Removal:</u> All lead-based paint *<u>removed</u>* from a substrate by virtually any method will, almost without exception, be hazardous waste and should be disposed of accordingly. Polyethylene and personal protective suits will need to be considered for disposal too. Generally, HEPA vacuuming both suits and polyethylene will render these materials as non-hazardous. Specific factors must be considered for waste disposal when using different paint removal methods for abatements.

<u>Removal of Components:</u> The removal of components containing or contaminated with LBP vastly increases the volume of waste material. Wastes from this type of abatement are typically windows and window sills, doors and door frames, shelves, baseboard, and other trim. Though the amount of waste increases with this type of abatement, the adherence of the LBP to a substrate may decrease the amount of leachable lead in the waste. . As a result, the chance of component waste failing the TCLP test may be lower than that of paint removal waste.

Waste Characterization

This section describes procedures and methods used to provide characterization of the solid waste generated during demolition, Operations and Maintenance (O&M) tasks, and LBP abatement activities.

As described in other Air Force Instructions and guidance documents (AFI 32-7042, Solid and Hazardous Waste Compliance) the installation must develop an installation Waste Analysis Plan (WAP). Waste generated from projects involving LBP must be included in the Installation WAP and should be managed appropriately.

Demolition Projects

Overview: Before characterizing the waste, it is necessary to define the wastestream. This presentation defines the wastestream or "population" that is being characterized as the debris generated during a given demolition project at a given site. Similar buildings scheduled for demolition (consider: age, use, construction materials) may be grouped to form a population. Typically, a Civil Engineering project would constitute the sample population.

Sample: The goal is to collect a "homogenous sample" whenever characterizing hazardous waste. Demolition waste containing LBP is no different. The sample should be representative of the *entire building* to be demolished. A representative proportion of the entire structure should be included in the sample to include glass, wood, cement, brick, and roofing materials. It is important to identify what portions of the buildings are to be recycled or disposed of separately from the general building debris. For instance, asbestos (transite) siding on some structures may be removed and disposed of separately. Metal ductwork, furnaces, piping, light ballasts and metal siding may be removed and reused/recycled as scrap metal. The components to be recycled or disposed of separately should not be included in the LBP composite homogenous sample.

Sample Collection:

a. For the typical LBP sample going to Armstrong Lab for TCLP, 250 grams (6-8 ounces) of the solid material needs to be collected in a wide-mouth colorless sturdy glass container (Qorpak or equivalent).

b. The following tactic should be used to collect the representative sample from an intact building. The proportional size of the various building areas based on (estimated) square footage must be determined. For instance a building may be 70 feet long, 40 feet wide and 12 feet high; if all four of the exterior walls are made of the same material, there should be 2,640 ft^2 of the material/component. Window and door space should be subtracted out of the exterior-interior walls and considered as separate areas. The total estimated areas (i.e. exterior wall, interior plaster wall, interior plywood/paneling wall, floor, cinder block supports, etc.) should be compared to one another in order to establish ratios. The ratios will determine the number of samples to obtain from each individual area. Generally 60-70 subsamples are necessary to makeup one 250 gram sample (number will vary depending on building material).

c. Using a 1 - inch bit drill or similar device, a "core" subsample should be obtained from the selected areas of the building. (use caution when drilling into unknown areas containing live wiring or plumbing). The subsample material should be collected into a disposable container (such as large sheets of paper) as the drilling is done. The sampling crew should to the extent possible, drill through the entire substrate. For building components such as cinder block or cement an air powered hammer drill or similar device should be used. The number of drill holes obtained from each type of surface/area should be recorded. If the number of overall subsamples is not enough (less than 250 grams collected) for the TCLP, additional subsamples should be obtained from each of the specific areas until the sample minimum is obtained. [Note: For at least 5 percent of the samples (and a minimum of one sample), approximately 500 grams should be obtained for an adequate split laboratory analysis.]

Timing: One logical consideration that should be addressed before demolition occurs is when do we want to sample, before the building is torn down or after it becomes a pile of waste rubble. For safety purposes, it is recommended whenever possible to sample the building before it is torn down, as sampling rubble piles and climbing onto dump trucks filled with debris is not without risk. If sampling is required of a rubble pile, consult EPA Report EPA-60012-80-018, "Sampling and Samplers Procedures for Hazardous Waste Streams" for more information on hazardous waste sampling of Waste Piles. Pre-planning is critical, as the time to consider sampling is not after a building is ripped down and is waiting for disposal; CE & EM will want to know the answer of what to do with the waste *before* the wrecking ball and front-end loader arrive on site.

Operations and Maintenance (O & M) Tasks

Overview: The waste generated from O&M work in CE can generally be put into two categories; component replacement and repair. Usually, wastes generated from repair activities (i.e. replacement of window glass in a window frame coated with LBP) does not require sampling. The wastes generated from component replacement (i.e. doors, windows, garage doors, etc.) coated with LBP *may require* sampling. Coordination with local and county regulators concerning disposal of these items in a construction or municipal landfill is crucial. As stated earlier in this section, the relationship of TCLP sampling versus cost of waste disposal must be established. For small jobs generating LBP waste, the approximate quantity and type of material (i.e. wood window frame or door) that will make up the waste debris must be estimated. The cost of disposing this waste as hazardous waste (HW) should then be established. In most cases EM, HW disposal contractor or DRMO can provide the cost estimate based on pounds and volume of waste destined for disposal. The cost of disposing of the waste as HW should then be compared to the analytical costs for performing the TCLP for lead. Generally, it may be cheaper to dispose of one or two doors or a 5 - gallon can of paint chips as HW rather than taking a sample for analysis. Local circumstances govern this procedure, and the guidance in this report should not be construed to be Air Force Policy on this topic. Larger scale renovation projects may fall into the O & M arena and may involve generating larger volumes of waste (usually a dumpster or truck load of waste); in this case it may be beneficial to obtain samples and characterize the waste. The number of samples to obtain will depend on the types and amounts of materials being tested. The sampling protocol stated above in the demolition section (drill bit method) should be used to characterize waste in this category when local authorities require sampling.

Toxicity Characteristic Leaching Procedure (TCLP)

The TCLP test is used to determine if lead contaminated material is classified as being hazardous waste. Specific TCLP laboratory analysis procedures are outlined in Appendix II to EPA regulation 40 CFR Part 261, "Identification and Listing of Hazardous Waste." The TCLP test can be directed to analyze for all eight heavy metals and organic and inorganic compounds. Primarily, lead contaminated waste is considered to be hazardous waste if TCLP laboratory analysis results indicate a concentration of lead equal to or greater than 5.0 milligrams per liter (parts per million). Materials used in LBP abatement may also become hazardous waste due to ignitable or corrosive characteristics. Compounds and threshold limits for hazardous materials and waste are outlined in 40 CFR Part 261.

X-Ray Fluorescence (XRF)

At present, there is no correlation between known lead concentrations on components by XRF testing and failure of the wastestream by TCLP testing. Testing of painted surfaces in building components by XRF methods may determine that LBP exist above abatement thresholds (generally 1.0 microgram per square centimeter or 5000 ppm). Studies have shown, however, that this is not an indication that the wastestream will fail the TCLP test required to determine if the waste is hazardous or non-hazardous. XRF theoretically measures the *total* amount of lead in a specified area. TCLP measures *leachable lead*, which could possibly be the total lead content, but this is not likely. The amount of leachable lead depends on the layer of LBP within a sample, the substrate it is painted on, and the physical characteristics of the sample itself. The total lead content does not consider these qualitative properties.

Sampling Requirements

The Bioenvironmental Engineer must evaluate the waste produced by abatement to determine which types are hazardous. RCRA states that the determination can be based on prior generator knowledge of the particular waste. Unfortunately, many states require TCLP testing for all wastes related to LBP abatement. In addition, even if the state does not require testing, a specific landfill may not allow the disposal of certain wastes without testing based on their own risk analysis. BES must work with the installation's Environmental Management (EM)/Flight function and disposal contractor (usually the Defense Reutilization and Marketing Office (DRMO)) to determine unique sampling requirements for disposal.

Waste Awaiting Identification

Until sampling results are available, storing the waste can cause problems for the installation. A base may store the waste within the installation 90-day accumulation site and label it as "awaiting test results." State authorities and the EPA can then enforce the 90-day limit with the stored waste. In the past, their reasoning has been that once the installation began treating the waste as hazardous (by placing it in an accumulation site), the waste musty comply with RCRA. If test results do not come back within the 90-day storage limit, it can be construed as noncompliance.

References:

U S Army Environmental Hygiene Agency, Interim Final Report Lead Based Paint Contaminated Debris, Waste Characterization Study No. 37-26-JK44-92, May 1992-May 1993

AFI 32-7042, Solid & Hazardous Waste Compliance, 12 May 1994

Applicability of RCRA Disposal Requirements to Lead Based Paint Abatement Wastes, EPA Report: EPA 747-R-93-006, March 1993

Armstrong Laboratory Technical Report, AL/OE-TR-1993-0175, "Lead Exposure Hazard Management Guide", Armstong Laboratory, Brooks AFB TX, December 1993

SESSION XX

P2 IN CORROSION CONTROL/ PAINTING PROCESSES

<u>*Session Chairpersons*</u>*:*
Wayne Caughman, HQ AMC/CEV
Arthur Linton, EPA, Region IV

ENVIRONMENTALLY-COMPLIANT THERMOPLASTIC POWDER COATING

David F. Ellicks
Air Force Corrosion Program Office
WR-ALC/TIEA
255 2ND STREET, SUITE 122
ROBINS AFB GA 31098-1637
Phone: 912-926-3284

INTRODUCTION

In the early 1970s, inhibited epoxy primer and aliphatic polyurethane paint systems were applied to a majority of Air Force weapon systems. This coating effectively reduced the level of corrosion on the exterior surfaces of aircraft. This resulted from "built-in" corrosion inhibitors and the coating's capacity to bend without cracking as the surfaces of the aircraft flexed during flight. The Air Force recognized the 1980's as the decade of environmental awareness. The 1990's, on the other hand, will introduce the new technologies required to fully address all the environmental considerations. The current painting operations generate carcinogenic substances (methylene diisocyanates), air pollution (volatile organic compounds from solvent-borne coatings), and hazardous wastes (paint waste containing strontium, barium, or zinc chromates and cadmium). Historically, the Air Force has used primers and topcoats because of the excellent corrosion protection they provide. The Air Force, in general, and Warner Robins Air Logistics Center, in particular, have been striving toward the elimination of isocyanates, volatile organic compounds, and heavy metals. The goal is for the paint operation to conform to the increasingly stricter environmental and health requirements. The painting operation requires very expensive facilities (explosion proof lighting and fixtures, drainage system, and one pass heating/cooling ventilation systems), hazardous waste disposal facilities, air supplied respirator devices, medical examinations, and extensive training. In addition, special high volume/low pressure paint spraying equipment and high solids solvent-borne coating systems are being used to help reduce volatile organic compounds.

In order to reduce the environmental/health hazards and the cost of disposing of the hazardous waste, the Air Force Corrosion Program Office continually evaluates potential new coatings and application techniques. One new and promising coating and application technique is Thermoplastic Powder Coating (TPC) applied through flame spraying equipment. This paper describes the Air Force Corrosion Program Office's initial evaluation, economic analysis, environmental analysis, and the preliminary results from applications testing done at Warner Robins Air Logistics Center, Robins Air Force Base, Georgia.

BACKGROUND

There has been a long-term problem at many Air Force bases with the use of hazardous coatings/coatings removal materials and the lack of adequate facilities for performing corrosion prevention and control processes on nonpowered aerospace ground equipment, munitions handling equipment, nonfueled industrial vehicles, trailers, containers, components, and civil engineering real property facilities/structures. Standard coatings are not meeting the durability and maintainability requirements of the units and pose a hazard both to the health of personnel and the environment. Lack of authorized and available corrosion facilities in the munitions or aerospace ground support equipment organizational units for depainting/repainting of the end items and parts is a problem at many bases. Keeping this in mind, the Air Force Corrosion Program Office is always looking for new technologies to protect Air Force assets from corrosion damage. We are also mindful that the life cycle environmental considerations must be integrated into product/process engineering design procedures.

THERMOPLASTIC POWDER COATING AND APPLICATION EQUIPMENT SYSTEM DEFINITION AND EVALUATION

System Definition

Currently, there are three common techniques for applying powder coatings: electrostatic deposition, fluidized bed dipping and flame spraying. Electrostatic deposition is accomplished by immersing an electrically grounded part in a fog of powder sprayed from an application gun which transfers a static charge to the powder. The powder is attracted to the part and clings to the surface. The coated part is then heated (oven or infrared lamps) to bake and fuse the coating to the part. Fluidized bed coating involves dipping preheated parts into a column of powder which has been fluidized (agitated) by passing air up through the column. The heat retained by the part serves to melt and fuse the coating. In flame spraying, powder is blown through a flame, melted, and directed onto the material being coated.

The TPC and application equipment system is similar to metal flame spraying equipment with thermoplastic or thermoset powder replacing the metal powder. Some of this equipment is expensive and too complicated to use at field-level bases. The coating process is simple. In general, the bare metal surface to be coated is first inspected for cleaniness (oils, hydraulic fluids, etc.) and then preheated to approximately 175 degrees Fahrenheit with the application flame gun or nozzle to drive off moisture and to ensure that the applied plastic will flow smoothly. The preheating step is followed by application of the finely ground, pigmented polymer to the desired thickness either as solid or molten powder. The final step is the continued heating of the applied polymer to insure proper flow-out to the optimum coating temperature range of 320 to 425 degrees Fahrenheit, as monitored by a hand-held infrared pyrometer. After the coating cools, the painting operation is complete. For the thermoplastic powders, no chemical reaction or change in the molecular structure occurs during the coating process. Therefore, these coatings have the potential for easy repair if damaged by simply reheating or re-applying additional powder. The coating is soft, one coat, glossy, thick (10-12 mils), durable, easy to apply, repairable, safe for workers, and environmentally compliant.

The thermoplastic powder is generated by grinding polymer pellets at cryogenic temperatures using liquid nitrogen as a refrigerant. Originally, Envelon powder was supplied directly by Dow Chemical Corporation; however, Dow has now licensed that process to Morton, International, a major commercial supplier of industrial powder coating materials. Plastic Flamecoat Systems (PFS) of Houston, Texas (an alternate TPC equipment manufacturer) grinds DuPont Nucrel and is currently the only source for this powder. The Dow/Morton product is a "melt blend" material in which pigments, UV stabilizers, and other additives are blended with melted polymer before grinding. The DuPont/PFS powder is "dry blended" by mixing additives with the powder after grinding. Both powders cost relatively more than the conventional solvent-borne coating systems. Both materials are considered "environmentally compliant" by current EPA federal and state regulations.

Both the Dow and DuPont powders may be obtained in a range of "melt index" values. Low melt index polymers are more viscous at any given temperature than are high melt index polymers. In general, the low melt index powders yield tougher coatings but are more difficult to apply because they require higher temperatures to achieve flow-out during application. Both polymers melt at about 300 degrees Fahrenheit and flow over a substrate that has been preheated to a temperature of 150 to 175 degrees Fahrenheit. If coating temperature exceeds 425 degrees Fahrenheit for extended periods of time (minutes), significant polymer chain cross-linking occurs, and the coating effectively converts from a thermoplastic to a thermoset material. When this happens, field repairability of the coating by reheating is lost. If coating temperatures exceed 650 degrees Fahrenheit during application, the polymer is permanently damaged and the coating is destroyed. To avoid overheating, the coating temperature is carefully monitored by the applicator with a hand-held infrared pyrometer.

System Evaluation

A TPC application system was selected by the Air Force for a field-level test program. This system was chosen as the most suitable for evaluating the current state of flame coating technology and its potential for an alternate to conventional solvent-borne paint systems. The simplest and most commonly used TPC flame spray application systems are entirely pneumatic. These systems require only clean, dry compressed air and fuel (typically liquid propane) for operation. Powder is stored in a hopper and delivered by hose to the gun in a stream of compressed air that transports powder from the hopper with a venturi. Propane is delivered to the gun through a separate hose and mixed with air at the gun exit where it is ignited. The equipment operator sets the air, powder, and fuel flow rates with controls located on or near the gun. The powder/air mixture blows through the flame, melts and flows onto the surface to be coated.

Dow and DuPont are the two major domestic suppliers of thermoplastic polymer resins developed for flame spray application. Each manufactures a similar commercial thermoplastic resin. Dow "Envelon" is an Ethylene Acrylic Acid (EAA) copolymer. DuPont "Nucrel" is an Ethylene Methacrylic Acid (EMAA) copolymer. These copolymer formulations were developed to enhance polyethylene coating adhesion. Dow and DuPont have worked closely with application equipment manufacturers to develop effective TPC flame spraying systems. Some equipment suppliers restrict the use of their hardware to specific polymers. The flame spraying equipment manufactured by American Thermoplastics, Inc. (AT) of Mesa, Arizona, has been selected for field-level evaluation at several Air Force bases. AT allows the use of all commercially available TPC materials; however, the use of Dow Envelon is recommended. Dow materials were used in this test program.

System Characteristics and Modifications

Of the three flame spraying systems evaluated, the UTP system had the most sophisticated flame application hardware. UTP uses an electro-pneumatic system requiring oxygen as well as compressed air and propane. This method provides a smaller, hotter flame yielding better temperature control and better flowout of thermoplastic powder. This has lead to the current development effort focused upon improving flow-out temperature and the spray pattern. The Air Force is looking at modifying the nozzle to use a premixed combustion instead of a diffusion flame for better heating control. In addition, we are seeking modification of the nozzle to change from a circular to a tapered oval spray pattern to widen the pattern and to improve the coating uniformity (thickness variations). Further nozzle development may also be necessary for coating hard-to-reach areas, e.g., angles, tubing, and grating, found on maintenance stands or other complex equipment residing in the Air Force inventory.

Thermoplastic powder coatings have notable performance properties that address the environmental/health problems inherent with standard Air Force polyurethane coating systems. For example, these coatings exhibit excellent resistance to various chemicals, solvents, and reagents. This coating should not be used in contact with chlorinated solvents, fuming or strong oxidizing acids, aromatic alcohols, or heterocyclic aldehydes. These coatings have shown excellent abrasion resistance and good barrier qualities to prevent corrosion, and they are environmentally compliant. These coatings have the ability to be applied in almost all types of weather in any area, inside or outside, where it is safe to use a flame. The thermal spray coatings are proving useful in many Air Force applications. They are not appropriate for every application. This process does have drawbacks such as incompatibility with live munitions or combustibles, problems with thin metal and composites, slow application rate (50 to 100 square feet per hour), high substrate temperature effecting the heat treatment of alloys, and high material cost. This information is based on the preliminary laboratory testing using the test requirements in MIL-C-83286 as a comparison and guide to base our above conclusions.

Continuing Efforts

Warner Robins Air Logistics Center is pursuing an aggressive program to test and evaluate thermoplastic powder coating flame spray and fluidize bed application methods with the desire to implement this technology as one of the new alternatives to solvent-borne coatings. Current efforts involve the development of a prototype TPC application system (flameless) using hot combustion products (propane/air) to melt the polymer powder. Future efforts are going to evaluate the use of:

-- Electrostatic/oven TPC application methods on bombs and support equipment.

-- Thermo Plasma Spray process, enabling thermoplastic/thermoset powders to be applied to such surfaces as fiberglass, thin skin aluminum, steel, rubber, concrete, and wood.

The Air Force Corrosion Program Office will continue to strive to identify a coating system that will provide corrosion protection while eliminating environmental/health problems throughout the Air Force.

Conclusions

Thermoplastic powder coating flame spray application methods produce a simple, highly reliable, safe, environmentally compliant, single coat capability to augment the standard Air Force epoxy-polyurethane coating systems. TPC will also eliminate some requirements for several current maintenance operations, e.g., chemical conversion coatings, long paint drying times, air supply respirators, and expensive facilities. The need to convert from standard coating to thermoplastic/thermoset powder coatings is being driven by the requirement to reduce hazardous wastes, enhance personnel safety provide a cleaner environment, and minimize coating facilities.

COATING ATTRIBUTES

EPOXY/POLYURETHANE COATING	THERMOPLASTIC POWDER COATING
- THREE COAT SYSTEM	+ ONE COAT SYSTEM
+ EPOXY PRIMER	+ NO PRIMER (BARRIER COATING)
+/- CORROSION INHIBITORS (CHROMATES)	- NO CORROSION INHIBITORS
+ THIN (2.2-3.2 MILS)	- THICK (10-15 MILS)
+ HARD SURFACE (SMOOTH)	- SOFT (SLIGHT ORANGE PEEL)
+ FLEXIBLE	+ VERY FLEXIBLE
+ SEMI-GLOSS TO FLAT	- GLOSSY
+ GOOD WEATHERABILITY	+ GOOD WEATHERABILITY
+ GOOD CHEMICAL RESISTANCE	+ GOOD CHEMICAL RESISTANCE
+ ABRASION RESISTANCE	+ VERY ABRASION RESISTANCE
+ EXCELLENT CORROSION RESISTANCE	- GOOD CORROSION RESISTANCE
+ EXCELLENT ADHESION	+ EXCELLENT ADHESION
- LIMITED SHELF LIFE	+ EXTENDED SHELF LIFE
- LIMITED TEMP. RANGE (60/95 ^{O}F)	+ EXTENDED TEMP. RANGE (-20/110 ^{O}F)
- LIMITED AREAS FOR APPLICATIONS	+ EXTENDED AREAS FOR APPLICATIONS
+/- MODERATELY EASY TO APPLY	+ EASY TO APPLY
+/- MODERATELY EASY TO REPAIR	+ EASY TO REPAIR
- EXTENSIVE VENTILATION REQUIRED	+ MINIMUM VENTILATION REQUIRED
- EXPENSIVE FACILITIES REQUIRED	+ NO ADDITION FACILITIES REQUIRED
-/+ HIGH AND LOW VOCs	+ LITTLE OR NO VOCs
- HAZARDOUS WASTE GENERATED	+ NO HAZARDOUS WASTE
- TOXIC FUMES GENERATED	+ NO TOXIC FUMES
- LONG CURE TIME (72 HOURS)	+ SHORT COOLING TIME (60 MINUTES)
+ FAST COATING RATE	- SLOW COATING RATE
+ UNLIMITED ITEMS TO COAT	- LIMITED ITEMS (THIN, COMPOSITES)
+ HIGH TEMP. ABILITY	- HIGH TEMP. DEGRADATION

Air Force

Corrosion Program

THERMOPLASTIC POWDER COATINGS (TPC)

Briefer: DAVID F. ELLICKS
Materials Engineer

Air Force

Corrosion Program

OBJECTIVE

OBJECTIVE

- EVALUATE POWDER COATING TECHNOLOGY AS AN ALTERNATIVE TO STANDARD AIR FORCE EXPOXY POLYURETHANE COATING SYSTEM

Air Force Corrosion Program

APPROACH

APPROACH

- ENGINEERING STUDY--STARTED 1 OCT 91
- CONTRACTOR: SCIENCE APPLICATIONS INTERNATIONAL CORPORATION (SAIC)
- FIVE POWDER COATING TECHNOLOGIES
  - » FLAME SPRAY
  - » FLUIDIZE BED
  - » FLAMELESS
  - » ELECTROSTATIC/OVEN
  - » PLASMA SPRAY

Air Force Corrosion Program

POTENTIAL USES

FLAME SPRAY THERMOPLASTIC POWDER COATINGS POTENTIAL USES

- NONPOWERED AEROSPACE GROUND EQUIPMENT
- MUNITIONS HANDLING EQUIPMENT
- NONFUELED INDUSTRIAL VEHICLES
- TRAILERS
- COMPONENTS

Air Force

Corrosion Program

POTENTIAL BENEFITS

FLAME SPRAY THERMOPLASTIC POWDER COATINGS

- ONE COAT
- NO VOLATILE ORGANIC COMPOUNDS (VOCs)
- NO TOXIC FUMES
- NO HAZARDOUS WASTE
- FIELD APPLIED/REPAIRABLE COATING
- EXTENDED SHELF LIFE
- REDUCE VENTILATION/FACILITIES REQUIRED
- NO CURE TIME - COOLING TIME

Air Force

Corrosion Program

DRAWBACKS

FLAME SPRAY THERMOPLASTIC POWDER COATINGS DRAWBACKS

- NO CORROSION INHIBITORS
- THICK
- ORANGE PEEL APPEARANCE
- SLOW COATING RATE
- LIMITED USE (FLAME)
- HIGH TEMPERATURE DEGRADATION

Air Force

Corrosion Program

PROCEDURE

FLAME SPRAY TPC/APPLICATION EQUIPMENT PROCEDURE

- PREPARE SURFACE TO BARE METAL
- INSPECT FOR CLEANLINESS
- PREHEAT SURFACE TO 150-170 DEGREES F
- START APPLYING TPC
- ENSURE PROPER FLOW-OUR TEMPERATURE
  - » USING HAND-HELD, INFRARED PYROMETER
- AFTER COATINGS COOL, ITEM READY TO USE

Air Force

Corrosion Program

STATUS

STATUS

- FLAME SPRAY - BEING IMPLEMENTED
- FLUIDIZED BED - BEING IMPLEMENTED
- FLAMELESS - BEING OPTIMIZED
- ELECTROSTATIC/OVEN - STARTING
- PLASMA SPRAY - PROJECTED

Assessment of Economic and Environmental Performance of Compliant Coating Systems

Mike Callahan, P.E.
Carl Fromm, P.E.

Jacobs Engineering Group Inc.
Pasadena Operations
251 S. Lake Ave.
Pasadena, CA 91101
(818) 449-2171

Silicone alkyd paint is widely used as a protective coating on outdoor structural steel. Silicon alkyd paint provides moderate corrosion protection while possessing good gloss retention. The volatile organic content of these paints ranges from 2.6 to 3.5 pounds per gallon. The recently enacted southern California South Coast Air Quality Management District Rule 1113 places an upper limit of 2.8 pounds per gallon on VOC content. A project was undertaken to identify, test, and select a viable replacement coating system that would be considered to be environmentally preferable to the existing system in use at a coastal facility.

Screening was conducted using a set of well defined pass/fail criteria followed by a weighted-sums evaluation of key criteria. Thirty-four systems (i.e., a given primer and top-coat combination) were screened and 14 were eventually selected for accelerated testing. The methodology employed to identify and select systems for testing has been documented in a recent article (Pollution Prevention Review, Winter 93/94). The methodology took into account differences between longer life high-VOC coatings and shorter life lower-VOC water-based coatings. The highest rated replacement systems were the water acrylic coating systems.

The VOC content of the selected coatings ranged from a low of 0 lbs/gal (excluding water) for a water epoxy system to a high of 2.8 lbs/gal for the silicone alkyd, acrylic urethane, and zinc epoxy coatings. The listing of coating systems selected for testing is given below (note: specified combinations and applied dry film thicknesses were in accordance with vendor recommendations).

1. 1 mil Rust Reformer, 3 mils Water Acrylic Primer, 3 mils Silicon Alkyd Top-Coat
2. 3 mils Water Acrylic Primer, 3 mils Silicon Alkyd Top-Coat
3. 2.5 mils Water Acrylic Primer, 4 mils Water Acrylic Top-Coat
4. 5 mils Water Acrylic Primer, 2.5 mils Water Acrylic Top-Coat
5. 2 mils Water Acrylic Primer, 3 mils Water Acrylic Top-Coat
6. 1.5 mils Water Acrylic Primer, 3 mils Water Acrylic Top-Coat
7. 3 mils Water Acrylic Primer, 4 mils Water Acrylic Epoxy Top-Coat
8. 3 mils Water Acrylic Primer, 3 mils Water Epoxy Top-Coat
9. 2 mils Water Epoxy Primer, 2 mils Water Epoxy Top-Coat
10. 3 mils Water Epoxy Primer, 3 mils Water Epoxy Primer
11. 6.5 mils High Build Epoxy Primer, 2 mils Silicon Alkyd Top-Coat
12. 6.5 mils High Build Epoxy Primer, 2.5 mils Water Epoxy Acrylic Top-Coat
13. 7 mils High Build Epoxy w/Al Primer, 3 mils Acrylic Urethane Top-Coat
14. 3 mils Zinc Epoxy Primer, 3 mils Acrylic Urethane Top-Coat

Accelerated performance tests were conducted to assess the comparative performance of the selected systems to the current system and to verify screening results. Cyclic failure data was then used to predict expected field life using a new methodology developed for this work. Environmental impacts were assessed in terms of initial and annualized VOC emissions. Initial and annualized costs were also determined.

Project results showed that while some water acrylic systems performed better than the current system as expected, the high performance coatings demonstrated lower impacts at lower cost. These findings may be at odds with the current regulatory drive towards low VOC water-based coatings.

LABORATORY TESTING AND RESULTS

A total of 14 different coating systems were applied to steel panels which had been solvent cleaned. After at least a 10 day cure time, the panels were subjected to mechanical, accelerated weathering, and cyclic failure testing. All test results following 35 days or cycles of testing are presented in Table 1.

Mechanical testing consisted of adhesion (ASTM D-3359) and direct impact resistance (ASTM D-2794). To simulate sunlight exposure, duplicate panels from each system were exposed to 35 days of accelerated weathering in an ASTM G-53 cabinet equipped with UVA-340 bulbs. The test cycle was four hours of ultraviolet exposure at 135 °F, followed by four hours of condensation at 112 °F. At the conclusion of the testing, the panels were also evaluated for adhesion and impact resistance.

Cyclic failure testing was performed in accordance with ASTM D-2933, with each cycle consisting of four hours salt spray exposure (ASTM B-117), 18 hours exposure to 100 percent relative humidity at 38 °C (ASTM D-2247), and two hours of freezing at approximately -5 to 0 °F. The testing was conducted for 35 days, with rusting, blistering, and scribe corrosion evaluations performed every five days. All evaluations followed prescribed ASTM methods.

DATA ANALYSIS

The determination of expected field life is essential to establishing the true costs and environmental impacts of each system. While laboratory testing does provide a comparison of relative performance among coatings, these results reportedly cannot be directly extrapolated to expected field life. Reliable methods of correlating test data such as adhesion, rusting, or blistering to field life were not found through a search of available U.S. literature and inquiries with authoritative sources. However, intuitively it can be postulated that the relative performance shown in accelerated testing should be indicative of relative performance in the field. If so, then cyclic failure data can be used to develop a system specific adjustment factor for expected field life based on generic data. To do this, the following steps were taken:

1. Conduct cyclic failure tests to generate relative performance data. Run test until all systems show varied levels of rusting or blistering. For this project, 35 cycles (days) was adequate. Cyclic test is assumed to mimic exposure at an industrial seaside marine location on steel prepared to SP-6 (SSPC specification for commercial blast).

2. Using data from Brevoort and Roebuck (1993), estimate the ideal life for each system as applied to SP-6 prepared steel located at a heavy industrial marine site. For systems not in the database, the closest analog is assumed. This data comes from many sources and represents an average life for a given generic system. Actual performance is reported to vary by +/- 15 percent.

3. Ideal life at SP-6 is next adjusted to reflect the effect of coating film thickness. This step is necessary to account for the differences in recommended film thicknesses and its effect on coating life. Depending on the type of coating applied, added life may range from 0.5 to 1.0 years per mil.

4. Plot total area affected (A_T) versus expected ideal life on a log-log graph. Figure 1 presents the results of this step for the data following 35 days of cyclic testing. Total area affected is related to area blistered (A_B) and area rusted (A_R). Calculation of blister area follows the reference section.

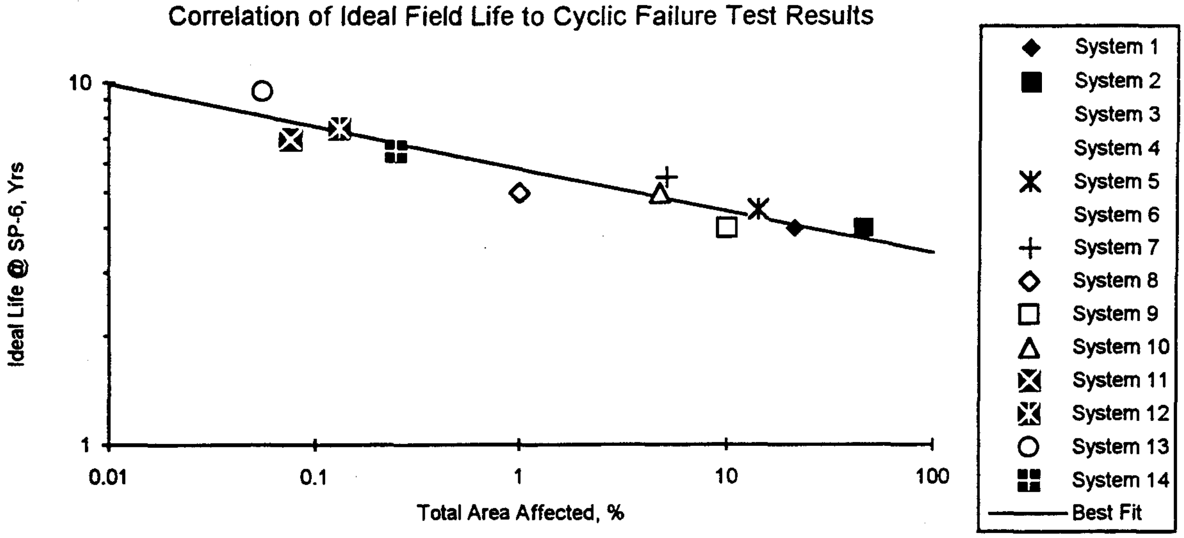
Coating System Performance Data After 35 Days of Accelerated Testing

System	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Primer	WA	WA	WA	WA	WA	WA	WA	WA	WE	WE	HBE	HBE/Al	HBE	E/Zn
Top-Coat	SA	SA	WA	WA	WA	WA	WA	WA	WE	WE	SA	WEA	AU	AU
Initial Conditions														
Impact (in-lbs) D-2794	160/160	160/158	160/160	160/160	160/160	78/78	160/160	158/152	20/14	54/50	38/38	20/20	40/36	42/42
Adhesion D-3359	0/0	0/0	5/5	5/5	5/5	0/0	3/3	5/5	0/0	5/5	4/4	5/5	5/4	4/3
Failure (a) ---	C/C	C/C	--/--	--/--	--/--	S/S	S/S	--/--	S/S	--/--	S/S	--/--	--/P	P/P
Specular Gloss (%) D-523	84/85	85/86	67/66	74/71	68/68	54/54	80/78	41/38	71/70	53/51	43/43	57/60	52/59	85/85
Cyclic Weathering														
Impact (in-lbs) D-2794	88/78	156/156	160/160	160/128	160/160	28/34	160/160	38/34	24/24	30/30	32/34	24/20	30/30	34/34
Adhesion D-3359	0/1	5/5	5/5	5/5	5/5	5/4	3/3	5//5	2/2	5/5	4/4	3/3	3/3	1/1
Failure (a) ---	P/P	--/--	--/--	--/--	--/--	--/--	P/P	--/--	S/S	--/--	T/T	P/P	P/P	P/P
Specular Gloss (%) D-523	64/71	74/74	27/28	58/59	31/35	35/36	46/48	39/37	5/6	47/48	21/21	58/60	48/54	81/79
Chalking D-659	10/10	10/10	10/10	10/10	10/10	9/9	10/10	10/10	6/6	10/10	10/10	10/10	10/10	10/10
Flaking D-772	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10
Blistering D-714	8D/8D	8F/8F	10/10	8F/8F	10/10	8F/8M	10/10	10/10	10/10	10/10	8F/10	10/10	10/10	10/10
Rusting D-610	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	9/9	10/10	10/10	10/10	10/10
Corrosion (Area %) D-1654	100/100	8/8	0/0	10/3	0/0	67/92	0/0	0/0	3/2	0/0	10/0	0/0	0/0	0/0
Corrosion D-1654	0/0	6/6	10/10	6/8	10/10	1/0	10/10	10/10	8/8	10/10	6/10	10/10	10/10	10/10
Cyclic Failure														
Impact (in-lbs) D-2794	30	15	70	18	40	38	100	56	44	30	40	20	20	20
Adhesion D-3359	0	0	0	0	3	0	0	3	0	0	3	0	0	0
Failure (a) ---	C	C	S	S	S	S	C	S	S	S	S	S	S	S
Blistering on Panel D-714	6D/6D	4D/4D	2D/2D	2D/2D	6MD/6MD	2D/2D	4M/4M	6M/6M	4MD/4MD	2M/2M	10/10	8F/8F	10/10	8F/6F
Blistering at Scribe D-714	6D/6D	2D/2D	2D/2D	2D/2D	6D/6D	2D/2D	2D/6D	6M/6M	6D/6D	2M/2M	8F/8F	6D/6D	4F/6F	8D/6D
Rusting D-610	10/10	10/10	6/5	3/2	5/4	3/3	6/5	10/10	10/10	9/8	9/9	9/9	10/10	9/10
Scribe Corrosion, Mean D-1654	4/4	2/5	0/5	7/8	7/7	2/0	7/6	8/8	10/10	3/2	8/10	6/5	10/8	10/6

a) Failure of coating system occured at substrate (S), within the primer (P), within the topcoat (T), or between coats (C).

b) Two panels were tested for each system. Both ratings are shown above.

Figure 1
Correlation of Ideal Field Life to Cyclic Failure Test Results



5. Use least-squares regression to best-fit a straight line to the data. Data points exhibiting greater than 33 percent total rusting and blistering are excluded from the fitting. These data points are assumed to be too far degraded to provide any reasonable level of detail for an accurate assessment of condition. Use the best-fit correlation to establish new expected field lives for each system.

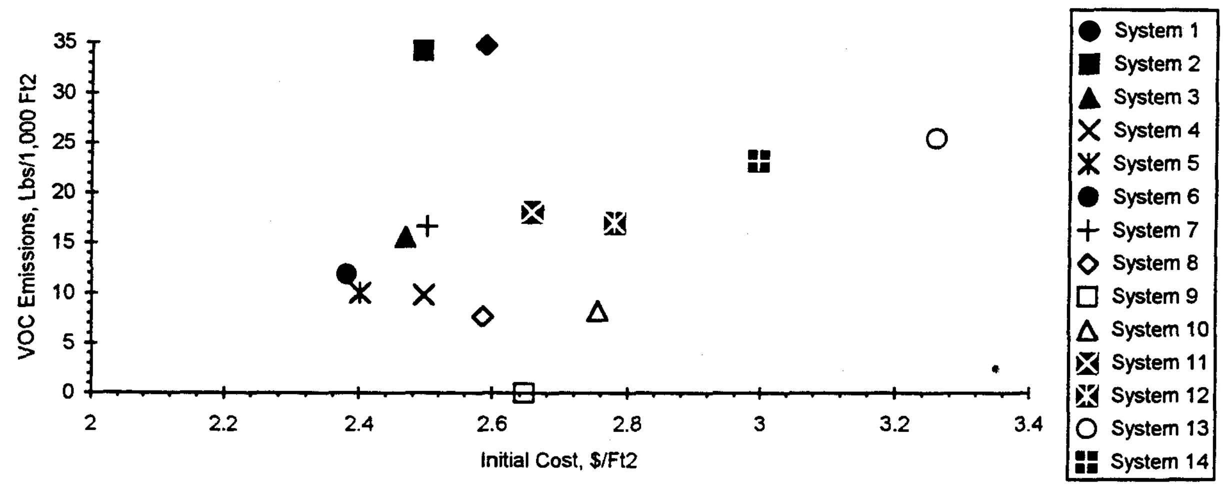
6. The final step is to account for the difference in surface preparation and/or painting philosophy practiced in the field. Reducing the level of surface preparation from SP-6 to SP-2/3 (hand and power tool cleaning) can reduce ideal life by 1 to 2 years. The difference between an ideal and practical painting philosophy equates to a 50 percent increase in life over the ideal level.

APPLICATION COSTS AND ENVIRONMENTAL IMPACTS

The determination of application costs in terms of dollars per square foot is based on the method of Brevoort and Roebuck (1993). The method accounts for material costs (including spray loss), labor for surface preparation, and labor for applying each coat. Waste generation and disposal costs are not included in the model. These costs are sensitive to the waste handling and disposal methods employed and are not a direct function of paint type. Therefore, all reported costs are low and it is assumed that regardless of paint type used (i.e., solvent or water based), waste generation costs can be optimized to equivalent levels. The vendor supplied application data for each system was used to determine the amount of VOC emitted for painting 1,000 square feet (ft^2) of surface. Comparison of initial costs to VOC emissions is plotted in Figure 2.

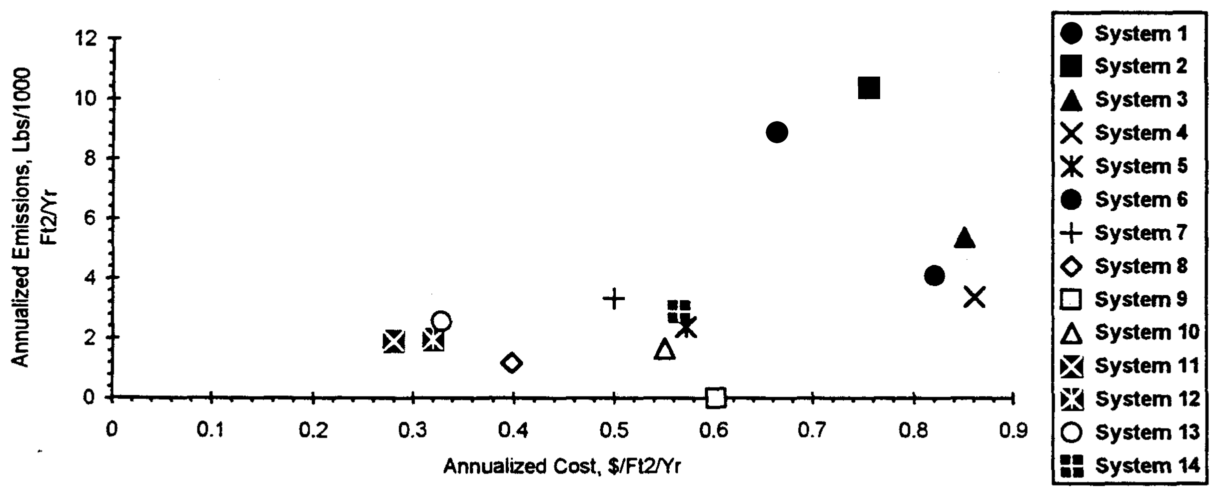
This plot shows that all of the tested systems emit lower levels of VOCs than the current system (System 1) for a given amount of coverage. The water acrylic systems (3 - 8) do so at slightly lower cost while the water epoxy systems and the first two high build epoxy systems (9 - 12) cost slightly more. The last high build epoxy system (13) and the epoxy with zinc system (14) cost the most. Faced with a limited maintenance budget, and the desire to adopt the lowest emitting system with the prospect of ever tightening regulations, many would be drawn towards the use of the water acrylic systems. Many regulations, based only on the VOC content of the coatings, give the impressions that the use of a low VOC coating minimizes environmental impact.

Figure 2
Initial Costs Versus VOC Emissions



This is not always true. Emissions, as well as costs, are best compared on an annualized or "life-cycle" basis. Annual emission rates were determined by dividing the pounds of VOC emitted per 1,000 ft^2 values by the field life of each system predicted using the correlation shown in Figure 1 and adjusting for SP-2/3 preparation and a practical life painting philosophy. The analysis did not include the cost of touch-up and maintenance painting in the years beyond predicted field life. Results of this analysis are presented in Figure 3.

Figure 3
Annualized Costs Versus Annualized Emissions



As can be seen, several of the water acrylic systems performed poorly and would not be a good choice. While their use would still reduce annual emissions overall, their short life span would necessitate the need for frequent repainting, driving annual costs higher. The lowest cost systems (11-13) are all high performance epoxies that demonstrate low levels of emissions. This is in direct contrast to their prior showing. Of all the water acrylic systems tested, only system 8 was a fair competitor.

In conclusion, we observe that the VOC content of the coating is not a complete or an accurate indicator of environmental performance. A more accurate indicator is the annualized emission rate which is based on the entire life cycle of the system. Similarly, the initial cost of the coating is not an adequate indicator of economic performance. A better choice is the annualized cost which takes into account longevity, and thus the cost of repainting.

REFERENCES

Brevoort, G.H. The Importance of Paint and Coatings Selection. *Chemical Processing*. March 1989.

Brevoort, G.H. and Roebuck, A.H. Paint and Coatings Selection and Cost Guide. Paper No. 183 presented at Corrosion 88. NACE. Houston, TX. 1988.

SCAQMD. (South Coast Air Quality Management District) Rule 1113 - Architectural Coatings. Amended September 6, 1991.

SSPC. *Steel Structures Painting Manual*. Volumes 1 and 2. Second Edition. Steel Structures Painting Council. Pittsburgh, PA.

CALCULATION OF BLISTER AREA

Blister ratings consist of a number which represents blister size and a letter representing the density of blistering. Blister sizes range from 8 for the smallest size visible by the unaided eye up to 2 for very large blisters. ASTM Method D-714 does not provide a numeric indication as to the direct area of the blister. Blister density is reported as F for few, M for medium, MD for medium dense, and D for dense. A rating of 10 indicates that no blistering is present.

To determine the area blistered in terms of percent, the first step was to convert this number letter scale to a pure numeric scale. It was postulated that the density of blistering is more important to coating life than the size of the blister. Blister size represents the degree of moisture intrusion and lack of adhesion that is present at a given location. Formation of a large blister may be a random event or may indicate that a small area of the panel was improperly cleaned before painting. Dense blistering tends to indicate that the coating material provides poor adhesion across the entire panel and should therefore be a strong indicator of potential failure. The following matrix was used to convert the blister ratings to a single rating:

Blister Size Versus Density

	10	8	6	4	2
10	10	--	--	--	--
F	--	9	7	6	4
M	--	8	6	4	2
MD	--	7	5	3	1
D	--	6	4	2	0

Following the conversion of the alpha numeric scale to a purely numeric rating, a correlation converting each rating to a percent area blistered was required. ASTM D-714 fails to provide any insight as to how the rating system was derived other than by the use of photographic standards. A review of several recognized ASTM methods for relating rating scores to percent area found that an ASTM method used for measuring corrosion of electroplated parts might be suitable. The equation: Rating = 3 x (2 - log (area percent)) was used to convert blister scores to area blistered. Much work would be required to directly measure the area blistered during the test or to determine the actual areas involved in the original blister ratings. However, as long as a consistent method is employed, the relative degree of error should be minor.

Demonstrating Environmentally Responsible Organic Finishing Technologies

J. F. Meier, Ph.D., Principal Technical Staff
Jerry R. Hudson, Program Manager
Michael J. Docherty, Associate Project Engineer

Concurrent Technologies Corporation
1450 Scalp Avenue
Johnstown, PA 15904
(814) 269-2842

Introduction

The National Defense Center for Environmental Excellence (NDCEE), operated by Concurrent Technologies Corporation (*CTC*), assists both government and private sector clients by solving environmentally-related manufacturing problems in four main technical areas. These are paint stripping, parts cleaning, organic coating and inorganic coating. An organic finishing facility was the first process to be installed in the NDCEE's Demonstration Factory. Additional versatility and flexibility to the organic coating facility will be achieved through installation of electrocoating (E-coat) equipment in the last quarter of 1994.

The objectives of this paper are to describe the organic coating facility as it exists today, to describe the E-coat facility that is planned and to present an overview of work initiated and planned for both DoD and private sector clients.

Organic Finishing Demonstration Facility Overview

The organic finishing facility is a complete, industrial-scale finishing line, which includes a load/unload station, a multistage cleaning/pretreatment area, dry-off oven, liquid paint and powder spray booths and separate liquid and powder paint curing ovens. In addition to the liquid paint and powder coat systems, an electrocoating system will be installed. The entire facility, including the E-coat equipment, covers a floor area of about 20,000 ft^2 and is shown schematically in Figure 1. A brief description of each component of the facility is given in the following paragraphs.

Conveyor

The conveyor, which transports the parts suspended on racks, is a power and free unit with manual and automatic switching. For maximum flexibility in operation, the conveyor consists of three power and free chains, each functioning independently of the others. The first chain carries parts through the cleaning and pretreatment section of the process. The next chain, the high-speed transport conveyor chain, carries products to and away from the powder or wet spray processes. The third chain, the process chain, carries parts through the individual wet or dry painting processes. The chains have multiple variable-speed drives and are capable of simultaneous process operation. There are off-line spurs for in-process inspection.

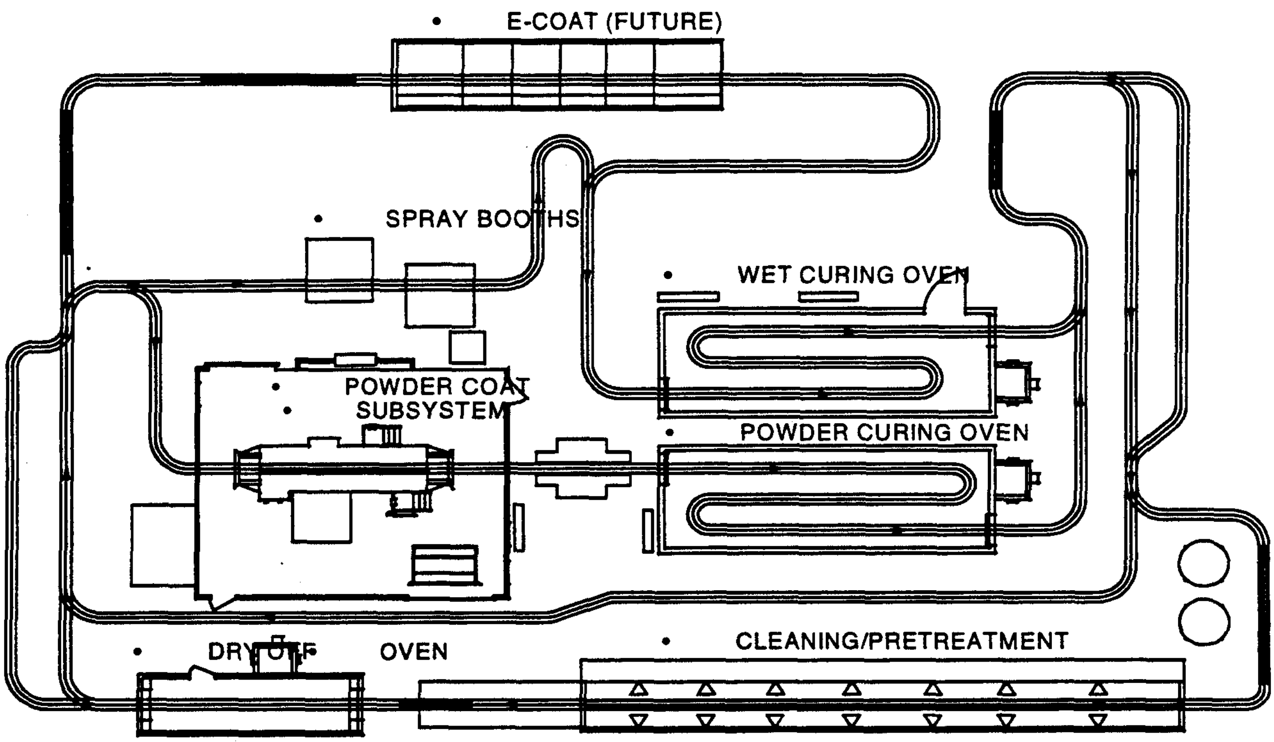


Figure 1. Organic Finishing Demonstration Facility Schematic

The conveyor is currently designed to operate at 5 to 12 feet per minute. The power and free conveyor system enhances flexibility by allowing variations in the process flow sequence and in-process residence times. The system is currently designed to accommodate parts fitting within an envelope of 3' wide, 4' high and 4' long, weighing up to 250 lbs. Up to one load rack can be processed per minute, while also accommodating test and evaluation batches.

Cleaning/Pretreatment

The cleaning/pretreatment section is a nine-stage (plus deionized water rinse) state-of-the-art power washer designed to accommodate a wide variety of cleaning and pretreatment processes. System flexibility is enhanced through the use of external plate and frame heat exchangers on all stages, stainless steel construction, and built-in expansion space. The key parameters of residence time, spray pressure, nozzle type, chemistry, and temperature may be varied. As configured, the system is designed for typical steel and galvanized steel pretreatments such as zinc phosphate. The operating parameters of the pretreatment area are presented in Table 1. We are actively investigating several non-chromium conversion coatings for aluminum and installation of an appropriate system will be completed within about six months.

Table 1. Operating Parameters of the Cleaning/Pretreatment Stations

Stage	Time, (seconds)	Temperature, (°F)	Nozzle Pressure, (psig)	Tank Capacity, (gallons)
1	40-240	ambient-140	10-25	1720
2	5-30	"	"	375
3	10-60	"	"	570
4	25-150	"	"	1290
5	"	"	"	"
6	5-30	"	"	375
7	10-60	"	"	575
8	15-90	"	"	510
9	"	"	"	"

Liquid Paint Coating Section

The liquid paint application section, shown as "spray booths" in Figure 1, has two dry-filter paint spray booths. Presently, liquid coatings are applied by High Volume, Low Pressure (HVLP) spray equipment. In the future, state-of-the-art, high-speed rotary electrostatic applicators and various other types of electrostatic spray applicators will be installed to apply low-VOC, high-solids, and water-borne coatings.

Powder Coat Subsystem

The powder coat subsystem is located in an enclosed, environmentally controlled room. The equipment consists of automatic reciprocator-driven and manual spray guns using both corona discharge and tribilogic technology. Since the spray booth has automatic reclaim and recycle capabilities, the transfer efficiency is nearly 100 percent.

Ovens

Three separate gas-fired convection ovens for dry-off, powder coat curing, and wet coat curing of parts are integral to the system. Each oven has been designed for variable temperature (200-550 F), residence time, and air flow patterns. These variables allow the evaluation of different cure cycles, heating zones, and porous-part outgassing to accommodate diverse curing schedules.

Electrocoat Subsystem

The soon to be installed E-Coat line will be an industrial-grade, closed-loop, cathodic electrocoating system with 5 stages, as defined in Table 2. The E-coat line is designed as a continuous/batch-type process to accommodate both rack and barrel configurations. In addition, the material handling system is designed for both continuous and dip operation.

Table 2. Stages of E-Coat Facility

Stage 1	Cathodic Electrocoat Immersion Tank (the organic coating)
Stage 2	Recirculated Permeate Spray Rinse
Stage 3	Fresh Permeate Immersion Rinse
Stage 4	Fresh Permeate/Deionized Water Immersion Rinse
Stage 5	Automatic Fresh Deionized Riser/Manual Fresh Deionized Water and Compressed Air

As with both powder and conventional spray equipment, the E-coat line will accommodate a 3' wide, 4' high, 4' deep parts envelope with a 250 lb./hanger weight limit. The cathodic paint tank size will be approximately 3500 gal. with a maximum throughput of 12 carriers/hour. The E-coat line subsystem is shown in Figure 2.

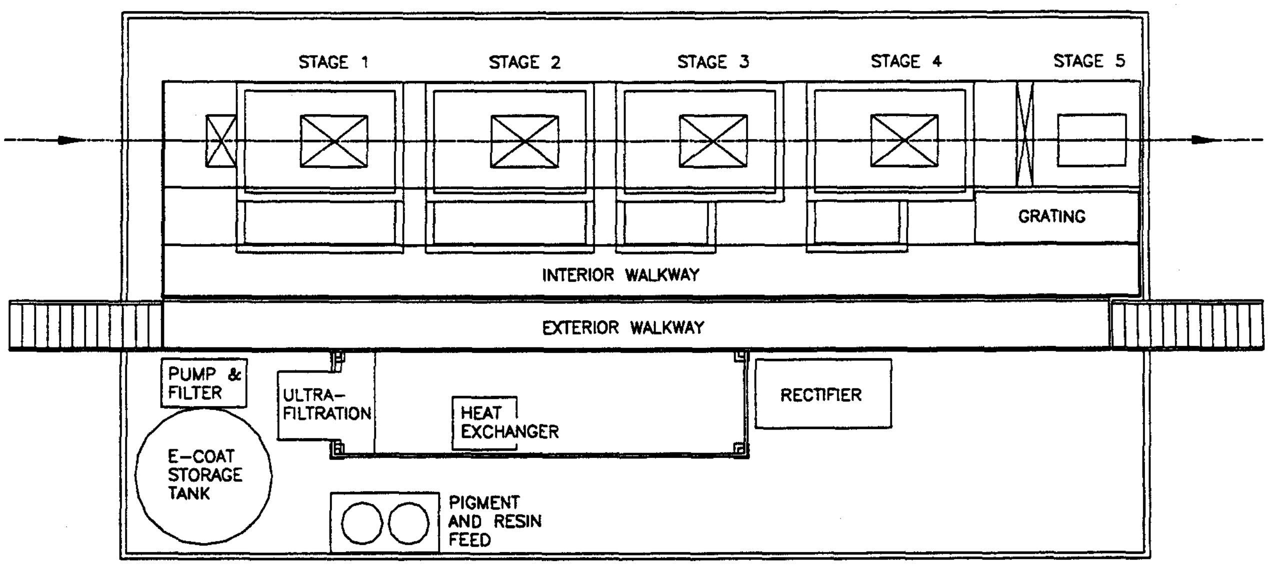


Figure 2. E-Coat Subsystem Schematic

<u>Developments in Progress</u>

Since the installation of the Organic Finishing Facility in April 1994, we have assisted several clients convert from typical high VOC containing coating systems to more environmentally benign powder coatings. Additionally, discussions are underway with several other potential clients and we are actively pursuing selected clients through an outreach program. The various applications currently under active development are summarized in Table 3. Of those listed the most notable success to date has been with Emglo Products, Inc. Converting their solvent based coating line to powder coating is projected to eliminate about 37,000 lbs./year VOC and result in a coating with enhanced abrasion resistance and a cosmetically more appealing finish.

Table 3. DoD and Civilian Clients

Client	Product
Corpus Christi Army Depot	miscellaneous helicopter and airframe parts
Red River Army Depot	miscellaneous interior parts of tracked vehicles
Jacksonville Naval Air Station	airframe parts
Bath Iron Works	shipboard components (e.g., hatch doors)
Gilmour	lawn tools, sprinklers, etc.
Emglo Products, Inc.	air compressors and components
Rockwood Manufacturing Company	brass doorknobs and lock sets
Johnstown America Corporation	railroad car components

In addition to actual coating trials with customer products or hardware, we are actively engaged in a task with a U.S. Navy facility to evaluate a non-chromium containing conversion coating for aluminum. The process incorporates a potassium permanganate treatment and requires a 290-300° F steam treatment step.

Another area under investigation is the application of spray marine coatings with Supercritical CO_2 as a replacement for solvents in paint. An additional project is underway on evaluation of paint handling and spraying equipment. We anticipate that additional DoD tasks will be defined such as development/application of a chemical agent resistant coating (CARC) system.

Conclusions

The NDCEE's Organic Finishing Demonstration Facility provides both DoD and private sector clients with a unique facility for testing, evaluating, demonstrating and transitioning environmentally compliant organic finishing processes. The facility focuses on reducing the emission of VOCs, hazardous air pollutants, and heavy metal discharges associated with discrete parts painting operations. Focusing on associated pollution prevention and waste minimization technologies, the facility has, or soon will have, the capability to examine: alternative cleaners, non-chromium containing conversion coatings, powder coating, electrocoating, high-efficiency liquid spray coating, and low VOC/HAP coating formulations. In addition, waste minimization technologies for solution recovery and water recycling are being installed to ensure that we are a near zero wastewater discharge facility.

Additionally, the Organic Finishing Demonstration Facility has been designed to allow industrial scale product coating demonstrations, with process flexibility, data acquisition, and control to permit the evaluation of client process parameters, as well as to perform environmental and financial analyses.

SESSION XXI

SOLVENTS

<u>*Session Chairpersons*</u>*:*

Clare Vinton, NCMS

SMSgt Pat Zuñiga, HQ AETC/LGSPP

Total Cost Assessment Shows the Real Cost of Solvent Substitution

Mitchell Kennedy
Sr. Pollution Prevention Specialist
GZA Geo Environmental
27 Naek Rd.
Vernon, CT 06066
203-875-7655

How much does it really cost to switch from chlorinated solvents and Chlorofluorocarbons (CFCs) to an environmentally preferable alternative? As companies make their move to adopt substitutes, they are becoming aware of the importance of accurate financial analysis to select projects that meet environmental and bottom line objectives.

One method that allows managers to see the short and long term financial impacts of pollution prevention projects is Total Cost Assessment (TCA). Providing data on the real costs and benefits of such projects motivates change within a company and sets the stage for management support of additional P2 initiatives.

In a study conducted last fall at six small to mid-sized manufacturing facilities in Massachusetts, TCA was used to analyze the financial impact of solvent substitutions options available and those that were chosen. Eight different projects were examined, over half of which resulted in net operating savings of more than 95 percent. Market trends and limits of the available technologies were discovered as well.

This paper illustrates the application of TCA at one of the six facilities and explores the value of such analysis as a tool to support pollution prevention and reveal hidden costs of solvent substitution.

Project Methodology

The participating companies had recently switched or were in the process of locating a suitable solvent replacement. Traditional degreasing solvents such as TCE, TCA and CFCs used in vapor degreasers, conveyorized units or hand dip tanks were the norm at these facilities.

A comprehensive financial analysis of the previous cleaning operation and the substitute options was conducted using TCA methodology. Cost data was gathered through interviews, site assessments, and records reviews. Missing data elements were not estimated. This reflects the current practices at most companies and underscores the importance of accuracy in cost tracking.

The study used certain assumptions and methods of analysis to simplify calculations and protect confidential information. These include; the straight line method of depreciating capital equipment and start up costs; a standard 40% corporate tax rate to calculate savings from depreciation; a standard cost of capital of 10%; and 1993 market prices for chemicals and equipment.

CFCs & Electronic Components

Case Summary:	Electronic Equipment
Substrate:	Printed circuit boards
Soils:	Solder and Flux
Current Process:	CFC vapor.
Alternative:	HCFCs / Ultrasonics
Outcome:	87-120K / year savings

Background

This facility , located in West Springfield, Massachusetts, is a medium sized manufacturer of military and civilian electronic equipment. Products include power supplies for night vision goggles for military use, channel electron multipliers and high ohmic resistors. The circuit boards for these products are manufactured outside the facility but components are soldered and assembled in house. Due to the high voltages and low currents of these types of electronic devices, soil contamination must be kept at a minimum or result in product failure.

The company had been using CFC-113 in a vapor degreaser to remove flux and soils from printed circuit board assemblies. Between 1990 and 1992 the company used an average of 14,043 pounds of Freon 113 annually. The costs associated with regulatory compliance totaled $10,150 per year including paperwork, filing fees, TURA fees, and worker health and safety training.

The company began looking for alternatives to CFC-113 in early 1992. In this case, changeover required a two-stage approach. First, the company purchased an ultrasonic cleaner, recognizing that they would need approximately two years to find a suitable chemistry for the new unit. In the interim, HCFC 141b was quickly brought in as a drop-in replacement for the CFC-113. This required the installation of customized bench-top vapor degreasers. (A summary of the total cost assessment for this project appears in Table 1).

HCFCs Using Bench-Top Degreasers

The custom-built bench-top degreasers took two engineers at the facility six months to design and develop at a cost of $48,000. Manufacturing the units in-house cost an additional $9,180. The existing solvent distillation system was modified to recycle HCFCs. No permits or building changes were required for the switch to HCFCs. The company estimates that research and design costs to make the transition from HCFCs to ultrasonic cleaning will be about $7,500.

Because of the change to HCFC 141b, the company will not have to develop a TURA plan, resulting in a one-time savings of approximately $8,000. This savings was distributed over the lifetime of the alternatives (two years for the HCFC and seven years for the ultrasonic cleaner). Annual chemical costs for HCFCs are $37,800 versus $120,348 for CFCs.

The bench-top systems allow workers to clean their own parts without waiting and do not require an extra person to operate a vapor degreaser. Eliminating this salary substantially reduced production costs. Servicing eighteen bench-top degreasers, however, increased annual maintenance costs in this category from $120 using the CFC degreasers to $1,875.

Ultrasonic Cleaner With Terpenes

The purchase price for the ultrasonic system was $25,525 plus $1,009 for building adjustments to raise the suspended ceiling and install new water and sewer discharge lines. Disposal costs for this unit are marginally higher than those for the CFC degreaser. Under heavy use, chemicals would have to be changed every month at a cost of $1,400 a year for chemicals and approximately $330 for disposal. Electricity costs are $1,209 a year versus $2,580 to run the CFC degreaser.

Maintenance costs, primarily the costs of materials, rose sharply because of the need to replace filters for the ultrasonic system on a regular basis.

The Savings

Based on $163,228 in annual operating costs for the CFC vapor degreaser, a changeover to the bench-top-style units using HCFCs saved the company $87,408 a year. At this interim stage, and after the company has made the full transition to ultrasonic cleaning, the company saves nearly $10,000 a year by avoiding TURA fees. Thirty-four percent of the total savings, however, comes from eliminating the one worker who operated the vapor degreaser.

From a productivity standpoint, the company believes that worker efficiency has risen, because assembly workers can clean parts at their convenience without waiting. On the other hand, managers have observed that chemical use per part is probably higher because of the difficulty that workers have raising and lowering their parts at a correct rate, carefully emptying and refilling their bench-top units, and keeping them covered when not in use.

The interim solution actually saves more money per year than the ultrasonic cleaning alternative ($57,408 versus $79,281), but the ultrasonic option will be more profitable in the long term. Comparing two options that have different lifetimes requires the use of the Equivalent Annual Annuity (EAA). In this case, the ultrasonic's EAA looks more cost effective even when the salary cost of an additional employee (to operate the unit) is factored in ($53,843 for HCFCs and $72,290 for ultrasonics).

Table 1. Total Cost Assessment for Electronic Manufacturer

		CFC degreaser	HCFC degreaser	Ultrasonics
Capital Costs				
Equip. Purchase		NA	$9,810	$25,525
Disposal of Old Process		NA	in storage	in storage
Research & Design		NA	$48,000	$7,500
Initial Permits		NA	0	0
Bldg/Process changes		NA	$440	$1,009
TOTAL CAPITAL COSTS		NA	$58,250	$34,034
Operating Cash Flows				
Chemical Purchases		($120,348)	($37,800)	($1,400)
Waste Mgmt.	Treat. Chem.	0	0	0
	Testing	0	0	0
	Disposal	($150)	($150)	($330)
Safety Training / Equip		($50)	nominal	($50)
Insurance		NA	NA	NA
Fees (ie. TURA)		($9,700)	0	0
Filing Paperwork time		($400)	$3,600	$742
Annual Permitting		NA	NA	NA
Maintenance	Time	($120)	($1,875)	($108)
	Materials	0	0	($1978)
Production Costs	% Inc./Dec.	0	0	0
	$ / yr.	($30,000)	0	($30,000)
Utilities	Water	0	0	nominal
	Electricity	($2,460)	($740)	($1,209)
	Gas/Steam.	0	0	0
TOTAL. ANN. OPER. CF		($163,228)	($36,965)	($34,333)
Cash Flow Summary				
Total Ann. Oper. Cash Flow		(163,228)	(36,965)	(34,333)
After Tax Cash Flow		NA	$87,408	$79,281
Net Present Value		NA	$93,446	$351,941
EQUIV. ANNUAL ANNUITY		NA	$53,843	$72,291

Study Observations

The TCA exercises conducted at all six facilities revealed a number of important issues associated with the cost of solvent substitution. Most importantly, the study showed the value of gathering cost and other data related to the project in a systematic fashion. Some of the findings are explained below.

Research and Design Costs are Difficult to Track

One of the most difficult costs to track was time associated with finding new alternatives. In this case, estimates given by people involved in finding the alternatives were the only data available. Nobody had records of exactly how much time had been spent, and frequently, tasks such as testing part quality, contacting vendors, and estimating costs were split among several individuals.

Chemicals are Largest Cost

Chemical purchases were by far the largest operating-cost factor in the old cleaning systems, averaging 81.7 percent of operating costs at the six study facilities.

Changing chemicals represented the largest potential source of savings. There are three reasons for this. First, the prices of chlorinated solvents and CFCs have risen dramatically in the past two to three years. Trichloroethylene's (TCE) going rate in 1989 was $3.95 a gallon. Today's market rate is over $12.80 a gallon. Trichloroethane (TCA) has risen from $5.20 a gallon in 1991 to $16.71 a gallon in 1993. Taxes on CFCs have raised their price over 800 percent from 1990 to 1993. Federal taxes on these chemicals account for roughly 40 percent of their market price.

Second, aqueous and semi-aqueous chemistries have, in the past, been more expensive than chlorinated solvents. Now, they are often less expensive due to federal taxes on CFCs and the larger numbers of alternatives to traditional solvents. For example, terpenes are currently selling around $12.00 a gallon, offering a significant cost savings over CFCs and TCA.

Third, most alternatives are not used at full strength, which further lowers the in-tank costs. For example, alkaline aqueous chemistries are often diluted by at least 50 percent, effectively halving their cost. Lower evaporation rates also decrease fugitive emissions, further reducing the quantities needed.

Regulatory Costs Not a Major Factor

Although reducing regulatory obligations is often one benefit of chemical substitution, this study clearly identified the cost of CFCs, not the costs associated with compliance, as the largest potential source of savings. Eliminating the need to file forms has certain intangible benefits, such as reduced stress and time demands, but the overall financial impact in these cases was small.

On the other hand, the dramatic increase in taxes on CFCs has, as the regulators intended, become a major factor influencing corporate decisions to find substitutes. One company in the study is currently paying close to $50,000 in federal taxes on purchases of CFCs, and such taxes increase every year. Thus, there is indirect but powerful regulatory pressure stimulating the switch to new cleaning options.

NON-HAZARDOUS SOLVENT SUBSTITUTION - NOT AS EASY AS IT LOOKS

By

David S. Naleid
EARTH TECH
1420 King Street, Suite 600
Alexandria, Virginia 22314
Telephone (703) 549-8728
Facsimile (703) 549-9134

Introduction

The United States Air Force, along with the other service branches, is probably one of the largest users of solvents. These solvents are used in parts washing, parts degreasing, and parts preparation activities as well as general cleaning operations. The majority of the solvents used are disposed of as hazardous wastes due to their low flash points. Substituting high flash point solvents for the low flash point solvents would vastly reduce the need for hazardous waste disposal and would save the U.S. Air Force a significant amount of capital. There are, however, several obstacles to what seems like an easy solution. These include varying flash points within a specific type of solvent, technical manuals that specify a hazardous solvent, and complex procurement paths that make it difficult to review the solvent specifications prior to distribution. This paper presents actual case studies of Air Force installations using hazardous solvents, an overview of the impediments to substitution and makes recommendations for overcoming the obstacles. A successful case study is given where substitution was completed with annual cost savings. A comparative study of several solvent vendors is shown to illustrate the variance in flash point. Technical manuals are discussed and the difficulty in making modifications is reviewed. A flowchart is presented that depicts a typical complicated path for procurement of materials. Knocking down all of these barriers is not as effortless as it looks, but once accomplished, another hazardous waste stream is eliminated making the Air Force mission safer and more economical.

Impediments to Non-Hazardous Solvent Substitution

Elements that can obstruct the substitution of non-hazardous solvents include varying flash points for a specific type of solvent, limiting specifications in a technical manual, and complex procurement procedures. The most difficult of these three elements to control is the varying flash points within a specific type of solvent. The flash point property is determined by the manufacturer of the solvent and can only be administered through strict vigilance at the procurement level. The flash point limit for a non-hazardous solvent is 140° Fahrenheit. Solvents with a flash point below 140° F. are considered hazardous due to their flammability. An example of how widely flash points can vary for a specific solvent is presented in Table 1. This table presents flash points for the solvent PD - 680 Type II from several different vendors. PD-680 Type II has been recommended as a non-hazardous substitute for PD-680 Type I at several Air Force Bases.

TABLE 1 VARYING FLASH POINTS FOR PD - 680 TYPE II

Manufacturer	National Stock Number	Trade Name	Flash Point (° F.)
Octagon Process, Inc.	685000D002645	Dry Cleaning Solvent, PD-680 Type II	113
Solvents and Chemicals, Inc.	685002858011	Petroleum Solvent	107
MSCI Limited	6850001104498	Dry Cleaning Solvent, PD-680 Type II	140
Home Oil Company	685002745421	Dry Cleaning Solvent, PD-680 Type II	143
Ashland Oil Company	6850002858011	Dry Cleaning Solvent	138
CSD, Inc.	685006376135	Dry Cleaning Solvent, Type II	142
Magnaflux Surface Conditioners, Inc.	6850001104498	PD-680 Type II	140
Fine Organics Corporation	6850002745421	FO 425 Petroleum Solvent	160
Shell Chemical Company	68500082377935	Shell Sol 140 (Dry Cleaning , Type II)	142

The information presented in Table 1 is a random sampling of the 1993 DoD Hazardous Materials Information System (HMIS). Even though all of the solvents are PD-680 Type II, 33 percent have flash points below the 140° F. limit. These solvents are regulated as hazardous due to their flammability and will require disposal as hazardous waste. Many bases have substituted PD-680 Type II for PD-680 Type I under the belief that Type II has a high enough flash point to make it non-hazardous. As can be demonstrated by this random sampling, not all Type II solvents are non-hazardous. Also it should be noted that solvents that have a flash point at or near 140° F. may become hazardous after being used. The mixing with petroleum products can sometimes lower the flash point. Wastes should always be tested before disposal because not only the flash point is cause for hazardous waste disposal. Contaminants in the materials that are being removed by the solvent may also be hazardous, such as heavy metals or organic compounds.

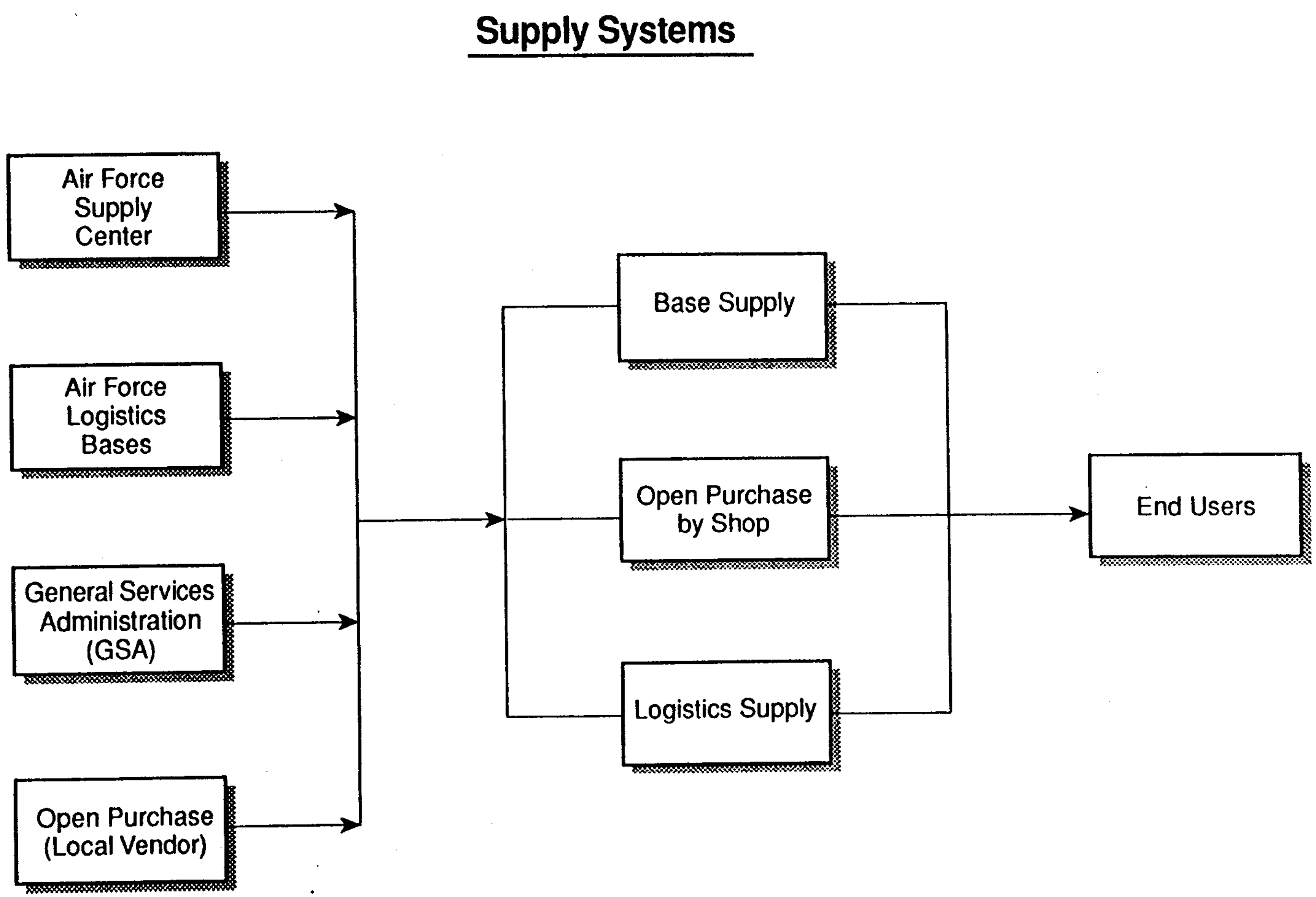
A second obstacle to non-hazardous solvent substitution is the technical manuals that specify certain solvents that are hazardous. This occurs most frequently in the maintenance of aircraft, especially for cleaning the interior of engines and treating metal surfaces of the fuselage. Specific solvents are required due to the sensitivity of parts within the engine such as rubber gaskets and the potential damage the solvent may incur on the metal surface of the fuselage. Long-term degradation of rubber gaskets is another concern. Research is currently being carried out at the Air Force Civil Engineering Support Agency (AFCESA) at Tyndall Air Force Base to determine if other non-hazardous solvents can be substituted. This is a long process and once a solvent has been identified, it must be tested and approved. After the solvent has passed the laboratory standards, it must be tested and approved by the maintenance personnel at the shop level. Then the process of changing the technical manuals must be initiated. As with any specifications, change is a slow and uphill battle. Decades can pass before technical manuals are rewritten.

The third obstacle that can impede the implementation of non-hazardous solvent substitution is the complexity of the procurement processes. This obstacle is indirectly related to the use of solvents with varying flash points because it makes it difficult to oversee the procurement of the proper solvents. The procurement departments are often unaware of this problem and do not scrutinize the flash point for solvents. A flow chart showing the procurement paths for an Air Force Base in Hawaii is depicted in Figure 1. Many bases have two or three different paths for procuring supplies. Most bases have independent local purchases with a limit on cost. The personnel making these purchases make not be properly trained and purchase hazardous solvents. Another source of hazardous solvents is through the use of contracted parts washers. The supplier will supply the solvent that can bring the higher profit and this is often the hazardous solvents. Even though the contractor changes out the solvents, hazardous solvents are still manifested as such and the cost for disposal is put on the Air Force. The contract negotiating department must stipulate that only non-hazardous solvents will be used.

Recommendations for Overcoming the Obstacles

The obstacle presented by varying flash points is one that must be confronted at several different points. Initially all personnel that come in contact with the solvents, whether it is in the maintenance shop or in the supply room, must be trained to identify what makes the solvents hazardous. The personnel must fully understand the objective of substituting a non-hazardous solvent. Suppliers must be made aware that no solvents with flash points under 140° F. will be accepted. The departments that are responsible for procuring the solvents should be trained in how to determine the flash points of the solvents from the Material Safety Data Sheets (MSDS). An example of a MSDS is presented in Figure 2 to where the flash point is found. Although, MSDSs vary in style, the information required is consistent and the flash point will always be in the same section. Lastly, all wastes must be tested prior to disposal to determine if they are hazardous and then disposed of in an appropriate manner.

Changing a technical manual requires lengthy research, multiple testing, and approval of the proper levels of command. This is a difficult hurdle to overcome in the pursuit of non-hazardous solvent substitution. Unfortunately, not much can be done at the base level to bring this change about. Once the request for change has been submitted, the base must wait for the research, testing, and approval to occur at the various levels. However, when the military set a goal of 50 percent reduction in the amount of hazardous wastes generated by 1992, it encouraged this recommendation to be implemented more strongly. As the military continues to strive for a 50 percent reduction in hazardous wastes, more research will become necessary.



EARTH TECH

Figure 1

Material Procurement and Distribution for Typical Air Force Base

GF/Pers./David N./Flowch.

FIGURE 2 MATERIAL SAFETY DATA SHEET

FSC: 6850
NIIN: 001104498
Manufacturer's CAGE: 60672
Part No. Indicator: A
Part Number/Trade Name: P-D-680, Type II

General Information

Item Name: DRY CLEANING SOLVENT
Manufacturer's Name: MSCI Ltd
Manufacturer's Address: 6935 W 62nd St
Chicago, Illinois 60638-3901
MSDS Serial Number: BCYYP
Specification Number: P-D-680
Spec Type, Grade, Class: Type II
Hazard Characteristic Code: F4
Unit of Issue:
Net Unit Weight:
NRC/State License Number: NA

Ingredients/Identity Information

Proprietary: YES
Ingredient: Proprietary
Ingredient Sequence Number: 01
Percent:
Ingredient Action Code:
CAS Number:
OSHA PEL:
ACGIH TLV:

Physical/Chemical Characteristics

Appearance and Odor: CLEAR, WATER-WHITE LIQUID, MILD ODOR
Boiling Point: 355F; 179C
Melting Point:
Vapor Pressure:
Vapor Density:
Specific Gravity: 0.79
Decomposition Temperature:
Solubility in Water: NEGLIGIBLE
Viscosity:
pH:
Radioactivity:
Corrosion Rate:
Autoignition Temperature:

Fire and Explosion Hazard Data

Flash Point: 140F; 60C
Flash Point Method:
Lower Explosive Limit:
Upper Explosive Limit:
Extinguishing Media: FOAM, CO2, Dry Chemical

Health Hazard Data

Route of Entry:
Carcinogenicity:
Signs/Symptoms of Overexp: Excessive Inhalation may cause dizziness or nausea
Emergency/First Aid Proc: Eye & Skin: Flush well with water for 15 minutes, If eye irritation persists, call doctor.

Precautions for Safe Handling

etc.

Control Measures

The obstacle of complex procurement procedures is already being surmounted at several bases. The recommendation is to simplify the system and restrict the amount of materials being kept at the shop level. Traditionally, shops have ordered more materials than were needed in order to stockpile for times when the materials were not so available. Bases are now implementing the "pharmacy system", where shops are only allowed to order on an as need basis and any materials that remain after one month are returned to the supply department. This eliminates expired shelf life wastes and the responsibility of managing storage areas at the shop level. When the system is in the starting stages, the shop personnel often complain of unavailability of materials, but after it has had time to balance out supply with demand, the complaints diminish quickly. Time must be allowed for the system to reach equilibrium with the demands of the shops. This recommendation allows for better vigilance due to less handling of the materials and removes the storage responsibilities from the shops.

Case Study of Successful Substitution

EARTH TECH performed a Hazardous Waste Minimization Study on 25 military facilities in the state of Hawaii in 1991. Recommendations were made, both short-term and long-term, to minimize the amount of hazardous waste being generated by the DoD. One of the bases included in this study was Submarine Base, Pearl Harbor. During 1988, 23,200 pounds of hazardous solvent were disposed of as hazardous waste. It was recommended that the solvent be substituted with a higher flash point solvent that was non-hazardous. In 1992 the amount of hazardous solvents disposed of was 5,968 pounds. This is a reduction of 74 percent and with the disposal cost of the hazardous solvent being $0.40 per pound, the base was able to save $6,893 per year. Through proper training and vigilance, this facility was able to implement non-hazardous solvent substitution.

Conclusion

When investigating the minimization of hazardous waste streams, hazardous solvents are frequently found to be one of the largest contributors. Following the Environmental Protection Agency's hierarchy for pollution prevention, source reduction is the primary method with material substitution as one of the techniques for attaining waste minimization. Substitution appears to be an easy solution for hazardous waste solvent generation, however, within the military there are three barriers that must be overcome. These are varying flash points for a specific type of solvent, technical manuals that specify usage of a hazardous solvent, and complex procurement systems that hinder standardization of the solvent's flash point. These obstacles can be surmounted through proper training, strict guidelines for suppliers, research to identify viable substitutes, and streamlining of the procurement process. These recommendations will significantly reduce the hazardous waste solvent stream and save the U. S. Air Force significant capital as well as improve the environment.

Replacement of Hazardous/Toxic Carbon Removal MILSPECS

Peter von Szilassy, P.E., Dr. Adolf Gessner, P.E.
Versar, Inc.
6850 Versar Center
Springfield, VA 22151
1-800-2-VERSAR

INTRODUCTION

For several years, the Defense Logistics Agency (DLA) has been conducting a waste minimization program referred to as HAZMIN. Under this program, hazardous/toxic commodities purchased by DLA under military specifications (MILSPECs) are examined to determine the availability of less hazardous or non-hazardous replacement materials. Laboratory and field tests may be conducted to ensure the satisfactory performance of such replacement materials. The MILSPECs may then be revised as appropriate to reflect the substitution of less hazardous or non-hazardous, non-toxic replacement materials.

In the present investigation, two commodities for loosening and removing carbon and fuel-gum deposits from parts of internal combustion and jet engines were examined. These are purchased under MIL-C-19853C and MIL-C-25107B. Both MILSPECs use substances considered hazardous under the Resource Conservation and Recovery Act (RCRA), require annual toxic-chemical-release reporting under Section 313 of the Emergency Planning and Community Right-to-Know Act (EPCRA), and have relatively low permissible exposure limits according to the Occupational Safety and Health Administration (OSHA). All but one of the toxic substances used are included on the list of pollutants in the Clean Air Act Amendments of 1990. The hazardous substances in question are methylene chloride, phenol, cresols (all isomers), and o-dichlorobenzene (1,2-dichlorobenzene). To enhance carbon deposit removal performance, additional substances, including hazardous, toxic ones, may be added to the formulation by the suppliers of these MILSPEC products.

MIL-C-19853C, a specification for all military services, covers compounds that remove or loosen carbon deposits from components of internal combustion engines by immersion at room temperature or below. The MILSPEC refers to a water-immiscible solvent mixture that is heavier than water and has a water seal floating on top to minimize solvent evaporation losses. The MILSPEC is subdivided into two categories: Type I material, which may contain phenol and phenolics such as cresols and xylenols; and Type II material, which is free from phenolic compounds. The principal solvent ingredient in both Type I and Type II material is methylene chloride (specific gravity, 1.33; boiling point, 40°C). Because of the high volatility of methylene chloride, this carbon removal product can only be used at room temperature and below (0-25°C).

MIL-C-25107B is a specification used by the Air Force. It also refers to compounds for removing or loosening carbon deposits from components of internal combustion engines, including the hot sections of jet engines, as well as fuel-gum deposits in engine fuel-feed systems. Its principal solvent ingredients are o-dichlorobenzene (specific gravity, 1.31; boiling point, 180°C) and cresol isomers (specific gravity, 1.03-1.04; boiling point range, 190-200°C). Although the material covered by this specification is relatively non-volatile, a water seal may be employed to reduce evaporation loss of the solvent components. The formulation covered by this MILSPEC may be used at slightly elevated temperature (up to about 50°C).

One key issue in the replacement of hazardous, toxic, carbon removal compounds is the list of chemical substances that should be excluded from such replacement compounds to assure that they are indeed non-toxic, non-hazardous, and environmentally acceptable. The criteria used in this investigation to recommend the exclusion of chemical substances were fire/explosion hazards, potential health risks to workers, and listing as hazardous under federal regulations. These criteria are reflected in RCRA regulations concerning hazardous substances, the Clean Air Act Amendments of 1990, the annual reporting requirements under SARA Title III, and the Occupational Safety and Health Administration Regulations. Subjective factors, such as an irritating odor, whether associated with a substantial health risk or not, were also considered because they may affect worker productivity.

LABORATORY PHASE

Steel and aluminum alloy coupons measuring approximately 1/16 inches by 1/4 inches by 3 inches were used to screen candidate formulations. The carbon was simulated by baking a 50 weight, pure mineral oil, aircraft lubricating oil onto the coupons at 300°C for 90 minutes in a muffler furnace. The simulated carbon coupons allowed rapid screening of potential compounds, mixtures, and ingredients. In all, approximately 1,000 coupons were used to screen 150 various formulations.

Performance of the compounds were measured subjectively. The coupon(s) were placed in either a small ultrasonic (40 kHz) bath or a stirred bath for 60 minutes at 60°C or 100°C, removed, air dried, and then wiped with a single stroke using a soft paper towel. The percentage of carbon removed was estimated on an area basis. While simple, the method was repetitively accurate. The procedure provided a rapid assessment of whether or not the compound or formulation had potential and, in many cases, indicated the direction that the reformulation should take.

Both anhydrous organic compounds and aqueous alkaline compounds were tested. The compounds included commercially available formulations, the two MILSPEC compounds, and Versar's own formulations. Without exception, all the anhydrous organic compounds tested, including the two MILSPEC compounds, performed poorly with carbon removal ranging from zero percent to ten percent during the 60 minute residence time. The aqueous alkaline compound's performance ranged from poor to excellent depending on the specific formulation.

The most promising candidate formulations were also tested against actual carbon encrusted engine components. These components included carbon encrusted gasoline/diesel pistons, valves, and fuel injector nozzles as well as gas turbine/jet turbine blades, bearing rings, and fuel injector nozzles. In all cases, carbon removal performance was similar to that observed with the simulated carbon coupons for a specific formulation.

CANDIDATE COMPOUNDS

Two candidate compounds were selected for field testing. Mixture A, composed of monoisopropanolamine, butyl carbitol, a non-ionic surfactant, and water, is suitable for aluminum, magnesium, and steel substrates. Mixture A should normally be used at 60°C with agitation provided by ultrasonics at 40 kHz or by mechanical mixing. The formulation is non-hazardous and non-toxic.

Mixture B, composed of sodium hydroxide, sodium EDTA, a non-ionic surfactant, and water, is suitable for magnesium and steal substrates only. Mixture B is for use in medium pressure parts washers at 80 to 100°C. The mixture is RCRA hazardous due to its high pH characteristic. The recommended method of disposal is neutralization followed by discharge to a domestic or industrial wastewater treatment plant (IWTP). The spent formulation should be used for pH control at an IWTP or other treatment plant in place of virgin caustic, if possible.

FIELD TESTS

Two field tests were performed under actual process line operating conditions. One field test was performed at Anniston Army Depot, Anniston, Alabama, using Mixture A. The second test was performed at Cherry Point Naval Aviation Depot, Cherry Point, North Carolina, using Mixture B.

ANNISTON ARMY DEPOT - MIXTURE A

Anniston Army Depot overhauls the 1,500 horsepower, M1A1 combat tank gas turbine engine. The parts used for the field test included the #5 bearing housings, #5 seal housings, #6 spacer sets, and fuel injector nozzles. The bearing housings and spacer sets incorporate 0.017 inch oil passages that are difficult and labor intensive to clear. Normal carbon removal procedures include degreasing the component in a TCE vapor degreaser for 2 to 3 minutes prior to placing them into a ultrasonic vat containing MIL-C-PC111. The parts remain in the ultrasonic vat from 24 hours to 72 hours depending on the overhaul schedule requirements. The part is then washed with hot detergent and rinsed with water. Most of the carbon is normally removed or loosened by the PC111. If necessary, the part is immersed for a short period of time in a highly alkaline, aqueous bath (MIL-C-14460C)to remove the remaining carbon. The oil passages are cleared by poking the passages with fine stainless steel wire and flushing with WD-40 until hydraulic oil flow tests indicate that the passages are clear.

Two identical 40 kHz ultrasonic vats were used. One was charged with Mixture A, and the other with a fresh batch of PC111. Both vats were preheated to 70°C, the normal operating temperature. Two identical sets of M1A1 gas turbine engine components were selected, vapor degreased, and loaded into the two separate vats at the same time. Periodically, the parts were removed from the vats, inspected for carbon removal, and returned to the vat. Performance was measured subjectively by Anniston Army Depot process line personnel in comparison to PC111. The following is a chronological events with the depot personnel's comments:

1 December 1993

a. 1000 hrs - placed components into ultrasonic vats.

b. 1100 hrs - inspected parts - "both sets partly clean".

c. 1230 hrs - inspected parts - "pars immersed in Mixture A somewhat cleaner".

d. 1416 hrs - inspected parts - "parts cleaned in Mixture A somewhat cleaner".

e. 1600 hrs - inspected parts - "Both batches about the same".

2 December 1993

f. 0838 hrs - parts removed from vats, washed with hot aqueous detergent for 5 minutes, rinsed with water - "parts treated with Mixture A slightly cleaner".

g. 0855 hrs - place parts into 61.6°C alkaline clean er.

h. 1116 hrs - parts removed from alkaline cleaner and rinsed - "Mixture A immersed parts 95% clean", PC111 immersed parts 80% clean".

A similar but shorter test was performed with only fuel injector nozzles with similar results. The conclusion of the Anniston Army Depot field test was that the non-hazardous, non-toxic Mixture A was slightly more aggressive in removing and loosening carbon deposits, and equal to, if not slightly better in overall performance to, the toxic PC111.

CHERRY POINT NAVAL AVIATION DEPOT - MIXTURE B

Cherry Point Naval Aviation Depot overhauls jet aircraft jet engines and gas turbine engines from various types of aircraft. Normal carbon removal operations are performed in conjunction with corrosion removal by immersing engine components in a heated alkaline bath of MIL-C-14460C for 20 minutes to 1 hour followed by a 15 minute hot water dip. Any remaining carbon is removed by bead blasting. Bead blasting is seldom required.

The equipment used in this test included an enclosed spray-cabinet parts washer (Mart Corporation Cyclone 30). This washer has a 30" diameter turntable for rotating stacked parts to be cleaned, and a row of high-intensity spray nozzles directed at the parts stacked on the turntable. The carbon removal formulation circulates from the sump of this machine through a centrifugal pump delivering a pressure of about 100 psig in the spray nozzle manifold. The velocity of the liquid issuing from the spray nozzles is about 100 ft/sec. The solution was heated to about 75°C in the sump by an electric heater. The length of the wash cycle, up to 30 minutes, was set on a timer. After removal from the parts washer, the engine parts were rinsed with cold water and then dipped into a hot water vat for 15 minutes.

Carbon removal performance was subjectively determined by Cherry Point Naval Aviation Depot quality assurance personnel. A component was required to be 100% carbon free to pass inspection for non-destructive dye indicator testing. Table 1 shows the carbon removal results of various engine components and the residence time required to achieve those results.

Table 1: Carbon Removal Results

Engine Component	Residence Time Minutes	Carbon Removal Percent
3rd stage turbine disk	30	100
4th stage turbine disk	30	100
T2 disk	30	100
turbine vane cooling nozzle - 3rd stage	90	90
turbine vane cooling nozzle - 4th stage	90	90
gas generator turbine shaft	45	99
combustion frame	30	100
combustion liner	30	100
bearing support	30	100
power turbine case	45	99
gas generator turbine case	30	100
exhaust frame	60	100
spool - FR	45	99
2nd stage turbine case	15	99
3 bearing covers - scrap	30	100
automobile exhaust manifold	60	100

Residence time periods longer than 30 minutes indicate that, due to its geometry, the engine part required rotation or re-orientation to achieve the resultant carbon removal efficiency. The turbine vane cooling nozzle geometry prevented complete carbon removal. It is suspected that the smooth curvature of the vanes necessary to maintain laminar airflow at high rotation speeds vectored the water jet impingement forces as well as reduced turbulent solution flow along the length of the cooling vanes.

SESSION XXII

AFFIRMATIVE PROCUREMENT & COSTING/ BUDGETING OF P2 PROJECTS

<u>*Session Chairpersons*</u>*:*
Nancy Carper, HQ AFCEE/EP
Rick Whittier, HQ AETC/CEVV

Pollution Prevention in Contract Acquisition

By

E. Alexander Stokes III

Purpose:

The purpose of this paper is to present and discuss options, approaches and techniques available to reduce, prevent and avoid generation of any waste or unnecessary pollution during contract acquisitions. The discussion is intended to be broad and applicable to most, if not all, contract acquisition processes. This paper demonstrates that P2 actions often reduce costs, speeds the process, and are not difficult to implement. Potential problems associated with the changes are identified along with potential solutions. The focus of this paper is on P2 opportunities in the Air Force (AF) contract acquisition process in general with specific attention given to the source selection process.

Background:

Pollution prevention is more than just a Civil Engineering problem (or program). It is growing and expanding to encompass all aspects and areas of the Air Force. P2 is more than turning out lights; setting the thermostats back; and recycling oil, paper and aluminum cans. Each of these activities will reduce pollution, however, they are often viewed as programs. Programs, unfortunately, are usually viewed as something operated by other agencies, organizations, or branches.

P2 is more than waste reduction, hazardous waste minimization (hazmin), reuse, recycling, and safe disposal programs. It incorporates all of these and more. P2 is simply avoiding the production of any waste (hazardous or non hazardous) or unnecessary pollution.

The Air Force acquires most goods and services by obtaining competitive bids. This may be as simple as requesting a price for a known good or service (i.e. listed in a catalog) and then selecting the vendor based solely on price. For items which can not be exactly specified due to their current nonexistence, or do not lend to being precisely specificed (e.g., engineering studies) then proposals must be solicited.

The proposals are then evaluated based on numerous factors. These factors may include things such as: quality, schedule, technical capability, previous performance, cost and other considerations. The weight of each factor may vary based upon a number of considerations. Thus, the proposals must be evaluated to determine if they meet the minimal identified requirement, the amount of risk associated with the proposal, and which proposal best meets the needs of the government. For example, the lowest bid may not represent the lowest overall cost to the government when all costs (i.e. life cycle costs) are evaluated. The evaluation usually involves a comparison of cost to value received.

The process of requesting, evaluating and selecting proposals is called source selection (SS). The individuals involved in evaluating the proposals are collectively called the source selection evaluation team (SSET).

Typically the SSET consists of several smaller teams. The teams vary depending upon the type of contract and services being procured. Typical teams are Cost, Technical, Management, Quality Control, Performance Risk and Subcontracting.

Discussion:

P2 opportunities exist throughout the source selection acquisition process. It is important to note that many P2 ideas will solve one problem while bringing a different problem to light. Problems associated with each of the identified P2 opportunities are briefly identified with potential solutions offered in many cases.

There are a number of opportunities to reduce waste and pollution during the steps leading up to actual contract award. To fully implement these opportunities will require a close working relationship by all parties involved in the acquisition, a willingness to be innovative and deviate from the norm, and flexibility.

These opportunities include:

Opportunity 1. Maximize use of electronic media

The first step is to agree to receive and distribute as much information using electronic media (i.e. computer diskettes) as is feasible. Items which lend to easy transfer via electronic media include: capability statements, capability statement evaluations, proposal preparation guidelines, proposals, clarification requests, and deficiency reports.

Benefits to using electronic media include: reduced paper usage, less paper shredding required, and reduced shipping and packaging wastes. There are also non environmental benefits to this mode of operation. These benefits include: reduced reproduction costs by offerors and the Air Force, ability to quickly locate information using computer searches, and reduced shipping costs.

The most likely problems are: accidental erasure of information, computer viruses, incompatible word processing programs, internal resistance to change, and dislike of reading information from video screens.

Solutions to these problems include: read only files, virus checking programs, and education of SSET members.

Opportunity 2. Double sided copying

This option should be implemented for all information printed on paper by the government or offerors. Examples of items which should be printed double sided are: capability statements, capability statement evaluations, proposal preparation guidelines, proposals, clarification requests, deficiency reports, and letters.

The benefits of double sided copying are reduced paper usage, decreased shipping costs, and decreased storage space requirements.

The most likely problems are: disliking double sided copies, inability to make double sided copies due to old equipment, lack of equipment and potential cost concerns.

The solution to all of these problems is to require all information submitted by any party (government or offeror) to be double sided. This requirement should be noted in the request for proposals and in the source selection evaluation guide. Any proposals not printed on both sides of the paper should be viewed negatively as the offerors are actually hindering the AF in its efforts to meet its waste reduction goals.

Opportunity 3. Discuss and agree on completion of each evaluation block early in process

Consistency is vital. Failure to have everyone (contracting officer, evaluators, item captains, advisors and reviewers) agree on how each block is completed will result in wasted time and paper. This problem should be avoided by clearly specifying the exact information and format for each block prior to beginning evaluations.

The benefits of implementing this option include: consistency, reduced corrections and format changes, and less wasted time reprinting or modifying evaluation forms.

The three problems most likely to be encountered are: inexperience with completing the evaluation form; failure to have all persons with inputs to the form agree to the format, style and information to be used for each block; and having reviewers change their mind with respect to style or format use in each block.

The best solution is to get general agreement on completion of each block prior to beginning and then resolve difficulties after evaluating the first proposal. All parties should agree on the style and format to be used and understand that changes will only be made if all parties agree to the change.

Opportunity 4. Limit reviews

The requirement to have documents reviewed needs to be fully identified and justified. Additional reviews result in additional changes. Often times the changes are simply a matter of style and each reviewer will have a different opinion. Ensure sufficient review of each document but limit the number of reviews and reviewers to the minimum. Avoid the "we want to be safe so we will review the document again and let Mr X and Ms Y review the document also" mentality. In addition, have everyone comment on the same document.

This strategy is beneficial as it avoids wasting valuable manpower resources performing unnecessary reviews. The fewer the reviews the fewer changes there will likely be. The fewer the changes, the less likely a printed version will require reprinting.

The primary problems likely to come up are reviewers providing conflicting comments, reviewers requiring minor irrelevant format changes due to differences in style, and insecurity by SSET members that are unsure about what or how information should be written.

Potential solutions are to have all reviewers comment on the same document (reviewers will see previous comments and reduce or eliminate conflicting comments), provide training for SSET members, have competent and capable SSET members at higher levels, and avoid excess reliance upon advisors.

Opportunity 5. Maximize use of telephone and Fax machine in lieu of mail

Using a Fax machine reduces packaging requirements and speeds information transfer. It may often be less expensive. Use the telephone to call and obtain minor clarifications if required. Example, offeror refers to subcontractors A and B in one place and specialty subcontractors A and B in another. A simple telephone call with instructions to the offeror to answer questions yes or no can avoid preparation of a clarification request (CR) and all addition documentation. Question is "Are specialty subcontractors A and B the same as subcontractors A and B?" If the answer is "yes" then continue, if "no" then a formal CR or deficiency report (DR) may need to be prepared.

Benefits to this are reduced paper usage, faster responses, reduced cost for both the government and offeror. The primary problem likely to be encountered is fear that a telephone call would be considered "having discussions." The solution is to carefully read the acquisition regulations and follow them as opposed to following extremely conservative or worst case interpretations of the regulations. Air Force regulations clearly state that clarification of apparent minor clerical errors is not considered having discussions.

Opportunity 6. Use recycled paper

This opportunity reduces pollution indirectly. It also increases compliance with regulations and Executive Orders requiring the acquisition and use of paper containing recycled materials. The only potential problem that should be associated with this opportunity is obtaining the paper.

Opportunity 7. Use computer video show for briefing

Briefings using video projectors connected to computers are becoming more popular as the equipment becomes available. This approach enables changes to be made to the briefing right up until the last minute. It also enables the preparation of many detailed slides having additional or back up information with out printing out the slides.

The benefits associated with this opportunity include avoiding use of transparencies and the ability to rapidly locate slides during the briefing (see benefits associated with Opportunity 8. also).

Potential difficulties associated with this option are lack of equipment, unsatisfactory lighting in the room, and the requirement to transport equipment. Solutions to these problems include equipment purchase or loan and locating a different room.

Opportunity 8. Minimize handouts of SS briefings

All attendees do not need copies of SS briefings (e.g., Competitive range and Final decision). Information in the briefings is SS sensitive and therefore should not be carried away from the briefing except by select individuals. The general reason copies are provided to everyone is that "everyone always hands out a copy so everyone can follow along" and because briefing slides may be difficult or impossible to read.

The benefits associated with this option are reduced paper usage, reduced shredding requirements, increased security, and better control of the briefing by the presenter(s). Implementing this opportunity in conjunction with the previous opportunity will greatly reduce the amount of waste generated by a SS acquisition.

The primary problems likely to be encountered are the grumbling of briefing attendees (because they will not be able to browse the briefing but must listen to the briefer, they "expected" their own copy, or inability to read slides) and the inability to write comments on the slide.

Solutions to these problems are to number the slides so viewers can have an easy point of reference for questions or comments and have attendees make comments on a blank page for collection at the end of the briefing. Slides should be made with large print to ensure all attendees can easily read and follow the briefing.

Summary and Conclusion:

The eight examples given above demonstrate that there are a number of opportunities available to reduce pollution during the acquisition process. Each of the examples discussed has the potential to reduce pollution. Implementing any or all of these changes will greatly reduce the amount of pollution and waste generated during the acquisition process.

None of the opportunities identified have insurmountable problems. The biggest problem is recognizing that just because something has been done a certain way does not make it the best way, or even the right way (this might be the best reason to consider change). All of the problems associated with the identified P2 opportunities can be resolved. Resolving the problems, however, may require a willingness to look at things from a new perspective and a willingness to change with the times.

A Framework for Household Hazardous Waste Management

by

Lt Col Steven T. Lofgren
and
Dr. William G. Ferrell, Jr.
Department of Industrial Engineering
Clemson University
Clemson, South Carolina 29634
Voice (803) 656-4716; FAX (803) 656-0795

Introduction

Environmental degradation occurs as human population and technology increase and impact natural systems. Recognition of the impact of human activity on the environment led to the passage of a variety of federal laws and regulations geared toward protecting the natural environment.

These laws and regulations were aimed at point sources of pollution, much of which was generated by industry. Consequently, industry was required to properly manage its hazardous waste.

Hazardous waste management has progressed from proper handling and disposal of residuals through waste minimization and toward designing processes which generate less waste. The motivating force behind waste minimization and the design of environmentally compatible processes was avoiding costs associated with compliance.

The next challenge is proper management of nonpoint source pollutants, of which one category is Household Hazardous Waste (HHW). HHW management is evolving similarly to hazardous waste management, from disposal of residuals through waste minimization and toward designing environmentally compatible, or green, products. The industrial motivation to design green products is increasing profits. Demand reflected by green consumerism is spurring competition based on environmentally related product improvements. The purpose of this paper is to develop a framework for HHW management based on this motivation encompassing local and national issues, agencies, and responsibilities.

Hazardous Waste Management

Industrial management of hazardous waste began with understanding and complying with regulatory requirements. These requirements included proper handling, packaging, transporting, disposal, and record keeping on the part of hazardous waste generators.

However, compliance with regulatory requirements became a costly activity. Cost avoidance efforts led to voluntary waste minimization activities. Industry realized that minimization of the usage of hazardous materials resulted in less hazardous waste being generated, and consequently satisfied both the environmental protection objective and the corporate cost minimization objective (Shelton 1992). At first, this minimization was aimed at streamlining existing systems. It is now progressing into the design of new systems and processes which reduce or eliminate the generation of hazardous waste by means of Designing for the Environment (DFE).

DFE represents the industrial manifestation of integrating environmental considerations into the design process. Industrial design of production processes are incorporating the DFE philosophy in order to create systems which generate less hazardous waste.

Thus, hazardous waste management efforts have progressed from compliance with regulations and proper disposal of residuals into minimizing the generation of waste and towards designing processes which produce less waste.

It is interesting to note that this backward movement parallels the evolution of quality control in industry. Quality control began with inspections of finished goods. Efforts to avoid costs associated with scrap and rework led to controlling variability during production through statistical process control. Finally, manufacturers recognized that quality starts with the design of a product.

Industrial hazardous waste management focused on process wastes. Industry also generates products which contain hazardous constituents. These products are used by consumers with residuals disposed of by any number of means. Hence, the hazardous constituents in these residuals reach the environment through a variety of mechanisms. In the case of household products, these residuals are known as HHW.

HHW Management History

HHW is defined as waste emanating from homes which contains hazardous constituents. Constituents are determined to be hazardous by the Environmental Protection Agency (EPA) regulations implementing the Resource Conservation and Recovery Act (RCRA). These regulations, contained in the Code of Federal Regulations (CFR), define a compound as hazardous either by being listed in 40 CFR 261.33 (e)-(f) or by being ignitable, corrosive, reactive, or toxic, as defined in 40 CFR 261.21-261.24 (U.S. EPA 1986). HHW generally falls into the major categories of household cleaners, automotive products, home maintenance and improvement products, lawn and garden products, and miscellaneous products, such as cosmetics (Bellafante 1990, U.S. EPA 1986). HHW management is evolving along the same path followed by hazardous waste management, beginning with management of residual wastes, progressing through waste minimization, and toward designing products which contain less hazardous material. However, because federal requirements are not in place to drive the process, the movement is slower and staggered.

Industry incurs no costs associated with handling and disposal of HHW. Thus, the industrial motivation to include environmental considerations in the design of products that become HHW is not cost avoidance; rather, they are the same forces that motivated a customer-oriented view of quality, namely, demand and competition.

Residual Waste Management

Although HHW is currently exempted from federal hazardous waste regulations, interest in it is growing. In 1976, Congress passed RCRA. This act defined hazardous waste and required generators and transporters of hazardous waste to initiate a manifest and track its disposal from cradle to grave. HHW was specifically excluded from compliance with these federal requirements. Additionally, small-quantity-generators of hazardous waste were not subject to full compliance. Small-quantity-generators were defined as activities which produced less than 1000 kilograms of hazardous waste per month or accumulated less than 1000 kilograms of hazardous waste at any given time. In 1984, Congress passed the Hazardous and Solid Waste Amendments to RCRA. Due to concern that the number of small-quantity-generators could, in the aggregate, be a threat to human health or the environment, the ceiling for small-quantity-generators was lowered from 1000 kilograms per month to 100 kilograms per month. Although HHW was still exempted from regulation, the amendments recognized that homes may be sources of hazardous waste going into landfills and expressed interest in the impact of this activity (Sarnat 1990). Thus, as the large generators of hazardous waste have complied with regulatory requirements and incorporated good management practices, attention is turning toward the larger population of small generators of nonpoint source pollutants, including HHW.

Interest in HHW programs began at the local level in 1980. During that year, two collection programs were held. By 1993, this grew to 1,223 collection programs (Duxbury 1993). These collection programs generally involve educating the public and soliciting their voluntary cooperation in bringing HHW to a collection center. The HHW is then properly packaged and disposed of.

Unfortunately, HHW collection programs are not federally mandated, have low participation rates, and are costly (U.S. EPA 1986; Bellafante 1990; San Francisco 1991;). Consequently, their effectiveness in reducing the HHW stream is minimal (Kelly et al. 1989). It can be concluded that HHW collection programs, in and of themselves, are not the solution to the HHW problem. HHW collections are after the fact and deal with cleaning up the existing problem of waste in garages and basements after both purchase and use. A proactive approach to the problem is needed in order to minimize the impact of HHW on the environment.

Waste Minimization

Balanced HHW management programs consider waste minimization in addition to residual waste management. As with hazardous waste, minimization initiatives are taken by the generator. In the case of HHW, the generators are consumers. Consumers must be made aware of the consequences of their purchase decisions. Thus, the heart of a HHW minimization program necessarily involves consumer education.

Consumer educational efforts can involve a variety of techniques, including: brochures describing alternative products; television and radio spots; and, handouts. A multitude of these off-line educational efforts are currently on-going (U.S. EPA 1986). This education has contributed to a phenomena characterized by the creation of the terms "enviro-shopping" and "green consumerism." Enviro-shopping is defined as consumers weighing environmental factors along with other considerations and green consumers practice enviro-shopping. They include environmental impacts as part of their purchase decision.

A mechanism exists that informs consumers of the environmental impact of a product at the point of purchase. This mechanism is a product label. At present, the government does not regulate or set standards for product environmental labels. Instead, two private companies, Scientific Certification Systems (SCS) and Green Seal, have developed approaches to product certification. SCS uses a life-cycle analysis methodology to provide a comprehensive evaluation of a product. Green Seal investigates selected aspects of a product, such as recycled content and toxic constituents.

These consumer educational efforts are aimed at changing consumer buying patterns, or demand. The goal is for environmental impacts to be weighed along with other considerations, such as price and performance, at the point of purchase. It is thought that these changing demand patterns will create new market opportunities for progressive industries. Wise companies will consider these changes during product research and development.

Design for the Environment (DFE)

In the design of environmentally acceptable products, DFE has two goals: waste prevention and better materials management (OTA 1992). Waste prevention strives to reduce weights and toxicities of the waste stream. Better materials management focuses on sustainable development, that is, continued progress through responsible usage of limited natural resources.

HHW management has not yet evolved to the point where DFE has been integrated. This is due to the fact that the focus has been on consumer/governmental interactions through proper disposal of residuals and education. However, consumers would prefer not to have to deal with the problem of HHW at all. This was clearly shown in a study conducted by the Massachusetts Department of Environmental Quality Engineering, in which 77 percent of respondents favored having manufacturers develop substitute non-hazardous products (Tuthill et al. 1987). This indicates the advantage to industry of practicing DFE and developing greener products.

<u>HHW Management Framework</u>

HHW management will necessarily involve all three activities discussed above: residual waste management, waste minimization, and designing for the environment. The level of effort devoted to each of these activities, however, has a time dependence. Initially, a great deal of time is devoted to residual waste management, as is currently the case with HHW collection events. There is evidence that these HHW collection programs educate consumers and change behavior. A survey at the San Francisco HHW collection facility (San Francisco 1991) revealed that 76 percent of those participating were buying fewer products with hazardous constituents. These collection events, coupled with other formal educational efforts, initiate changes in buying patterns, and consequently result in waste minimization.

One implicit assumption in this scenario, however, is that either an environmentally friendly product is available or the consumer is willing to do without a product. It is entirely conceivable that neither is the case. Consequently, industrial design of products becomes very important. As consumers increasingly practice enviro-shopping and weigh environmental impact considerations more heavily at the point of purchase, industry needs to respond by designing environmentally friendly products. This time dependent relationship is depicted in Figure 1.

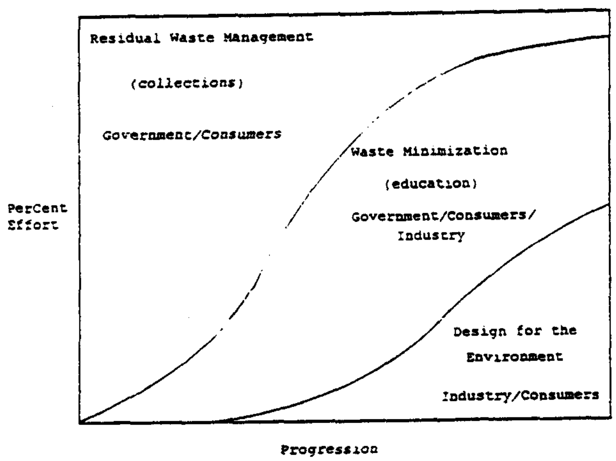


Figure 1. HHW Evolution

At first, virtually all HHW efforts involve governmental residual management efforts through HHW collections and educational activities. These collections and educational efforts raise consumer awareness, which leads to enviro-shopping. Industry responds to this change in demand by practicing DFE, and designing environmentally friendlier products. Residual waste management (HHW collections) and waste minimization (education and enviro-shopping) activities never end. Over time, however, the efforts devoted to them diminish as industry produces environmentally friendly products and consumer demand for them rises.

The players involved in the model change over time, as well. Residual waste management efforts involve both local governments and consumers. Local governments conduct HHW collection events and consumers participate. Waste minimization efforts involve government (education), consumers (enviro-shopping), and industry (labelling products). DFE efforts involve consumers (demand) and industry (design). Thus, the HHW management emphasis transitions over time from government action to industrial action.

A comprehensive framework for HHW management needs to outline the issues of concern to the parties involved, the activities to be taken by each, and the interactions between them. This is first done at a national level, then at a local level, and finally, in the "middle ground." The objectives and activities of the three parties involved (government, industry, and consumer) are different at each level, as is their degree of involvement and interaction.

National HHW Management

The federal government is responsible for overseeing HHW issues that have national or international ramifications. For example, the Clean Air Act Amendments of 1990 placed restrictions on ozone-depleting chemicals, a global environmental issue. Furthermore, the EPA has banned products which are judged to have a severe detrimental effect on national health.

These restrictions and bans are the exception rather than the rule, however. There are a variety of products on the market with hazardous constituents which do not pose an immediate threat to human or ecological health. Still, minimization of the hazardous constituents in products is environmentally desirable .

This philosophy is being encouraged within the federal government through Executive Order 12873, dated October 20, 1993, which requires federal procurement agencies to give preference to environmentally preferable products. In this way, the federal government is trying to influence demand patterns toward environmentally friendly, or greener, products.

Industry is recognizing the advantage of voluntarily incorporating environmentalism into basic corporate decision processes both as a way to avoid costs associated with regulatory compliance and to increase profits. Increased profits result from increased market share as consumers become more environmentally conscious.

Actions which can be taken by industry include reformulation of products, changes in packaging in order to reduce the quantity of hazardous waste by selling only the amount required, and labelling products in order to educate consumers of both hazards and proper disposal methods.

Not all HHW issues can be resolved at the national level. Products with hazardous constituents will still be manufactured which do not have international or even national ramifications. Additionally, different population groups have different desires in terms of HHW management. Furthermore, environmental stresses and concerns vary regionally. Thus, HHW management on a local scale has a different focus.

Local HHW Management

If hazardous products continue to be manufactured by industry and sold to consumers, some HHW decisions will need to be made from a local perspective. These decisions involve city and county governments, industry, and consumers.

In order to be successful, the decisions need to consider both local environmental conditions and population characteristics. Local environmental conditions include water quality, air quality, solid waste disposal practices, and sewage disposal practices. The HHW management program needs to be designed to match these environmental issues. For example, a city concerned with groundwater contamination might advise citizens to leave latex and oil-based paint cans open until the solvent evaporates, and then discard the container in the trash. This would be an unacceptable solution for an area with significant air pollution.

Population characteristics need to be considered, as well. Individual differences in terms of HHW exist due to both preference and behavior. A study done in Canada indicated that HHW generation varied by both dwelling type (apartments versus detached dwellings) and economic status of the occupant (Jones and Atwater 1991). A telephone survey in Massachusetts disclosed that 70% of rural groups would travel up to five miles to drop off items at HHW collection sites, but only 46% of urban residents would travel that far (Tuthill et al. 1987).

Furthermore, a local HHW management program needs to recognize that the best plan which can be devised will not be effective without participation of citizens. This means that the educational component of the plan must be emphasized. Citizens must be made aware of the dangers HHW poses to their specific locale and, consequently, their way of life. One company may reformulate a product, but, if its hazardous constituents are not banned, competing companies may still offer consumers hazardous alternative products. Consumers need to be educated to understand the results of their choice and its impact on their life.

The Middle Ground

There is a gap between national HHW management and local HHW management. The political subdivisions used for local HHW management do not necessarily match ecological boundaries. Consequently, an aquifer may encompass several counties and many cities, but not, obviously, have national ramifications. Thus, state governments have a role in HHW management.

State governments need to coordinate efforts between cities and counties, as well as insure national HHW management reflects state interests. Additionally, ecological boundaries may cross state lines, in which case the state needs to coordinate activities with neighboring states. Thus, the state role becomes one of coordinating efforts within and between states, and lobbying to represent state interests at a national level.

Conclusion

Management of nonpoint source pollution in general, and HHW in particular, is more complicated than management of point source pollution. Hazardous waste management has matured from reactive disposal of residuals to proactive waste minimization and DFE. The focus, however, remains cost avoidance.

A framework for HHW management has been presented. At the national level, industry needs to focus on the changing attitudes of consumers and on increasing profits. This is being encouraged by the rise of green consumerism, which is reflected in federal procurement guidelines.

At the local level, HHW management needs to focus on local environmental issues and consumers. Programs need to be tailored to match these needs.

Finally, it must be recognized that political and ecological boundaries do not coincide. Industrial and governmental HHW management plans need to account for this discrepancy.

References

Bellafante, Ginia. "Minimizing Household Hazardous Waste." Garbage, March-April 1990, 44-48.

Duxbury, Dana. "A Good Year." Household Hazardous Waste Management News, December 1993, 1,7.

Jones E.L. and J.W. Atwater. "Survey of Household Hazardous Waste Generation and Collection Preferences in the City of Vancouver." Canadian Journal of Civil Engineering. June 1991, 525-534.

Kelly, Barbara G.; Cassandra S. Goldwater; and, Michael S. Brown. "Evaluation of a Statewide Matching Grant Program for the Collection of Household Hazardous Waste", JAPCA: Journal of the Air and Waste Management Association, April 1989, 427-430.

Office of Technology Assessment (OTA). "Green Products by Design: Choices for a Cleaner Environment." OTA-E-541. Washington, D.C.: U.S. Government Printing Office, October 1992.

San Francisco Solid Waste Management Program. San Francisco's Household Hazardous Waste Collection Facility, Third Year 1990 Annual Report. April 1991.

Sarnat, Carol L. "County Develops a Permanent Household Hazardous Waste Collection Program." Public Works, January 1990, 58-60.

Shelton, Robert D. "New Strategies for Corporate Environmental Management." Circuitree. February 1992, 8-10.

Tuthill, Robert W.; Edward J. Stanek III; Cleve Willis; and Gary S. Moore. "Degree of Public Support for Household Hazardous Waste Control Alternatives," American Journal of Public Health, March 1987, 304-306.

U.S. Environmental Protection Agency. A Survey of Household Hazardous Waste and Related Collection Programs. Washington, D.C.: Government Printing Office, October 1986.

Biographical sketches:

Lt Col Steven T. Lofgren is currently a Ph.D. candidate at Clemson University. His next assignment will be as an instructor in the Graduate Environmental Management (GEM) program at the Air Force Institute of Technology.

Dr. William G. Ferrell, Jr. is an associate professor in the Department of Industrial Engineering at Clemson University. His previous environmental experience involved solid waste management in the wake of Hurricane Hugo.

PROCUREMENT OF RECYCLED PRODUCTS: FLORIDA TECHNICAL STUDY

Lisa K. McDaniel, W. Gregory Vogt

SCS ENGINEERS
11260 Roger Bacon Drive
Reston, Virginia 22090
(703) 491-6150

INTRODUCTION

Successful recycling is a three step process. It begins with collection of recyclable materials which are then remanufactured into new products. Finally, the recycled products are returned to the marketplace as new consumer goods. The long-term success of recycling depends on developing markets for recyclable materials.

There are several reasons why federal government agencies buy recycled products. First and foremost, Congress and President Clinton think its a good idea and so does the Department of Defense. For example, Section 6002 of the Resource Conservation and Recovery Act requires the Environmental Protection Agency to designate items that are or can be produced with recovered materials and to recommend practices for the procurement of designated items by procuring agencies. Once EPA designates an item, RCRA section 6002 requires any procuring agency using appropriated Federal funds to procure that item to purchase it with the highest percentage of recovered materials practicable. EPA has five existing procurement guidelines in place: coal fly ash, paper, re-refined lubricating oil, re-treaded tires and building insulation.

In a proposed Comprehensive Procurement Guideline and accompanying Recycled Material Advisory Notice (RMAN) published in the Federal Register on April 20, 1994, EPA proposes to consolidate the existing guidelines and to streamline the guideline process. EPA also designates 21 new products, requests information about a range of other products, includes revised content levels for some products and proposes a change from "minimum content standards" to "recovered material content levels". Comments were due June 20, 1994. It should take some time for EPA to evaluate the comments and promulgate the final rules.

The 21 designated or revised products are:

Vehicular Products:	engine coolants (antifreeze)
Construction Products:	structural fiberboard and laminated paperboard plastic pipe and fittings geotextiles carpet floor tiles and patio block cement with blast furnace slag building insulation (content levels for fiberglass and rock wool)

Transportation Products:	traffic control cones and barriers
Park and Recreation Products:	playground surfaces and running tracks
Landscaping Products:	hydraulic mulch yard trimmings compost
Non-Paper Office Supplies:	recycling containers and waste receptacles plastic desk top accessories binders plastic trash bags remanufactured toner cartridges

Paper and paper products will be addressed in a separate Recycled Material Advisory Notice. Proposed changes, including reference to President Clinton's Executive Order 12873, are expected in mid to late summer of 1994.

Published on October 20, 1993, Section 504 of Executive Order 12873 established minimum recycled content standards for printing and writing paper for Federal agencies. Initial content standards are to be in effect by December 31, 1994 with increased amounts to be implemented by December 31, 1998. Two minimum content standards were set:

- 20 percent postconsumer, rising to 30 percent postconsumer by 1999: High speed copier paper, offset paper, forms bond, computer printout paper, carbonless paper, file folders and white wove envelopes

- 50 percent recovered material of which 20 percent is postconsumer, rising to 30% postconsumer by 1999: Other uncoated printing and writing paper

An alternative is allowed; the 50 percent recovered material requirement can be met with waste byproducts of finished products under certain conditions:

- The finished product cannot be paper or textiles, and

- The waste material would otherwise be disposed of in a landfill according to the state in which the facility is located.

Only sawdust in the state of Maine currently meets the qualifications for an alternative material.

Finally, the Department of Defense has established policy showing preference for recycled paper. In a 1993 memo, Principal Deputy Assistant Secretary of Defense (Production and Logistics) stated the following policy:

- Specify and purchase only paper and paper products containing recycled materials consistent with EPA procurement guidelines.

- Require all reports (or other paper products) produced by or for the Department to be consistent with the EPA guidelines.

- Require paper deliverables to contain recycled materials.

- Order only letterhead stock containing recycled materials.

- Require all documents longer than two pages be double-sided copied.

- Make maximum use of General Services Administration schedules for paper and paper product procurements pursuant to DFAR Subpart 208.404.

With all the directives requiring agencies to purchase products containing recycled materials, there is growing interest in "how much" and "what kind" of recycled material should be in products.

OVERVIEW OF THE FLORIDA MINIMUM CONTENT TECHNICAL STUDY

The purpose of this presentation is to describe a study that SCS Engineers currently is conducting for the Florida Department of Management Services. As a requirement of the Florida 1993 Solid Waste Management Act, the Department of Management Services (the entity responsible for negotiating state-wide contracts) must report to the state legislature appropriate recycled content levels for products procured by the state's 37 agency and ten universities. At a minimum, the report must consider the use of recovered plastic, paper, newsprint, glass, steel cans, aluminum cans, and used oil.

To reach the ultimate goal of recommending minimum content standards, there were several tasks that were undertaken. The first task was to determine the items purchased by state agencies and universities that should contain recycled content. Agencies and universities buy "lots of things;" however, not everything purchased by these entities are appropriate candidates for minimum content standards. For example, food, pharmaceuticals, wooden furniture, computers, laboratory equipment, and vehicles are all purchases for which recycled content policy is either inapplicable or practically impossible to apply. The SCS team developed a list of more than 1100 items routinely purchased by State agencies which made sense to further evaluate as candidates for minimum content standards.

The second task was to estimate the quantity of the above 1100 items purchased by directly by State agencies during fiscal year 92-93 and estimate demand for the next five years. The study does not evaluate items purchased through service contracts such as construction materials purchased by a contractor. To evaluate state purchases, a survey was sent to the state's 47 agency and university purchasing offices; 41 surveys were returned.

The preliminary survey results indicate that the 41 agencies and universities spent nearly $50 million on items that are candidates for minimum content standards. By material type, purchases include:

- Paper products (including printing contracts): $42,800,000
- Plastic products: $6,900,000

- Glass products: $575,000
- Lubricants: $157,000
- Newsprint-based products: $120,000

Of this total, over $9 million was spent on recycled products. Most of the recycled products were made from paper.

The statute requires that minimum content standards provide for orderly market development. In other words, a minimum content standard should not be so high that a product manufacturer can't meet it because a sufficient supply of recyclables is not collected. Alternatively, a standard must not be too low and not promote market development. The third and currently ongoing task is to:

- Estimate the quantities of available materials in Florida that can be used to manufacture recycled products.

- Forecast changes in materials expected to be recovered for recycling.

- Evaluate the effect that increased demand for recycled products will have on the markets.

Once the market forces have been investigated, minimum content standards will be evaluated.

The minimum content standards recommended for Florida will be based on:

- Availability of recovered materials,

- The need to stimulate demand,

- The ability of existing manufacturing processes to accommodate greater amounts of materials, and

- Product quality required by the State.

Minimum recycled content standards will be developed for categories of products in each of the material types under study. Similar products will be grouped together with the same content standard (e.g., coated papers, uncoated papers, groundwood forms).

Another goal of the study is to recommend price preferences, where necessary to meet recommended procurement goals. Florida has had a 10 percent price preference in place for several years. Florida statute has recently allowed for additional price preferences, up to 5 percent, for products made from materials recovered in the State.

In July, SCS completed a preliminary draft report on steel cans and aluminum cans. Use of minimum content standards and price preferences were not recommended for aluminum and steel products purchased by state agencies:

- Initial market and product research indicates that aluminum and steel markets are absorbing all the cans they can get. Florida experiences a recycling rate of greater than 50 percent for these materials.

- Both the metal industries are expanding their use of postconsumer materials for economic reasons.

- Tracking and certifying minimum content standards for aluminum and steel products would be onerous for state agency/university personnel.

Work currently is ongoing for the remaining materials included in the study.

A METHODOLOGY FOR INDEXING COSTS ASSOCIATED WITH A POLLUTION PREVENTION OPTION

Hayes, R. and R. A. Vogel
Radian Corporation, Oak Ridge, TN

INTRODUCTION

Properly calculated cost savings for a pollution prevention option is critical for the pre-implementation screening and feasibility evaluation, and provide the financial justification necessary to obtain project funding. Frequently, efforts towards determining the cost savings for a pollution prevention option are been based on inconsistent or unknown methods. These inconsistencies often lead to a lack of confidence about the overall feasibility and need for the pollution prevention option, and result in funding not being awarded for the project. Additionally, inadequate costing methods make it difficult for review committees to accurately compare, screen out and select projects that have avoided significant costs and truly contribute to the base's efforts to achieving specific pollution prevention goals. Therefore, the need exists for a methodology that consistently estimates (i.e., indexes) the costs associated with a pollution prevention option.

This paper introduces a methodology for indexing costs associated with a pollution prevention option. The methodology is based on:

- selecting categories that represent the major process costs that can be easily obtainable and can be quantified,
- developing standard cost tables to enhance uniformity and consistency, and
- compiling the categories for indexing cost avoidance (and determining cost savings) into easy-to-use worksheets for use by personnel.

This index is intended to assist its users with determining the cost savings and cost benefits of a pollution prevention option. This guidance does not capture all process costs, and is **NOT** a substitute for life cycle costing or other cost accounting procedures associated with process or waste management. The index is strictly intended to allow a more fair, uniform, consistent basis for evaluating the economic value and feasibility of a pollution prevention option.

METHODOLOGY

WORKSHEET 1: INDEX OF ANNUAL COST AVOIDANCE

Worksheet 1, presented in the attachment, provides specific categories (cost elements) for indexing the annual costs associated with facility processes. Categories considered for indexing include: raw materials purchasing, process operations, personal protective equipment (PPE) and related health/safety supplies, waste management, and recycling. Two columns are provided for entering the index of annual cost: one for annual costs associated with the current process, the other for annual costs associated with the new process. For this methodology, the "current process" should be considered the process used before the pollution prevention option was initiated. The "new process" is the process resulting from the pollution prevention option. Procedures for calculating and indexing the costs for the categories and determining a total index of annual cost avoidance are presented in the attachment with Worksheet 1. The following sections discuss the aspects of the categories selected for indexing.

Annual Raw Material Purchasing Costs

Annual raw materials purchasing costs reflect only the purchasing of hazardous and nonhazardous process materials affected by the pollution prevention option. Do not list hazardous or nonhazardous materials used for refrigeration or equipment maintenance. These materials will be listed in subsequent categories. Sources for obtaining material costs include the base procurement and materials organizations and specific item vendors.

Annual Process Operation Costs

Annual process operation costs selected for indexing are utilities, process labor, and equipment maintenance (parts and labor). Utilities, as defined for this category, include refrigeration, electricity, coal, fuel oil, process water, steam, cooling water, and gas. Utility units are kilowatt hour for electricity, pound for refrigeration, ton for coal, cubic feet for natural gas, and gallon for fuel oil. To allow uniformity and consistency with the indexing, it is recommended that standard utility costs be used. Sources for obtaining utility costs include the base operations, utilities, maintenance, or engineering organizations.

Annual process operation labor costs represent the labor involved with operating equipment, handling materials and supplies, and handling process waste. To allow uniformity and consistency with the indexing, it is recommended that standard labor rates be used. Sources for obtaining labor costs are the wage and salary organizations for the site or facility. Annual process equipment maintenance costs include the annual purchase cost of parts and supplies, as well as annual labor costs for performing the maintenance. Base procurement and material supply organizations, as well as specific item vendors, are considered the primary sources of obtaining costs for parts and supplies.

Annual PPE and Related Health/Safety Supply Costs

Personal protective equipment (PPE) and related health/safety supply costs include the purchasing of items such as protective footwear, safety glasses, hearing protection, respirators and cartridges, gloves, coveralls, and hard hats. Other costs in this category include monitors, dosimeters, labels, laundry charges, and cleaning supplies. The costs of these items vary and should be obtained from the base procurement and material supply organizations, the Bioenvironmental Engineer, or specific item vendors.

Annual Waste Management Costs

Waste management costs are often the only costs reviewed during the evaluation of a pollution prevention option. This index incorporates waste management costs as a separate, but equal cost category contributing to the determination of an option's total avoided costs. Annual waste management costs selected for indexing include waste containers, waste treatment/ storage/disposal (TSD), site inspection/maintenance, and recycling.

To allow uniformity and consistency with the indexing, it is recommended that standard costs be developed for waste containers and TSD activities. The base civil engineering office, procurement and materials organizations, or specific item vendors, are considered the primary sources of obtaining costs for waste containers. The base civil engineering office should be consulted for obtaining standard TSD costs. Typical TSD activities may include waste landfilling, incineration, compaction, storage, and neutralization. Both solid and liquid forms of all waste types (i.e., hazardous and non-hazardous) should be considered.

Annual waste storage site inspection/maintenance costs include primarily the labor time needed to inspect waste containers for properly labeling, packaging, and integrity, and for maintaining the orderly appearance and cleanliness of the site. It is assumed that two to four hours per week will be required, depending on the size, location and condition of the site. Other time estimates for inspecting and maintaining waste storage sites should be used for the base if the time estimates presented here are not acceptable.

Annual recycling costs include specific costs for material preparation, separation, collection, and recycling of any waste stream generated from the current process, or as a result of the pollution prevention option. The base Recycling Coordinator or recycling vendors should be contacted to obtain specific item recycling costs. If the base pays for materials to be recycled, a positive value should be entered in the column for vendor recycling. If the base gets paid for the recycled item, a negative value should be entered in the column.

WORKSHEET 2: ONE-TIME IMPLEMENTATION COST

Worksheet 2 is to be used to estimate the one-time implementation cost for a pollution prevention option. The one-time implementation cost is not an avoided cost and is not used to determine an annual index of cost avoidance. It is the one-time payout of capital for the purchase and installation of new or salvaged equipment; the development of associated operating, safety, and waste management procedures; and employee training to operate the equipment. This payout of capital, the implementation cost, is not used to determine an annual index of cost avoidance. However, with the index of annual cost avoidance (Worksheet 1), the implementation cost can be used to determine the payback period. Procedures for calculating the one-time implementation cost are presented in the attachment with Worksheet 2.

WORKSHEET 3: INDEX OF ANNUAL COST AVOIDANCE SUMMARY

Worksheet 3 provides a summary of the cost avoidance information from Worksheet 1 and the implementation cost from Worksheet 2. This worksheet also provides a place to calculate the payback period, which for the purposes of this index is an estimate of the time, in years, required to recover the implementation cost. The payback period is determined by dividing the one-time implementation cost by the total annual index of cost avoidance. Specific procedures for completing Worksheet 3 and calculating the payback period are provided in the attachment.

WORKSHEET 4: DESCRIPTION OF THE POLLUTION PREVENTION OPTION

Worksheet 4 describes the targeted process, the pollution prevention option, and the benefits (cost- and process-related) associated with that option. Accurate and detailed descriptions should be provided on this worksheet so that the data included in the subsequent worksheets can be easily understood. Because this worksheet summarizes the information developed in the first three worksheets, it should be completed last. Worksheet 4 is intended to be used as the cover sheet to introduce and brief the reviewers of the pollution prevention option before presenting the specific costs. The specific instructions for completing Worksheet 4 can be found on the worksheet, which is provided in the attachment.

Information required on Worksheet 4 includes the objective, a description of the current process, description and benefits of the pollution prevention option, and any additional information and methods used to determine the implementation cost and the index of annual cost avoidance.

The objective should address the overall contribution of the pollution prevention option toward achieving the pollution prevention program goals established by the department and the facility. When describing the current process-specific information on the key raw materials used, waste streams generated (including hazardous and nonhazardous), equipment used, maintenance cycles, pollution controls in use, and process costs should be included.

When describing the pollution prevention option, comparatively discuss how the new process differs from the current process, emphasizing the key process areas changed, the waste stream(s) reduced or eliminated, and the annual costs incurred. If new equipment will be required, indicate the type and number of units needed, as well as the overall implementation cost.

Discussion of the benefits of the pollution prevention option should not be limited to the economic benefits of the option. If applicable, discuss the benefits of reducing or eliminating a waste stream; reducing, eliminating, or substituting hazardous raw materials by using less hazardous items; reducing maintenance time and costs; improving employee and community relations; and reducing or eliminating health and safety requirements.

Additional information to be considered for inclusion on the form includes a written explanation of assumptions or special circumstances used to determine implementation costs, annual process costs, and the index of annual cost avoidance. Calculations and other methods for determining the index of annual cost avoidance and the implementation cost should also be included.

WORKSHEET 1

INDEX OF ANNUAL COST AVOIDANCE

Category	Index of Annual Cost for the Current Process ($)	Index of Annual Cost for the New Process ($)
1A. ANNUAL RAW MATERIAL PURCHASING COSTS		
Subtotal (1A)		
1B. ANNUAL PROCESS OPERATION COSTS		
1. Annual Utility Costs		
2. Annual Process Operations Labor Costs		
3. Annual Process Equipment Maintenance Costs		
Subtotal (1B)		
1C. ANNUAL PPE AND RELATED HEALTH/SAFETY SUPPLY COSTS		
Subtotal (1C)		

Quick Reference Instructions for Completing Worksheet 1

Category 1A: Annual Raw Material Purchasing Costs

- Use the formula: Annual material cost = (material unit cost) × (units used annually).
- Units for materials may be expressed in pounds, gallon, quart, pint, cubic foot, or other unit of measure.
- Total all raw material purchasing costs for the current process and the new process and enter the total in Subtotal 1A.

Category 1B: Annual Process Operations Costs

- Category 1B.1: Utility Costs

  –Use the formula: Annual utility costs = (utility units used annually) × (standard utility unit cost)
  –Use standard utility unit costs.
  –Calculate and enter appropriate annual utility costs for the current process and the new process.

- Category 1B.2: Annual Process Operation Labor Costs

  - Use the formula: Annual process operation labor cost = (number of employees involved with process) × (number of hours process will operate annually) × ($/labor hour).
  - Use standard labor rate for hourly, weekly, and monthly employees.

- Category 1B.3: Annual Process Equipment Maintenance Costs

  - Parts:
  - Determine parts/supplies needed for equipment maintenance.
  - Calculate the annual cost for each part or supply item by using the formula:

Annual part/supply cost = (unit cost) × (number of units needed annually)

  - Add all annual part/supply item costs calculated.
  - Labor:
  - Use same method outlined in Category 1B.2. Modify the method to base cost on equipment maintenance rather than on process operations.
  - Add the parts/supply cost and labor cost to get the process equipment maintenance cost.

- Add annual utility, process operation labor, and equipment maintenance costs for the current process and for the new process and enter the cost values in their respective column in Subtotal (1B).

Category 1C: Annual PPE and Related Health/Safety Supply Costs

- Determine the types of PPE and health/safety supplies needed for the process.
- Determine the annual cost for each type of PPE and supply item by using the following formula:

Annual PPE/supply item cost = (unit cost) × (number of units needed annually)

- Add all PPE/supply item costs for the current process and for the new process and enter the cost values in their respective columns in Subtotal (1C).

WORKSHEET 1

INDEX OF ANNUAL COST AVOIDANCE (continued)

Category	Index of Annual Cost for the Current Process ($)	Index of Annual Cost for the New Process ($)
1D. ANNUAL WASTE MANAGEMENT COSTS		
1. Container Costs		
2. Disposal/Treatment/Storage Costs		
3. Storage Site Inspection/ Maintenance Costs		
Subtotal (1D)		
1E. ANNUAL RECYCLING COSTS		
1. Source Separation, Collection, and Material Preparation Costs		
a. Material and Supply Costs		
b. Operations/Maintenance Labor Costs		
2. Vendor Cost for Recycling		
Subtotal (1E)		
1F. TOTAL INDEX OF ANNUAL COST (1A+1B+1C+1D+1E)		
1G. Index of Annual Cost Avoidance (Total index of annual cost for current process - total index of annual cost for new process)		

Quick Reference Instructions for Completing Worksheet 1 (continued)

<u>Category 1D: Annual Waste Management Costs</u>

- Category 1D.1: Annual Waste Container Costs
  - Use the formula: Annual container cost = (unit cost of container) × (number of containers required)
  - Use standard waste container costs.

- Category 1D.2: Annual Treatment/Storage/Disposal (TSD) Costs
  - Determine the waste stream(s) generated for the current process and for the new process.
  - For each waste stream, determine the annual TSD costs using the formula: Annual waste stream TSD Cost = (annual quantity generated) × (standard cost for waste stream TSD).
  - Use standard waste stream TSD costs.

- Category 1D.3: Annual Storage Site Inspection/Maintenance Costs
  - Costs are primarily associated with labor needed to inspect storage containers and maintain safe storage conditions.
  - Initially assume 2 to 4 hours/week to inspect and maintain waste storage site. Select different time periods needed based on the condition, size, and location of the site.
  - Use standard labor costs to calculate.

<u>Category 1E: Annual Recycling Costs</u>

- Category 1E.1a: Annual Material and Supply Costs
  - Use the same method as provided for Category 1B.3 for calculating material, parts, and supply costs.

- Category 1E.1b: Annual Operations and Maintenance Labor Costs
  - Use the same method and formula as presented in Category 1B.2. Include both equipment operation and maintenance.

- Category 1E.2: Annual Vendor Cost for Recycling
  - Use the formula: Annual material recycling cost = (unit cost of material) × (number of units generated annually).
  - Contact the base Recycling Coordinator or recycling vendor to get unit cost for recyclable materials.
  - Enter a positive cost value if the facility pays for recycling, and a negative cost value if the facility is paid for recycling.

<u>Category 1F: Total Index of Annual Cost</u>

- Add subtotals for categories 1A, 1B, 1C, 1D, and 1E.
- Enter the total index of annual cost in the respective column for the current process and the new process.

<u>Category 1G: Index of Annual Cost Avoidance</u>

- Use the formula presented in the category block on the front side of this worksheet.
- A positive value indicates that costs will be avoided with the pollution prevention option.
- A negative value indicates that costs will not be avoided with the pollution prevention option.

WORKSHEET 2

ONE-TIME IMPLEMENTATION COST

Category	Cost ($)
2A. New Equipment Purchases	
Item 1.	
Item 2.	
Item 3.	
Subtotal (2A)	
2B. Parts and Labor for Equipment Installation	
Item 1.	
Item 2.	
Item 3.	
Subtotal (2B)	
2C. Procedure Development	
Subtotal (2C)	
2D. Training	
1. Materials/Contracted Services	
2. Labor	
Subtotal (2D)	
2E. Total Implementation Cost (2A + 2B + 2C + 2D)	

Quick Reference Instructions for Completing Worksheet 2

Category 2A: New Equipment Purchases

- Enter name and purchase cost for each piece of new equipment using quoted price from the vendor.
- If more than one piece of the same type of equipment is required, multiply the equipment cost by the number of pieces needed.
- Total all equipment purchase costs and enter the cost in Subtotal (2A).

Category 2B: Parts and Labor for Equipment Installation

- Add up cost of all parts needed for equipment installation.
- Determine the labor cost for installation using the formula: Equipment installation labor cost = (number of employees involved) × (number of hours required) × ($/hour labor rate)
- Add parts cost and labor cost and enter cost value in Subtotal (2B).
- If vendor will install equipment, enter vendor cost in this category.

Category 2C: Procedure Development

- Assume 40 hours to complete each procedure.
- For each procedure multiply by the appropriate labor rate for the individual developing the procedure. Use standard labor rates.
- Add the costs for all process, health, safety, and waste management procedures requiring development.
- Enter the cost value in Subtotal (2C).

Category 2D: Training

- Enter the cost of training materials in Category 2D.1.
- Enter the labor cost for training employees on the new procedures developed.
- To determine the labor cost, use the same method and formula as that presented in Category 2B.
- Add material and labor costs and enter cost value in Subtotal (2D).

Category 2E: Total Implementation Cost

- Calculate the cost by adding the subtotals. Use the formula: Total implementation cost = Subtotal A + Subtotal B + Subtotal C + Subtotal D.

WORKSHEET 3

INDEX OF ANNUAL COST AVOIDANCE SUMMARY

Category	Index of Annual Cost Avoidance ($)
3A. Annual Raw Material Purchasing Costs from Worksheet 1 (Subtotal 1A of current process − Subtotal 1A of new process)	
3B. Annual Process Operation Costs from Worksheet 1 (Subtotal 1B of current process − Subtotal 1B of new process)	
3C. Annual PPE and Related Health/Safety Supply Costs from Worksheet 1 (Subtotal 1C of current process − Subtotal 1C of new process)	
3D. Annual Waste Management Costs from Worksheet 1 (Subtotal 1D of current process − Subtotal 1D of new process)	
3E. Annual Recycling Costs from Worksheet 1 (Subtotal 1E of current process − Subtotal 1E of new process)	
3F. Total Index of Annual Cost Avoidance (3A + 3B + 3C + 3D + 3E)	
3G. One-Time Implementation Cost (Worksheet 2)	
3H. Estimated Payback Period (3G ÷ 3F)	years

SESSION XXIII

POLLUTION PREVENTION INITIATIVES

Session Chairpersons:

Joe Saenz, Stone & Webster
Captain Paul Churchill, AFIT/CEV

DEPARTMENT OF ENERGY/UNITED STATES AIR FORCE MEMORANDUM OF UNDERSTANDING PROGRAM

Steven N. Brown
DOE/USAF Program Coordination Office
Human Systems Center/Environmental Planning
3012 Meder Dr., Bldg 437
Brooks AFB, Texas 78235-5139
(210)536-5468

Rebecca A. Winston
Idaho National Engineering Laboratory
EG&G Idaho, Inc.
2525 Fremont Ave.
Idaho Falls, Idaho 83415-3710
(208)526-1165

ABSTRACT

The Department of Energy (DOE)/United States Air Force (USAF) Memorandum of Understanding (MOU) program was formed as a result of the DOE and USAF combining forces to reduce or eliminate hazardous waste generation in areas common to both agencies. The projects and activities comprising the DOE/USAF MOU program support the pollution prevention and waste minimization objectives of the DOE and USAF complexes. The MOU program is hosted at the DOE Idaho National Engineering Laboratory (INEL), but involves participants from other DOE laboratories, the Department of Defense (DoD), private industry, and universities.

I. INTRODUCTION

To some degree pollution prevention and waste minimization needs of federal agencies are similar in nature. The MOU program exists for the purpose of utilizing the combined resources of the DOE and USAF to facilitate technology solutions in the area of waste minimization, pollution prevention, and recycle (see Figure 1). The USAF Armstrong Laboratory Environics Directorate (AL/EQ), formerly a part of the Air Force Civil Engineering Support Agency (AFCESA), located at Tyndall AFB, Florida, has been a major contributor in the USAF regarding cleanup efforts directed towards toxic and hazardous chemicals. Initially, the research and development efforts of the organization (circa. 1980) were focused on the remediation of such chemicals as dioxin (agent orange) and other toxic compounds prevalent at military facilities. As successes were found in developing new technologies for disposal and treatment of those chemicals, the AL/EQ began investigating other Air Force processes and activities that produce hazardous or toxic chemicals, primarily in depot maintenance and repair operations at the five USAF Air Logistics Centers (ALCs). Likewise, the DOE continues to develop new and innovative technologies to deal with hazardous, toxic, and radioactive wastes from defense, nuclear, and other energy related programs.

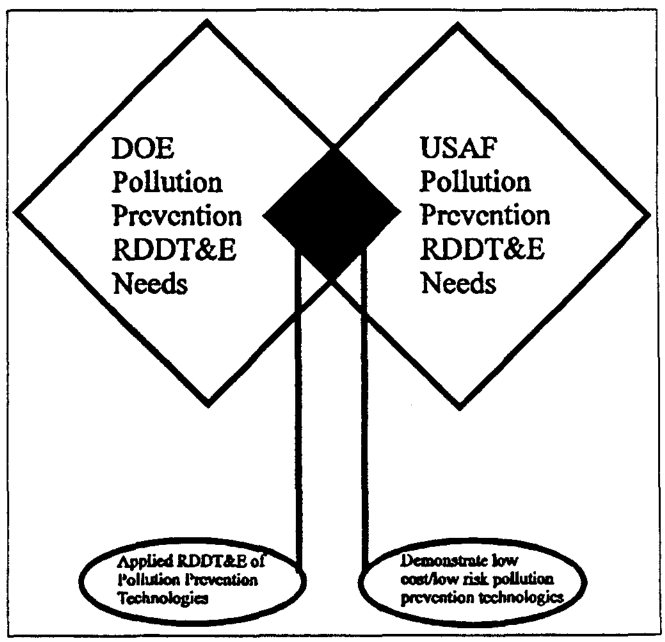


Figure 1. Common interests of DOE/USAF MOU program

Beginning around 1980, the then AFCESA, and the DOE began to collaborate on the development of several technologies that were beneficial to both organizations. It quickly became apparent that such collaboration was both fiscally and developmentally advantageous, saving time and money by minimizing duplication of effort, accelerating technology development schedules, and maximizing resource utilization. Initial treatment activities targeted electroplating, metals finishing, and paint stripping processes, as well as the widespread application of various chlorinated solvents used in industrial processes. The patented "Sodium Sulfide/Ferrous Sulfate Treatment Process" was developed by INEL scientists on a USAF sponsored program. It is estimated that this process alone will save the U.S. Government millions of dollars in waste treatment and disposal costs over the next decade. With this and other successful new technologies emerging from the relationship, the DOE Office of Technology Development (DOE-OTD) and the (then) AFCESA signed an "MOU" in 1990 to formally recognize the benefit from continued cooperative and mutually beneficial activities of the two agencies. Since then, an updated MOU has been signed between the DOE-OTD and the USAF Human Systems Center located at Brooks AFB, Texas.

The most recent phase of the program focuses on the development and deployment of pollution prevention, waste minimization, and recycle technologies that change materials or processes such that hazardous wastes are minimized or eliminated.

II. MISSION

The primary mission of the MOU program is to utilize, to the maximum extent possible, the combined resources of the DOE and USAF to facilitate technology solutions in the areas of waste minimization, pollution prevention, and recycle. As stated in the MOU, "This MOU is intended to facilitate cooperative efforts for mutual provision of research, development, and demonstration (RD&D) and technical assistance by both agencies in the conduct of programs affecting civil and environmental engineering, for example, improving the quality of the environment through waste cleanup and waste minimization."

The MOU, as stated previously, contains a secondary mission in the area of waste cleanup. However, technology development for environmental restoration is covered by a large multi-agency effort already. The MOU program does not presently fund technology development or solutions in cleanup unless, 1) the need exists within both agencies, and 2) a more appropriate program or organization within either agency cannot be found.

III. DRIVERS

The pertinent regulatory drivers for the MOU program are 1) the Resource Conservation and Recovery Act (RCRA) for solvents, heavy metals, corrosives and other hazardous and toxic wastes; 2) the Clean Air Act (CAA) for priority pollutants and other air toxics; 3) the Clean Water Act (CWA) for industrial rinse water; and as a strong political driver, 4) the Montreal Protocol for the reduction and eventual elimination of ozone depleting chemicals (ODCs). In addition, the MOU program has four agency drivers. They are as follows:

A. Waste Minimization Crosscut Plan

In Fiscal Year (FY) 1992, Secretary of Energy Watkins announced the waste minimization crosscut initiative. Led by the Office of Technical Support, Pollution Prevention Division, the initiative is aimed toward creating a DOE culture change that embraces the philosophy of conserving resources and minimizing waste. The initiative promotes environmental compliance, reduced waste management costs, and environmental impacts for DOE operations by identifying, developing, implementing, and reporting on waste minimization options. The initiative not only applies to the environmental restoration and waste management (ER&WM) organizations, but to all of the Program Secretarial Offices (PSOs), including Fossil Energy, Conservation and Renewable Energy, Nuclear Energy, etc.

B. USAF Zero Discharge Goal

The USAF has taken an aggressive approach to the hazardous waste problem by setting a goal of eliminating the discharge of hazardous waste from base boundaries by the year 2000.

C. Weapons Complex Waste Minimization

The DOE has embarked on a thirty-year environmental restoration and waste management cleanup for the nuclear weapons complex. That mission will entail numerous and varied waste treatment and environmental restoration processes and technology, many of which will produce secondary waste streams. During the course of that mission, DOE Environmental Management (EM) will be implementing their strategy for minimizing the generation of hazardous and toxic wastes while accomplishing their goals.

IV. LEVERAGING THE INVESTMENT

Government budgets are shrinking; even those budgets associated with research, development and demonstration of environmental restoration and waste management technologies. Any investment made by an agency of the government must build upon and complement the similar investments of other agencies. Duplicative investment among agencies must be eliminated, and, like any well-run product-oriented business, investments must show a reasonable return to investors, in this instance the U.S. taxpayer. Collaborative opportunities must be exploited among government agencies to their maximum extent. Any pollution prevention/waste minimization activity must be consistent with senior level government goals, and must be in full coordination with technology users at DOE sites and USAF installations.

V. TECHNOLOGY DEVELOPMENT NEEDS

Identifying the needs of the two agencies for pollution prevention and waste minimization technology development, and addressing those needs through a prioritized investment program has been, and continues to be, an evolutionary process. From early 1990 through late 1993, the needs of the two agencies were addressed by investment in projects possessing mutually identified benefit. In late 1993, an effort was completed to strategically focus the program and merge the technology development needs/opportunities of the two agencies into one source. A technology needs matrix (TNM) was developed which contains the individual pollution prevention/waste minimization technology development needs of each agency, with the intersection of the lists becoming the focal point from which the MOU program will be driven.

VI. STATUS OF PROJECTS

Currently, there are six projects funded under the MOU program. Five of these projects are technology based, while the last is a program support function which provides the structure to execute the formal program. A summary description will be provided for each.

A. Waste Acid Detoxification and Recovery (WADR)

Large quantities of metal-bearing spent acids are produced by electroplating, surface finishing, and chemical milling/dissolution operations common to DOE and USAF manufacturing and chemical processes. In addition, spent acids are widespread throughout U.S. private industry with over 15,000 companies generating over 8 billion gallons of metal-bearing spent acids each year. The WADR process, which received a Research and Development (R&D) 100 award for Battelle Pacific Northwest Laboratory in 1991, is based on specialized distillation methods that separate reusable acids in conjunction with selective precipitation techniques that concentrate and remove heavy metals. Components of the WADR process are constructed of corrosion resistant fluoropolymers. The design and materials used in the process allow the system to handle a wide and varied range of chemicals, from strong mineral acids to common organics.

Fiscal year 1993 scope included designing and fabricating a prototype WADR unit, that in the future would be demonstrated at a suitable USAF facility. An industrial defense and space production facility will host shakedown testing of the prototype on one of their production lines in fiscal year 1994. In conclusion, the final project effort will involve an on-site demonstration of the WADR system at a USAF Air Logistics Center (ALC).

B. Chemi-Microbial Processing of Waste Tire Rubber

A novel approach to diminish the enormous stockpiles of waste tires existing in this country is being developed at the DOE Pacific Northwest Laboratory. The objective of this research is to develop a process to biodesulfurize (devulcanize) the surface of ground rubber particles using thiophilic microorganism. The resulting materials will have improved compounding characteristics and will be better suited for incorporation into virgin tire rubber compounds. Development activities have evolved from a review of the literature involving biodegradation and biodesulfurization studies of polymers, coals, mining effluent, and crude oils.

The ultimate objective is to develop a bioprocess for recycling waste tires which is demonstratable at a full scale retreading or production facility. The process will introduce chemical reactivity to the surface of the ground rubber particles, thereby improving the chemical bonding and adhesion of the ground tire rubber into the virgin tire rubber matrix during compounding. The resulting product should have the same (or improved) level of quality as products manufactured with all virgin materials. As stated previously, the microbial process approach is targeted at alleviating the enormous problem of waste tire disposal in an environmentally sound manner by providing new and additional markets for the once classified waste tire rubber materials.

C. Spray Casting

The spray casting technology is a joint effort between the DOE-Office of Technology Development (OTD) and the USAF Armstrong Laboratory. The system utilizes a pressure controlled atomization process (PCAP) to spray liquid metal on a substrate as a coating, or into a mold for near net shape forming applications. The USAF effort is directed at the replacement of chromium electroplating as a repair/refurbishment technique on aviation parts. Chromium plating processes will be replaced by a thermally sprayed coating of equal or superior mechanical and physical properties. The DOE-OTD work supports pollution prevention and waste minimization in the fabrication of special nuclear materials. This portion of the project involves spray forming various DOE components to near net shapes. Spray forming would greatly reduce the amount of waste generated during the fabrication of components compared to existing techniques.

Fiscal year 1994 work scope for the DOE portion includes engineering evaluation of the sprayed deposit characteristics of high density and reactive materials, the fabrication of a near net shape component, and spraying of coatings for corrosion protection. Key hardware elements integrated into the spray casting system include a six axis robotic arm, automatic pressure control system, gas heater, two piece nozzle, and liquid metal feed system.

D. Real-time, Online Quantitative Monitor of Surface Cleanliness

In an effort to provide objective measures for determining acceptable surface cleanliness, Sandia National Laboratory is developing a real-time monitor using quartz crystal microbalance (QCM) technology. The development of this real-time cleaning monitor is especially useful at this time due to the large number of industries making significant changes in cleaning processes to meet current environment regulations. The key regulation impacting cleaning processes at this time is the Clean Air Act (CAA). In addition, the internationally recognized Montreal Protocol outlines aggressive measures to reduce and eliminate the use of ozone depleting chemicals. This monitor would find immediate use in studies to evaluate environmentally conscious cleaning solvents and processes. For both alternative and current cleaning processes, the real-time nature of the monitor could be used to effectively evaluate cleaning times required to assure proper cleaning. Any reduction in cleaning time translates directly into decreases in manufacturing costs, solvent usage, emissions, and waste generation. For critical components, the cleaning of each component could be effectively evaluated using a monitor that has been exposed to contamination along with the component. This would lead to improved quality and reliability while achieving waste minimization and pollution prevention.

Another DOE application which may have a larger potential due to current program needs involves decontamination and decommissioning (D&D) activities. Many of the D&D activities involve removing a toxic contaminant from a surface, often involving a liquid cleaning process. Since the key contaminants are typically know, the QCM cleaning monitor could be used to research and optimize cleaning processes for decontamination of equipment and facilities. The ability to work in gas or liquid environments would enable various decontamination processes to be used with the same basic probe. Since D&D activities are often costly, difficult to implement with personnel in protective clothing, and can generate significant amounts of secondary waste, techniques for optimizing cleaning processes and for in field evaluation of cleaning protocols could have a significant impact to reduce costs and enhance worker safety.

E. Contaminant Removal from Solid Waste by Supercritical CO_2

The DOE and USAF manufacturing, repair, and refurbishment complexes generate large quantities of solid wastes such as rags, wipes, swabs, coveralls, gloves, etc., that are contaminated with various oils, greases, and hazardous solvents. At present, most of these materials must be treated as hazardous waste, where the cost of disposal for large volumes is high. In calendar year 1992, for example, one DOE site alone was forced to spent $351,000 to dispose of solid waste contaminated with oils, greases, and solvents. The disposal of the same solid waste material as sanitary waste would have cost less than $3,000 for the entire year. If the hazardous components (oils, greases, and solvents) could be segregated from the much larger bulk of non-hazardous material, then these solid materials could be handled as sanitary waste at a significant cost savings.

Therefore, the objective of this joint effort between the DOE AlliedSignal Kansas City Plant and Sandia National Laboratory is to demonstrate the feasibility of using supercritical carbon dioxide (SC-CO_2) to segregate hazardous oils, greases, and organic solvents from non-hazardous solid waste such as rags, wipes, swabs, coveralls, gloves, etc. In the segregation process, the hazardous contaminant materials are dissolved and carried away from the non-hazardous solid waste by the supercritical carbon dioxide solvent and then "dropped out" in a separator upon pressure reduction. The scope of work focuses on: (1)the identification and removal of typical oils and greases from solid waste using supercritical carbon dioxide; (2)the identification and removal of typical organic solvents from solid waste using supercritical carbon dioxide; and (3)to develop and define the optimum conditions for the separation of the contaminants (oils, greases, solvents) from the supercritical carbon dioxide and to design an efficient separator to accomplish this, thus allowing the carbon dioxide to be recycled for further use.

The most compelling benefit that could be realized from the successful completion of this activity is the potentially enormous cost savings associated with the disposal of contaminated solid waste. Supercritical carbon dioxide as a segregating solvent is recyclable, nonflammable, nontoxic, and readily available at a very low cost. The process would contribute to waste minimization efforts both from the standpoint of the solid waste and the "cleaning" solvent. There would be no exposure of workers to hazardous materials other than those removed from the solid waste. Efforts to minimize the amount of hazardous waste requiring disposal are not only environmentally and socially conscious, but also minimize the "cradle-to-grave" liability associated with disposal. Not only is the waste minimized due to the segregation of the non-hazardous debris, but if the "debris" is recycled and reused a number of times before disposal, sanitary landfill waste will also be minimized.

F. DOE/USAF Interagency Program Support

The objective of the DOE/USAF Interagency Program Support project is to assist the DOE and USAF in the management, coordination, and integration of activities leading to successful technology needs identification, technology demonstration, transfer, and commercialization. The MOU Support project solves such problems as: the identification of joint DOE/USAF technology development needs and requirements; assisting industry and government in meeting Federal Ozone Depleting Chemical (ODC) phase-out requirements through solvent substitution information dissemination; coordination and integration of technology research, development, demonstration, test, and evaluation (RDDT&E) activities applicable to both agencies; technology information exchange; and program management.

The greatest benefit realized from the program support activity is the minimization of duplicative efforts through interagency information exchange, joint technology needs identification, and coordinated technology development strategic planning. Most of the coordination and information exchange activity occurs at the jointly sponsored DOE/USAF Program Coordination Office (PCO). The PCO, which was established in 1992 at the Armstrong Laboratory Environics Directorate, Tyndall AFB, plays a pivotal role in ensuring interagency collaboration, coordination, and information exchange. In fiscal year 1994, the PCO was transferred from Tyndall AFB, Florida, to Brooks AFB, Texas, to reside under the Air Force Human Systems Center (HSC). Results of this effort will ensure that the resources of the DOE and USAF will be utilized to the maximum extent possible, and will facilitate technology solutions aimed at eliminating or reducing waste through process modification and/or in-process recycling.

POLLUTION PREVENTION OPPORTUNITIES AT USCG AVIATION FACILITIES

LCDR Michele Fitzpatrick, USCG
USCG Research and Development Center
1082 Shennecossett Road
Groton, CT 06340-6096
(203) 441-2859

ADC Richard A. Peri, USCG
COMMANDANT (G-EAE-37)
U. S. Coast Guard Headquarters
2100 Second Street, SW
Washington, DC 20593-0001
(310) 937-0200

I. ABSTRACT

A Pollution Prevention (a.k.a. P2 or Waste Minimization) Opportunity Assessment was conducted at the United States Coast Guard (USCG) Aviation Training Center (ATC) in Mobile, Alabama in November 1993. The assessment was conducted under the U.S. Environmental Protection Agency's (EPA's) Waste Reduction Evaluations at Federal Sites (WREAFS) Program following the procedures in EPA's Facility Pollution Prevention Guide. This was the first P2 Opportunity Assessment conducted by EPA at a corporate-size facility (i.e., detachment or small squadron-size unit) in the aerospace industry.

The assessment was conducted as part of the USCG's pollution prevention program with a focus on the development of P2 policy for the USCG aviation community. It was also intended to serve as a prototype to help USCG field units conduct self-assessments and identify USCG-wide P2 opportunities.

USCG personnel performed an initial screening based on ATC Mobile's waste generation and identified four processes for further study: aircraft maintenance; aircraft fuel management; aircraft cleaning; and flight simulator operation and maintenance. The contractor and government personnel who then performed the assessment discovered that the primary P2 opportunities that are normally found at larger aviation facilities did not present themselves at the ATC, and they had to look for secondary, less obvious opportunities.

The assessment team found that the ATC had made substantial P2 progress to date, and identified opportunities for further action for each of the four processes identified in the initial screening, as well as general opportunities covering all ATC activities. Opportunities identified fell into three major categories: P2 activities that are already in place and can be expanded; procedural initiatives that ATC can implement now without further study; and opportunities that require further research, development, testing and/or evaluation prior to implementation.

II. INTRODUCTION

The USCG, like the other military services and federal agencies, is committed to pollution prevention as a first priority solution to reducing solid and hazardous waste generation. Unlike its sister services, most of the USCG's 400+ operational and support units (including 27 air stations) are small quantity hazardous waste (HW) generators. The primary processes that generate HW in the USCG are routine maintenance and repair of vessels, aircraft, ground support equipment (GSE), buoys, and facilities. The USCG has been working closely with EPA's Risk Reduction Engineering Laboratory (RREL) to characterize our waste streams and opportunities for pollution prevention and waste minimization. We have found that there is very little P2 information targeting small facilities. Most of the EPA's Pollution Prevention Opportunity Assessments (PPOAs) have been performed at large quantity generators involved in production or other large-scale industrial processes.

The PPOA at ATC Mobile was the first PPOA conducted by the EPA at a small facility under the WREAFS Program. It included a pre-assessment to identify priority waste streams; the on-site assessment; identification of alternatives; and development of an implementation plan.

III. WASTE STREAM/PROCESS IDENTIFICATION

A. Pre-assessment. In order to identify processes for analysis, a pre-assessment was performed by a project team from the USCG Research and Development Center (R&DC) and USCG Headquarters in June 1993. Using waste data and observations of ATC processes and discussions with ATC personnel, the team identified four waste-generating processes to be evaluated in further detail: (1) aircraft maintenance; (2) aircraft fuel management; (3) aircraft cleaning; and (4) flight simulator operation and maintenance. ATC Mobile personnel then prepared an information sheet on the materials and wastes associated with these processes.

B. Assessment. In November 1993 the project team returned to ATC Mobile with an EPA RREL representative and four contract personnel to conduct a full assessment on the four identified processes, as well as management, policy and awareness issues. The assessment included discussions with the Hazardous Material Coördinator and Point Managers; observation of processes; discussions with process personnel; and collection of appropriate data. The waste-generating processes are described below.

1. Management/Policy/Awareness. Although not a specific process leading to a waste stream, the overall awareness concerning P2 can have an effect on the amount and type of waste generated.

2. Aircraft Maintenance. The aircraft maintenance shops are responsible for interior and exterior cleaning; and installation, repair and replacement of aircraft components, subassembly, and engines. The shops visited during the assessment included airframe, engine, paint and composite, metal, survival, battery, and avionics. Waste streams resulting from aircraft maintenance include aircraft fuel; used lubricants and hydraulic fluids; waste solvents; containers; used rags and absorbents; masking material and rags from painting; paint blasting media; discarded batteries; and unused materials that are too old, contaminated, or no longer needed.

3. Aircraft Fuel Management. The aircraft fuel used at the ATC at the time of the assessment was JP-4, which was stored in three 34,000 gallon vaulted tanks at the fuel farm. Fuel is received from tanker trucks and loaded into the fuel farm holding tanks. The aircraft refuelers are then filled at the fuel loading station. Most of the waste from fuel management results from fuel samples, fuel tank repairs, and spills during fuel transfer at the fuel farm. Also, waste fuel is generated as a result of daily preflight inspections.

4. Aircraft Washing. Aircraft must be washed after the last flight of the day as part of the corrosion prevention program. The waste generated is soapy washwater containing small amounts of dirt, oil and grease from the aircraft surfaces.

5. Flight Simulator Operations and Maintenance. ATC Mobile has three flight simulators which are used for training USCG pilots. The simulators are dynamic replicas of the HH-3F, HU25A, and HH-65A aircraft. Each simulator is equipped with a hydraulic six degree of freedom motion system. The primary waste streams generated by simulator operations and maintenance are from hydraulic fluid leaks and spill cleanup.

IV. Pollution Prevention Opportunity Identification.

The contractors used suggestions of USCG, U.S. Air Force, EPA, aerospace industry, and their own experience, to identify P2 alternatives for current waste-generating practices. The following sections give suggestions for implementing those alternatives at ATC Mobile and other USCG units that have similar waste-generating processes.

A. Current P2 Practices. The assessment team identified several ongoing practices that contribute to P2 and waste minimization.

1. ACMS/Authorized Chemical Use Lists. Routine maintenance is scheduled and tracked for each individual aircraft by an Aviation Computerized Maintenance System (ACMS). The ACMS provides a systematic mechanism to ensure each aircraft is receiving required maintenance on schedule and to identify trends in maintenance and repair needs across similar aircraft. It also

provides information on what materials should be used for each repair job. This feature was used to develop authorized chemical use lists for each airframe. These systems make a substantial contribution to pollution prevention.

2. Centralized distribution of painting materials and tailoring paint/equipment to job requirements. A system for centralized distribution of painting materials was initiated in 1991 using the paint storage facility in the paint mixing room. It has resulted in significant reduction in paint and solvent use. Current P2 efforts also include matching the volume of paint formulated with the job at hand and cleaning paint guns immediately after painting.

3. Auto battery exchange program. Automobile batteries from GSE vehicle maintenance are exchanged on a one-for-one basis when purchasing new batteries. This results in reduced cost for new batteries and waste disposal.

B. P2 Alternatives for Unit Level Implementation.

1. Management/Policy/Awareness. The P2 alternatives that are not process specific but that relate to overall facility management include: (1) formalize the unit P2 program and environmental policy statement; (2) institute a formal recognition program; (3) define and track measures of progress; and (4) formalize P2 awareness training.

2. Aircraft Maintenance.

a. Collection, segregation, and disposal of spent fuels, oils and hydraulic fluids. Waste fuel and spent lubricating oils and hydraulic fluids are stored in a single waste oil bowser and collected for off-site disposal by a waste management contractor. If these wastes were segregated they could be reused or recycled at a reduced cost. Waste jet fuel could be recovered for original use as jet fuel or recovered and blended with diesel fuel, resulting in less fuel consumption.

b. Alternate Aerosol Dispensing System. The ATC purchases several products in aerosol cans which are used in relatively large quantities. They should consider replacing the aerosol cans with compressed air or manual pump dispensers for lubricants and solvents to reduce container disposal and release of aerosol propellants (often hydrocarbons) to the atmosphere.

c. Centralized Material Management. It is recommended that ATC investigate the feasibility of a centralized hazardous materials management system for the airframe shops to reduce inventory, shelf-life losses, and duplicate products.

3. Aircraft Fuel Management.

a. Absorbent Reuse. Currently, absorbent pads used to recover fuel from spill cleanup are disposed wet, increasing disposal weight and volume of waste. A wringer is available but seldom used. It is recommended that absorbents be run through the wringer and reused, and that the fuel recovered in this process be recycled. This practice would result in reduced waste and cost of absorbents.

b. Spill prevention. Reduce potential for spills through regular training and routine inspection and maintenance of fuel transfer area, and construction of a containment barrier in the fuel farm transfer area.

4. Aircraft Washing. Implement use of pre-mixing unit (foamer), providing proper mixing, less soap use, and increased dwell time.

5. Flight Simulators.

a. Absorbent Pad Reuse. Absorbent pads used for hydraulic fluid cleanup could be sent through a wringer similar to the one used for fuel absorbent pads.

b. Contractor P2 Incentives. The flight simulators are maintained by contractors. The contract (currently being renewed) should include pollution prevention incentives, including the wringer mentioned above.

C. **Program Implementation.** These opportunities require engineering support program level/policy assistance for implementation.

1. Reuse of simulator hydraulic fluid on-site. Investigate the availability of a filtration system to return fluid to simulator.

2. Paint Application Alternatives. Develop instruction for greater use of high volume-low pressure paint application guns to reduce use of paint, cleaning solvents, and aerosol cans.

3. Replace ASM raft wipe cleaner. Task aviation life support equipment (ALSE) prime unit (ATC Mobile) with replacing ASM Raft toluene wipe cleaner with less toxic material (e.g., acetone or isopropyl alcohol).

4. Aircraft Battery Reclamation. Investigate aircraft battery reclamation agreements with each supplier.

D. **R&D Initiatives.** These long-term initiatives require the assistance of the USCG's R&D program.

1. Life-cycle analysis of alternative cleaning agents for parts washing. Define cleaning needs and assess cost and benefits of alternative approaches to small parts washing. This alternative is currently being studied by the USCG R&D Center.

2. Investigate alternatives to fuel sampling and analysis. The current industry practice for preflight fuel sampling is the "clear and bright" test, which uses a quart of fuel per aircraft per flight. An alternative to this method would reduce the amount of waste fuel, while maintaining flight safety.

V. SUMMARY.

The USCG's Pollution Prevention Program has conducted Pollution Prevention Opportunity Assessments at several USCG facilities, most of which are small quantity generators. An assessment at the Aviation Training Center in Mobile, Alabama revealed that the primary P2 opportunities normally found at larger aviation and industrial facilities were not available. Smaller, less obvious opportunities were identified for this size and type of facility.

SESSION XXIV

NEW TECHNOLOGIES/EPCRA

Session Chairpersons:
Lt Col. Rick Drawbaugh, HSC/XRE
Jerris Harris, HQ AFCEE/EP

Implementation of Executive Order 12856 at United States Marine Corps Installations

James Hsu
Dynamac Corporation
2275 Research Boulevard
Rockville, Maryland 20850
(301) 417-9800

Craig Sakai and Hank Eacho
United States Marine Corps
Headquarters, Marine Corps (Code: LFL)
2 Navy Annex
Washington, DC 20380
(703) 696-2138

Abstract
Executive Order (EO) 12856 mandates Federal compliance with provisions of the Emergency Planning and Community Right-to-Know Act (EPCRA) and the Pollution Prevention Act of 1990 (PPA). The United States Marine Corps (USMC), in an effort to comply with EO 12856, is conducting in-depth evaluations of installation activities involved in procurement, supply/logistics, hazardous material management, and toxic chemical releases. Findings from these evaluations have led to standard methodologies and valuable "lessons learned" in complying with EO 12856.

Introduction
On August 3, 1993, President Clinton signed EO 12856, which requires Federal agencies to comply with provisions of the Emergency Planning and Community Right-to-Know Act (EPCRA) and the Pollution Prevention Act (PPA). This EO establishes the following requirements:

- Develop agency-specific pollution prevention strategies that will reduce each agency's total releases of toxic chemicals by 50 percent by December 31, 1999, using a CY94 baseline (installations of Federal agencies must conduct pollution prevention opportunity assessments and develop plans that specify toxic chemical reductions);

- Submit to the public toxic chemical use and release information required under sections 302 through 313 of EPCRA; and

- Establish plans to minimize the acquisition and procurement of toxic chemicals and revise specifications and standards that require the use of these chemicals.

The purpose of these requirements is to encourage Federal agencies (and their installations) to become leaders in pollution prevention, to be accountable to the demands for implementing pollution prevention placed on the private sector, and to provide information to the public concerning the use and release of toxic chemicals.

Headquarters, Marine Corps has undertaken a number of initiatives to help installations comply with EO 12856 requirements. These initiatives focus on the support for EPCRA notification and reporting requirements and for pollution prevention opportunity assessments and plans.

EPCRA Notification and Reporting
Under EO 12856 Marine Corps installations must prepare the following EPCRA notifications and reports:

- *EPCRA Sections 302 and 303* — notification to state and local authorities that extremely hazardous substances are present on-site and that the facility will participate in emergency planning
- *EPCRA Section 304* — notification of a chemical release to emergency response authorities
- *EPCRA Section 311 and 312* — report to state and local authorities listing materials requiring material safety data sheets (MSDSs) and an annual inventory of these materials
- *EPCRA Section 313 (Toxic Release Inventory)* — annual report to the Environmental Protection Agency (EPA) and the state identifying toxic chemical releases to the environment and pollution prevention efforts. The types of information that must be submitted in the report include
  - Facility identification, including points of contact and certification of the report by a senior official
  - Names of toxic chemicals, their quantities, and the uses of these chemicals at the installations
  - Quantities of listed chemicals released to air, water, and land, and transferred to off-site facilities (e.g., publicly-owned treatment works and waste disposal contractors)
  - Identity of off-site facilities where wastes are sent
  - Types and efficiency of on-site waste treatment methods
  - Types and impact of on-site pollution prevention and recycling methods

Pollution Prevention Assessment and Planning
The preparation of pollution prevention opportunity assessments and plans involves a variety of functional activities at each USMC installation. These assessments focus on identifying opportunities to reduce pollution at the source (e.g., materials substitution, process or operational modifications, housekeeping improvements), and on analyses of the costs and effectiveness of these opportunities.

Compliance Issues
Previously, the EPA approach to EPCRA, including their terminology and compliance guidance, had been developed for the industrial manufacturing sector. EO 12856, written broadly, raises uncertainties in the application of EPCRA requirements to military-unique issues (e.g., munitions, aircraft, and tactical

vehicles). Additional difficulties arise from a lack of (1) military information systems that can decipher chemical inventories and usage that should be reported (e.g., tactical vehicle maintenance) from those that should be exempt (e.g., grounds maintenance); and (2) procedures and systems to collect, estimate, and validate the information required for the EPCRA reports.

Compliance Support Through Headquarters, Marine Corps

Headquarters, Marine Corps has developed initiatives to resolve the compliance issues presented above and to help Marine Corps installations meet EPCRA reporting deadlines and prepare pollution prevention opportunity assessments and plans. These initiatives also have the following purpose:

- Reduce the compliance burden on each installation
- Eliminate duplication of efforts among installations
- Help ensure that USMC efforts are consistent and coordinated
- Help ensure that ideas and lessons learned are communicated to all installations

These initiatives are presented as part of the compliance methodology discussion below.

Compliance Methodology

The following steps represent the Marine Corps EO 12856 compliance methodology. These steps may not necessarily occur in the sequence shown; some steps occur in parallel. These steps form a comprehensive, organized, and systematic approach to sustainable compliance with EO 12856.

Coordinate Interpretative Guidance with DoD. Headquarters, Marine Corps worked with the other Military Services and DoD to prepare interpretive guidance for EO 12856 and the EPCRA and PPA requirements. This guidance helps installations resolve many of the military-unique issues for EPCRA reporting. However, several issues, such as reporting of munitions, remain to be resolved.

Conduct Expeditionary Installation Visits. The purpose of these visits is to evaluate an installation's compliance with EPCRA and PPA requirements and examine the availability and quality of the data needed to meet EPCRA and PPA requirements if the installation needs to comply.

Develop a Hazardous Materials Database. Headquarters, Marine Corps developed a Hazardous Materials Database (HMDB) that identifies hazardous substances (including EPCRA toxic chemicals) in items procured and used by the military. (The HMDB has data on over 90,000 National Stock Numbers). The HMDB is used as a tool for EPCRA reporting threshold determinations, access to Material Safety Data Sheets (MSDSs), validation of chemical inventories, validation and estimation of toxic chemical releases and transfers, and identification of pollution-reducing material substitutes.

Collect Centralized Supply/Logistics Data. Headquarters, Marine Corps has developed computer routines to access each installation's materials procurement information maintained in centralized supply/logistics systems (e.g., systems standardized across the USMC for this purpose). This information is used as input to inventory and usage models to determine the quantity of materials (many of which contain hazardous substances covered under EPCRA) stored and used by the installation. The gathering of centralized supply/logistics information reduces each installation's data collection efforts.

Collect Local Procurement Data. Local procurements through credit cards, blanket purchase agreements, and requirements agreements are not tracked through centralized supply/logistics systems. Additionally, the policies and the prevalence of local procurements vary from installation to installation. Therefore, the Marine Corps is collecting information on these procurements to capture all hazardous substances that enter the installation in procured items.

Perform EPCRA Threshold Determination. The quantity of materials stored at an installation is used as input to the HMDB to determine the associated quantity of EPCRA-reportable hazardous substances. Headquarters, compares this quantity to EPCRA reporting thresholds (if the threshold is exceeded then EPCRA reporting is required) and provides each installation with pertinent information, such as the type and quantity of EPCRA-reportable hazardous substances, for the installation to verify.

Evaluate Existing Data on Environmental Releases and Transfers. If the installation exceeds the EPCRA section 313 (Toxic Release Inventory) thresholds, then existing information at the installation in the form of air emissions, waste disposal, wastewater discharge reports, and permits may show representative quantities of releases and transfers to the environment. This information helps to characterize each pollution-generating process. The objective of characterizing each process is to be able to determine the releases and transfers of toxic chemicals from information on raw materials used.

Perform Material Balance to Estimate Missing Data. A material balance, based on the principal that materials entering a process (e.g., raw materials) must equal materials exiting the process (e.g., air emissions, wastewaters), uses existing data to estimate missing data. Usually, raw material use, air emissions, and waste generation data are used to estimate missing data on toxic chemicals that exit the process through wastewaters.

Implement Data Management/Reporting System. For installations that have numerous chemicals that must be reported, the Marine Corps is evaluating and implementing computer-based systems that archive process data (e.g., quantity and chemical constituents of wastes disposed) and, based the characterization of pollution-generating processes, can estimate emissions based on raw materials usage. These systems also can be used for "what-if" analysis to estimate pollution reductions through process or operational modifications, improved housekeeping, or the use of material substitutes.

Assess Pollution Prevention Opportunities. These assessments focus on source reduction opportunities for processes that release or transfer toxic chemicals into the environment and evaluate the technical, environmental (multi-media), and economic feasibility of each opportunity. The technical feasibility evaluation must establish that the opportunity maintains or improves system performance. The economic feasibility evaluation must compare the total cost of each opportunity (e.g., direct, indirect, liability, and intangible costs) to the existing process and to other identified opportunities.

Prepare Pollution Prevention Plans. Each Marine Corps installation will prepare a pollution prevention plan that documents the following:

- The installation's strategy for achieving the pollution prevention goal of reducing toxic chemical releases and transfers by 50 percent by the end of 1999
- Pollution prevention program structure, organization, and responsibilities
- Pollution prevention opportunity selection criteria and prioritizing schemes
- A summary of pollution prevention opportunities (from the assessment)
- Methods for measuring, tracking, and reporting pollution prevention progress

Develop Standard Operating Procedures to Ensure Compliance. Headquarters, Marine Corps is developing standard operating procedures (SOPs) to standardize procedures for EPCRA reporting and pollution prevention opportunity assessments. These SOPs provide step-by-step guidance on compliance with EO 12856 requirements and maximize the continuity of compliance efforts even with the routine reassignment of responsible military personnel (e.g., these SOPs will assist new personnel in preparing reports using previous reports as a foundation).

Lessons Learned

In implementing the above methodology, the Marine Corps has gained some valuable experience. These "lessons learned" enhance the efficiency and effectiveness of the USMC compliance efforts by reducing the burden on installation resources and improving data accuracy. The following paragraphs summarize these lessons.

Define Compliance Problem. Compliance with EO 12856 requirements may overwhelm installation resources. Therefore, a compliance evaluation can determine what has and has not been done and can establish a "roadmap" that prioritizes compliance efforts in a form that is manageable for installation resources.

Establish Compliance Criteria. For each reporting or planning requirement, installations should determine the management, personnel, data, and systems resources needed. This determination provides information on the adequacy of resources. In case of inadequate resources, the installation may find alternative resources (e.g., expertise within tenant activities) or request additional support from Headquarters, Marine Corps.

Use Centralized Supply/Logistics Data. Since all installations must perform threshold determinations (even though not all installations will exceed the reporting thresholds), Headquarters is using centralized data in preparing threshold determination reports for installations to verify. This approach significantly reduces the burden on the installations.

Evaluate Releases and Transfers on the Process Level. Releases and transfers should be characterized at the process-level because, if data are missing, material balances usually are performed at the process level. Additionally, pollution prevention opportunities usually pertain to a specific process; therefore, determination of reductions in environmental releases and transfers gained through taking these opportunities also must occur at the process level.

Collect Needed Data as Part of Routine Operations. Experience shows that collecting data on material inventories and uses through data requests to pertinent functional activities may take as long as five months. The reason for the long turnaround is that these activities are unwilling to "stop the train" to collect the requested data. The burden for collecting the data is greatly diminished if the collection becomes part of the routine operations.

Collect Data to Reflect Variability in Procurement/Usage. Data need to be collected for some processes only at the end of the year because these processes do not vary in the type and quantity of materials used in releases and transfers generated. However, if the process varies, then the frequency of data collection should match the variations. Otherwise, the data on materials usage and environmental releases and transfers may not be representative of the actual process.

Solicit Cooperation from All Affected Functional Elements. The extensive data collection effort associated with EO 12856 requires that all affected functional elements share the burden of data collection. Also, the affected functional elements must participate in the pollution prevention opportunity assessments and planning in order to achieve successful implementation of the pollution prevention opportunity.

Establish an Approach that Maximizes Continuity. An approach that transfers "lessons learned" is needed to prevent "reinventing the wheel" because of the routine reassignment of installation personnel. The purpose of the SOPs developed by the Marine Corps is to provide step-by-step guidance and "lessons learned" for compliance with EO 12856.

Conclusions

Compliance with EO 12856 is technically complex and resource intensive. A comprehensive method is needed to systematically 1) evaluate current compliance with each of the EPCRA and PPA requirements; 2) determine management, personnel, data, and systems resources needed to comply; and 3) develop standard procedures to collect and assess data and prepare the reports required by EO 12856. These procedures must focus on reducing the data collection, assessment, and reporting burden at the installation; involve all functional elements as part of data collection; and incorporate compliance efforts as part of routine installation activity.

Tools for Federal Facilities: EPA Guide for Developing Executive Order 12856 Pollution Prevention Strategies

by James R. Edward
Director, Planning, Prevention and Compliance Staff
Federal Facilities Enforcement Office, U.S. EPA
Washington, D.C.

- **Overview:**

Preventing pollution is one of the federal government's top environmental priorities. The new emphasis on pollution prevention has been spurred by the magnitude and seriousness of the environmental risks that remain in the 1990s, the limitations of end-of-pipe pollution controls, and our growing understanding of the complexity of ecological systems.

As President Clinton noted on August 3, 1993, upon signing Executive Order 12856 "Federal Compliance with Right-To-Know laws and Pollution Prevention Requirements":

> "...federal facilities will set the example for the rest of the country and become the leader in applying pollution prevention to daily operations, purchasing decisions and policies. In the process, federal facilities will reduce toxic emissions, which helps avoid cleanup costs and promotes clean technologies."

The federal government plays a crucial role in shaping the direction of environmental action through its multitude of policies and programs. Ultimately it has a major influence on the environmental choices and actions taken daily by people throughout society. Incorporating pollution prevention into the federal government's decision-making processes is a key challenge in addressing the environmental agenda of the 1990s and beyond.

Pollution prevention offers a cost-effective means of meeting environmental objectives in an era in which federal facilities are subject to stricter levels of regulation, greater public scrutiny of their environmental records, and tighter budgetary constraints. Indeed, the costs of failing to prevent pollution in the federal sector have become dramatically evident; in some cases, cleanup costs are estimated in the hundreds of billions of dollars. Pollution prevention is a strategy that meets the needs of the present while laying the groundwork for a cleaner future.

The federal government's role in promoting pollution prevention is significant. Federal agencies play a crucial role in shaping the direction and focus of our nation's policies and programs. Ultimately the government can have a major influence on the day-to-day choices and actions undertaken by businesses and households. Federal participation is key to changing the central premise of environmental protection from treatment and disposal to pollution prevention.

To help the government achieve this goal; EPA issued a guidance document in early 1994 to assist Federal agencies in complying with the requirements of Executive Order 12856 entitled "Pollution Prevention in the Federal Government: Guide for Developing Pollution Prevention Strategies for Executive Order 12856 and Beyond." (EPA-300B-94-007).

This document is intended to serve as a guide for the development of pollution prevention strategies by each agency in the federal government, in the context of Executive Order 12856 and several other executive orders that were signed by the President over the last eighteen months. These new executive orders place federal agencies in a visible and active position in several ways. They require the government to set prevention-related goals for acquisitions, emission reductions, and solid waste prevention and recycling. They establish timetables for achieving the goals and an intergovernmental structure to promote implementation. Finally, they bring the federal government under the rubric of the environmental "right-to-know" provisions that have placed the United States at the forefront of environmental progress worldwide.

o **Purpose of the Guide:**

The EPA Strategy Guide sets forth a framework to guide the development of pollution prevention strategies by each agency in the federal government. It explains the context of legislation, policy, and federal activity in the pollution prevention area, outlines goals and objectives, and summarizes programs, tools, requirements, and resources that comprise the building blocks for federal action in pollution prevention. Central to such action is the implementation of Executive Order 12856 and the other environmental executive orders signed by the President in 1993 and 1994. Armed with a clear sense of direction and specific goals to be achieved, federal agencies can assume a leadership role in promoting pollution prevention and in serving as a model for effective environmental action.

Executive Order 12856 requires federal agencies to develop written pollution prevention strategies by August 1994. Each federal agency strategy must include a pollution prevention policy statement incorporating source reduction in facility management and acquisition programs; outline plans for compliance with the requirements of the executive order; and designate an individual responsible for coordinating pollution prevention efforts. This guide is intended to assist Federal agencies in developing these required strategies.

The new executive orders place federal agencies in a visible and active position in several ways. They require the government to set prevention-related goals - for acquisition, emission reductions, and solid waste prevention and recycling. They establish a timetable for achieving the goals and an intergovernmental structure to promote implementation. Finally, they bring the federal government under the rubric of the environmental "right-to-know" provisions that have placed the United States at the forefront of environmental progress worldwide. This document is built around the executive orders and illustrates how they form the foundation of pollution prevention in the federal government.

The provisions of the executive orders, while ambitious in themselves, should not be taken as the sum total of federal agency action in the pollution prevention field. EPA encourages federal agencies to think broadly about their missions and activities and to find innovative ways to prevent pollution, both in their own activities and in the multiple interactive effects their activities have on other segments of society.

- **Goals and Objectives**

Pollution prevention must become a part of the environmental ethic at every level of the federal government. Government personnel should build environmental considerations into their daily decision-making processes, programs, and policies, in much the same way that economics has become a fundamental and integral component of all government planning and decision models. As prevention becomes more widely understood and implemented, it will be advocated not only for its environmental benefits but also for its economic benefits.

In its Strategy Guide, EPA sets forth the following goals and objectives for the Federal sector that embodies this vision:

Goal: To establish the federal government as the national leader in implementing pollution prevention policies and practices across all missions, activities and functions in order to promote the sustainable use of natural resources and protect the environment and human health.

The federal government has an enormous potential to promote pollution prevention. The strategy guide lays out four primary roles in which the government can make a significant impact:

1. **The government as policy maker and regulator.** Through policies, education, technical assistance, regulations, incentives, and enforcement, the federal government can exert a significant influence on environmental activities, and motivate change across all sectors of society (e.g., industry, agriculture, energy, transportation, consumers, etc.).

   Objective: To ensure that all programs, policies and regulations of federal agencies incorporate pollution prevention concepts and approaches; and to provide appropriate incentives for the private sector to undertake such practices.

2. **The government as a consumer and purchaser of goods and services.** The U.S. Government is the nation's single largest consumer of goods and services. Procurement by the Department of Defense alone account for 2 to 3 percent of total GNP.

   Objective: To implement affirmative environmental acquisition programs and life-cycle costing practices throughout the federal government in order to prevent pollution, reduce waste, reduce impacts on natural resources, and create markets for environmentally preferable products and technologies.

3. **The government as a generator of pollution and a manager of facilities.**
According to the General Services Administration (GSA), there are over 350,000 federal buildings, approximately 27,000 installations on more than 700 million acres of public land. The number of federal facilities of potential environmental concern is enormous. Environmental cleanup of 24,000 contaminated sites on federal facilities in the U.S. may cost between $100 and $400 billion, and will extend well into the next century.

Objective: To significantly reduce the quantity and toxicity of pollutants released and wastes generated by federal facilities and on public lands and to make pollution prevention the approach of first choice in all environmental management decisions.

4. **The government as an advocate for technology through research and development and technology transfer.**

Through policies and programs that support research and development and technology transfer, the federal government can promote pollution prevention across all sectors of society. By harnessing the capabilities of the federal laboratories, the government can work with industry to accelerate the flow of pollution prevention technologies to the national and international marketplace.

Objective: To develop technical solutions and foster technology transfer among federal agencies and between the public and private sectors with the aim of addressing pollution prevention needs and enhancing United States competitiveness in markets for goods and services that are environmentally preferable.

Each of these objectives is discussed in a separate chapter in the strategy guides.

o Defining Pollution Prevention

Under Executive Order 12856, pollution prevention means "source reduction," as that is defined in the Pollution

Prevention Act of 1990, as well as other practices that reduce or eliminate the creation of pollutants through:

> increased efficiency in the use of raw materials, energy, water, or other resources, or
>
> protection of natural resources by conservation.

The Pollution Prevention Act (Section 6603) defines "source reduction" to mean any practice that:

> Reduces the amount of any hazardous substance, pollutant or contaminant entering any waste stream or otherwise released into the environment (including fugitive emissions) prior to recycling, treatment, or disposal; and
>
> Reduces the hazards to public health and the environment associated with the release of such substances, pollutants or contaminants.

The term includes: equipment or technology modifications, process or procedure modifications, reformulation or redesign of products, substitution of raw materials, and improvements in housekeeping, maintenance, training, or inventory control.

Under the Pollution Prevention Act, recycling, energy recovery, treatment, and disposal are not included within the definition of pollution prevention. However, some practices commonly described as "in-process recycling" may qualify as pollution prevention. Examples might include solvent recycling or volatile organic recovery. Recycling that is conducted in an environmentally sound manner shares many of the advantages of prevention - it can reduce the need for treatment or disposal, and conserve energy and natural resources.

The Pollution Prevention Act established a new environmental management hierarchy as national policy. This hierarchy, also incorporated in Executive Order 12856, calls for the following:

> Pollution should be prevented or reduced at the source whenever feasible;

> Pollution that cannot be prevented should be recycled in an environmentally safe manner whenever feasible;
>
> Pollution that cannot be prevented or recycled should be treated in an environmentally safe manner whenever feasible; and
>
> Disposal or other release into the environment should be employed only as a last resort and should be conducted in an environmentally safe manner.

Pollution prevention approaches can be applied to pollution-generating activity across virtually all sectors of society, including energy, agriculture, the consumer sector, and the federal government.

As the Preamble to Executive Order 12856 states: "the environmental, energy, and economic benefits of energy and water use reductions are very significant; the scope of innovative pollution prevention programs must be broad to adequately address the highest-risk environmental problems and take full advantage of technological opportunities in sectors other than industrial manufacturing."

- **New Executive Orders Relating to Pollution Prevention**

Over the last five years, pollution prevention has become the preferred environmental strategy and a central focus for environmental efforts in the Congress, at EPA, and elsewhere. The following is a review of the six executive orders related to pollution prevention and waste prevention that were signed in 1993 and 1994. These orders (included as appendices to this document) form a framework for pollution prevention activities by federal agencies in the next decade. They are integrated, as appropriate, throughout the strategy guide.

- **Executive Order 12856: Pollution Prevention & Right-To-Know**

One of the most important milestones in federal pollution prevention activities was the signing of Executive Order 12856 ("Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements") in August 1993. This order is expected to serve as a central directive to federal agencies on pollution prevention over the coming years. Executive Order 12856 requires federal agencies to develop written pollution prevention strategies and facility-specific plans, and to set goals for eliminating the acquisition, manufacturing, processing, or use of toxic chemicals and extremely hazardous substances.

Under Executive Order 12856, federal agencies must comply with the planning and reporting provisions of the Emergency Planning and Community Right-to-Know Act (EPCRA) and the Pollution Prevention Act. Section 313 of the Emergency Planning and Community Right-to-Know Act established the Toxic Release Inventory (TRI) and requires certain manufacturers to report annually to EPA on whether they manufacture, process, or otherwise use any of over 300 toxic chemicals, and if so, the amounts of the chemicals involved. Under Executive Order 12856, the TRI reporting framework will now be extended to federal facilities.

In a short period of time, TRI has become one of the most powerful tools in this country for tracking pollution prevention progress among industrial sources. Unlike other data bases, TRI permits the tracking of chemical releases at specific facilities on a multi-media basis. Beginning with data submitted in 1992, TRI reports also contain detailed source reduction and recycling information as mandated by the Pollution Prevention Act. TRI is already being used widely by industry, the states, and environmental groups as a scorecard for prevention efforts. Many companies have already undertaken substantial voluntary public commitments to reduce the release of TRI chemicals.

Executive Order 12856 calls on federal agencies to develop a 50 percent reduction goal by 1999 for their releases of toxic chemicals, or toxic pollutants, with the baseline being no later than 1994. In February 1994, EPA issued Interim Final Implementation Guidance for Executive Order 12856 and expects to finalize the guidance by the close of FY 1994.

- **Executive Order 12873: Acquisition, Recycling, and Waste Prevention**

Executive Order 12873 ("Federal Acquisition, Recycling, and Waste Prevention"), signed in October 1993, directs federal agencies to implement acquisition programs aimed at encouraging new technologies and building markets for environmentally preferable and recycled products. Toward this end, all agencies are directed to review and revise their specifications, product descriptions, and standards. Agencies also must set goals for waste prevention and the acquisition of recycled products, and report on their progress in meeting the goals. EPA is directed to issue guidance on environmentally preferable products and to institute a new process for designating products with recycled content. The order requires high-level environmental executive positions and staffing in federal agencies to ensure implementation of the directives, establishes model facility and recycling programs, and contains specific requirements related to recycled paper.

- **Executive Order 12902: Energy Efficiency and Water Conservation**

Under Executive Order 12902 ("Energy Efficiency and Water Conservation at Federal Facilities"), federal agency use of energy and water resources is directed towards the goals of increased conservation and efficiency. Each agency must undertake a prioritization survey of all its facilities leading to a 10-year plan to conduct comprehensive energy and water audits.

Under the executive order, federal agencies must develop and implement programs aimed at: (1) reducing overall energy use in federal buildings by 30 percent by 2005; (2) increasing overall energy efficiency in industrial federal facilities by 20 percent by 2005; (3) significantly increasing the use of solar and other renewable energy sources; and (4) minimizing use of petroleum products at federal facilities by switching to less-polluting alternative energy sources.

- **Executive Orders 12843, 12844, 12845: Ozone-Depleters, Alternative Fueled Vehicles, Energy Star Computers**

Three other executive orders, signed on Earth Day 1993, commit the federal government to accelerated action on several fronts-phasing out ozone-depleting substances, purchasing alternative fueled vehicles, and buying energy-efficient computers.

Executive Order 12843 ("Procurement Requirements and Policies for Federal Agencies for Ozone-Depleting Substances") directs federal agencies to change their procurement policies to reduce the use of ozone-depleting substances earlier than the 1995 phase-out deadline called for in the Montreal Protocol. Federal agencies are directed to modify specifications and contracts that require the use of ozone-depleting substances and to substitute non-zone depleting substances to the extent economically practicable. Through affirmative acquisition practices, the federal government will provide leadership in the phase-out of these substances on a worldwide basis, while contributing positively to the economic competitiveness on the world market of U.S. manufacturers of innovative safe alternatives.

Executive Order 12844 ("Federal Use of Alternative Fueled Vehicles") places the federal government in the leadership of the use of alternative fueled vehicles, calling on each agency to adopt aggressive plans to exceed the purchase requirements of such vehicles established by the Energy Policy Act of 1992.

The use of alternative fueled motor vehicles can reduce air pollution, stimulate domestic economic activity, reduce vehicle maintenance costs, and provide market incentives for the development of such vehicles and the fueling infrastructure needed to support large numbers of privately owned alternative fueled vehicles.

Finally, under Executive Order 12845 ("Requiring Agencies to Purchase Energy Efficient Computer Equipment"), the U.S. government became a participant in the Energy Star Computer program by agreeing to buy energy-efficient computers, monitors, and printers to the maximum extent possible. To the extent possible, federal agencies must now purchase only those computer products that qualify for the Energy Star logo, as long as they meet other performance requirements and are available in a competitive bid.

A matrix of requirements across the six executive orders is shown in the attached Exhibit.

- **Conclusion:**

The government's pollution prevention role in acquisitions, facility management, policy-making and technology depends on the motivation and commitment of managers in each federal agency to initiate and implement successful pollution prevention programs. Federal agencies make thousands of decisions each year at every level in the course of carrying out their mandates - from drafting regulations to running hospitals, from funding educational programs to acquiring parts and supplies. Each of these activities presents opportunities to prevent prevention.

In the private sector, pollution prevention efforts have been found to be most successful when they are part of the corporate philosophy, that is, when they are instituted as a company-wide goal at the wide goal at the highest levels of management. In the federal sector, endorsement of pollution prevention has indeed been formalized at the highest level of leadership, with the President of the United States. That leadership and its accompanying vision for federal agencies are embodied in the executive orders signed in 1993. As a contributor to pollution and waste generation, the federal government has a responsibility to become a leader in finding solutions. These new executive orders provide both the means and the motivation for the federal government take the step. The emerging Federal Government Environmental Challenge Program, which EPA is charged with establishing under Executive Order 128565, should help more Federal agencies further into the a true leadership role in pollution prevention.

Through its many programs, policies, and acquisition decisions, federal agencies are in a strategic position to make pollution prevention the dominant approach to solving environmental issues in our society. Working cooperatively with departments and agencies, EPA hopes to advance pollution prevention at all levels of the government, signaling a new era in federal responsibility and innovation in environmental protection.

Cross Reference of Requirements of Recent Environmental Executive Orders

Common Requirements	EO 12856 August 3, 1993 Right-to-Know & Pollution Prevention	EO 12873 October 20, 1993 Acquisition, Recycling & Waste Prevention	EO 12902 March 8, 1994 Energy Efficiency & Water Conservation	EO 12843 April 21, 1993 Ozone Depleting Substances	EO 12844 April 21, 1993 Alternative Fuel Vehicles	EO 12845 April 21, 1993 Energy Efficient Computers
Review and Revise Documents (Specs, STDs, etc.)	Section 3-303(b)	Sections 401, 501, 505, 506	Section 507(d)	Sections 4(a) & (b)		Section 1(b)
FAR Changes	Sect. 3-303(c)	Section 903		Section 8		
Contract Language	Section 1-104	Section 701	Section 306(c)	Sections 3 & 4(c)		Section 1(b)
Life Cycle Concepts	Section 4-404	Section 401	Sections 306, 309		Section 2(c)	
Acquisition/ Procurement Policy	Sections 3-301, 3-303(a)	Sections 401-404, 502-504, 701-702	Section 501(d), 507	Section 1, 3, & 4	Section 1	Section 2
Goals	Sections 3-302, 3-303(a)	Sections 601, 602	Section 303		Sections 1 & 2	
Annual Reporting	Sections 4-402, 5-507	Sections 301, 501, 601	Section 308	Section 5 (One Time)	Section 6	Section 1(d)
Awards	Section 4-405	Sections 801, 802	Section 504			

TINKER AFB's ALTERNATIVE FUELS PROGRAM

OKLAHOMA CITY AIR LOGISTIC CENTER

by

Paul R. Therrien
OC-ALC/EMV
7701 2nd Street, Suite 220
Tinker AFB, OK 73145-9100
(405) 736-5102, DSN 336-5102

Abstract: Tinker Air Force Base is committed to implementing new technology that will reduce or eliminate pollution through the use of alternative fuel sources. Since environmental constraints are becoming increasingly stringent, it is necessary to investigate and develop new technologies that can be applied to the mission of transportation at Tinker AFB. The primary objectives of the Alternative Fuels Program are to reduce atmospheric pollution created by vehicle exhaust emissions and to reduce the consumption of gasoline and diesel.

Tinker AFB, Battelle, and BDM Federal have been evaluating, following EPA protocol for emission certification, the following seven alternative fuel sources: compressed natural gas, liquefied natural gas, liquid propane, electricity, electricity with solar recharge, solar and biodiesel. Although many of these fuels significantly reduce vehicle emissions, Tinker AFB is now looking to eliminate vehicle emissions through the implementation of electric and solar vehicles. Tinker AFB, in conjunction with Oklahoma Gas & Electric and the University of Oklahoma, are presently focused on improving current solar and electric technology and applying it to electric vehicles.

INTRODUCTION

Mission of Tinker Air Force Base

The Oklahoma City Air Logistics Center (OC-ALC) located at Tinker Air Force Base is one of five centers (depots) providing worldwide technical logistics support for Air Force weapon systems. OC-ALC's mission is defined as aircraft maintenance, propulsion management, commodities management, and technology and industrial support.

Oklahoma City ALC provides depot level maintenance support for a variety of weapon systems including the B-52, multipurpose 135 series aircraft, AWACS E-3 aircraft, Navy E-6 aircraft, the new B-2 Stealth Bomber, the B-1 Bomber, the short-range attack missile, and the presidential fleet.

In addition to the depot, Tinker is home to several units with worldwide impact. The 552 air control wing flies the E-3 Sentry aircraft and provides combat communications and control all over the globe. Tinker is also home to two squadrons of Navy E-6 aircraft. These units maintain a continuous flying communications link between the White House and ballistic missile submarines. The Communications Systems Command is headquartered on Tinker AFB and is the Air Force's single manager for engineering and installing communication, computer, and air traffic control systems around the world.

Base Location and Profile

Tinker AFB, which comprises approximately 5000 acres, is centrally located in Oklahoma six miles southeast of the downtown business area of Oklahoma City. In addition to Oklahoma City, the base is adjacent to the suburbs of Midwest City and Del City. The base employs over 21,000 civilian and military personnel making Tinker AFB the largest single employer in the state.

BACKGROUND

Oklahoma City is currently an attainment area for ozone, carbon monoxide, and particulates and is not required to participate in the Clean Fleets Program; however, Oklahoma City has come within 8/1,000 of a part per million for ozone of exceeding federal air quality standards. If Oklahoma City violates such standards, $43 million must go towards federally required clean air measures, such as special gas pumps and tougher auto inspections. The Clean Air Act Amendments of 1990 have also established tighter vehicle (tailpipe) emission standards for hydrocarbons, carbon monoxide, and nitrogen oxides. The Energy Policy Act of 1992 requires the United States to reduce its dependence on crude oil imports and to purchase alternative fueled vehicles as follows: 5,000 by 1993, 7,500 by 1994, and 10,000 by 1995; and phased in by 1999 of new vehicles purchased as follows: 25 percent in 1996, 33 percent in 1997, 50 percent in 1998, and 75 percent in 1999. In addition, Executive Order 12844 requires federal agencies to acquire alternative fueled vehicles in numbers that exceed by 50 percent the requirements for 1993 through 1995 set forth in the Energy Policy

Act of 1992." In accordance with the Energy Policy Act of 1992 to reduce crude oil imports, Executive Order 12759 requires federal agencies "operating 300 or more commercially designed vehicles domestically shall develop a plan to reduce motor vehicle gasoline and diesel consumption by 10 percent by 1995 in comparison with fiscal year 1991."

In association with the aforementioned Executive Orders, The Clean Air Act Amendments of 1990, and the Energy Policy Act of 1992, Tinker Air Force Base is implementing new technology that will reduce or eliminate pollution through the use of alternative fuels. Since environmental constraints are becoming increasingly stringent, it is necessary to investigate and develop new technologies that can be applied to the mission of transportation at Tinker AFB. The primary objectives of the Alternative Fuels Program are to investigate the use of various alternative fuels, to reduce atmospheric pollution created by vehicle exhaust emissions, and to reduce the consumption of fossil fuels.

ALTERNATIVE FUELS PROGRAM

Tinker AFB has a vehicle fleet (cars, trucks, buses, tugs, forklifts, etc.) exceeding 1000 vehicles. A total of 557 of the vehicles are now powered by alternative fuels. Tinker AFB "kicked-off" the Alternative Fuels Program by converting 270 of its general purpose vehicles (cars, trucks, and buses) to compressed natural gas. In addition, 287 tugs, forklifts, and utility carts have been converted to clean-burning propane or electric battery power.

The tailpipe emissions testing for the select group of compressed natural gas vehicles was performed by BDM Federal, formerly known as the National Institute of Petroleum and Energy Research (NIPER), using the Federal Test Procedure. The select group of vehicles tested consisted of twelve dual fueled vehicles, which were representative of the entire fleet. The results of the twelve representative vehicles were averaged and reported in Table I. These averages were then used to predict the entire fleets avoided emissions (9,600 lbs/year), assuming the 270 compressed natural gas vehicle fleet travels approximately 2,000,000 miles/year. In addition, the fleet will reduce gasoline consumption by approximately 141,000 gallons/year.

Exhaust testing of these vehicles have shown significant reductions in non-methane hydrocarbons and carbon monoxide emissions with an increase in total hydrocarbons and nitrogen oxide emissions. Increased total hydrocarbon emissions is of little significance from a smog standpoint because the primary hydrocarbon exhaust component is methane, which essentially is unreactive in the formation of photochemical smog. However, the emission of methane can be reduced if a methane-specific catalyst were used.

In addition, the increase in nitrogen oxide emissions is a result of the catalyst being unable to reduce nitrogen oxides due to the air-fuel mixture. The compressed natural gas vehicles' air-fuel mixture has been adjusted for a lean mixture, thus reducing the carbon monoxide emissions. Unfortunately, with dual fueled compressed natural gas vehicles there is a tradeoff between carbon monoxide and nitrogen oxide emissions. If the air-fuel ratio is adjusted to reduce carbon monoxide, the nitrogen oxide emissions increase (and vice versa). However, the nitrogen oxide emission levels still meet EPA emission standards.

TABLE I*

AVERAGE EMISSIONS FOR COMPRESSED NATURAL GAS VEHICLES

	TOTAL HYDROCARBONS (average)	NON-METHANE HYDROCARBONS (average)	CARBON MONOXIDE (average)	NITROGEN OXIDE (average)
BEFORE CONVERSION (grams/mile)	0.67	0.61	9.62	0.91
AFTER CONVERSION (grams/mile)	1.78	0.20	7.85	1.98
EMISSION PERCENT CHANGE	+167	-66.0	-18.4	+118

*Reference 1

In addition to the general purpose vehicles, Tinker AFB recently converted 33 diesel tugs and forklifts to liquid propane -- another 254 tugs, forklifts, and utility carts were already converted to propane or electricity. The propane forklifts and tugs were tested using an OTC 4-Gas Monitor, measuring the percent of carbon monoxide, carbon dioxide, oxygen and total hydrocarbons in the exhaust. An average reduction in total hydrocarbons (69%) and carbon monoxide (81%) emissions, with a slight increase in carbon dioxide (10%) emissions, was achieved.

Although the initial alternative fuels program and conversions were very successful, it was not enough. In 1993 an extensive effort was undertaken to identify, select, acquire, and demonstrate through field tests at Tinker AFB the benefits of a broad variety of alternative fuel vehicles and refueling provisions over a 90-day period (Table II). Under a technical coalition, Tinker AFB, Battelle, and BDM Federal, evaluated the following six alternative fuel sources using EPA protocol for emission certification: liquefied natural gas (LNG), liquid propane, electricity, electricity with solar assisted recharge, solar, and biodiesel (25% soybean oil methyl ester and 75% diesel blend). An underlying assumption is that such usage of the aforementioned alternative fuels should not impinge significantly on the ability of the subject vehicles to satisfy their intended missions. Thus, the overall functionality and practical applicability of the following vehicles were examined, as well as the impact on emissions and fuel usage.

A combination of test procedures were used to evaluate the alternative fuel vehicles: subjective driving evaluations, objective performance tests, and Federal Test Procedures. The subjective driving evaluations consisted of questionnaires, logbooks, and interviews that were administered to the vehicle operators by both OC-ALC and Battelle staff. The operators were asked to comment on the functionality (i.e., handling, acceleration, braking, etc.) of the vehicles, refueling procedures, and their overall impression of the vehicles. Table III shows sample comments on the six alternative fuels evaluated.

TABLE II*
SUMMARY OF SELECTED VEHICLES AND REFUELING PROVISIONS

ALTERNATIVE FUEL	VEHICLE DESCRIPTION	REFUELING PROVISION
Liquefied Natural Gas	1990 GMC Safari Minivan	500 Gallon - Cryogenic Sphere
Liquefied Natural Gas	1993 GMC Safari Minivan	500 Gallon - Cryogenic Sphere
Liquid Propane	1993 GMC Full Size Pickup	800 Gallon Skid Mounted Tank
Liquid Propane	1992 GMC Full Size Van	800 Gallon Skid Mounted Tank
Electricity	1993 VEHMA/GMC Full Size Van	Stationary Charger (208 V/45 A)
Electricity	1993 Ford Escort Station Wagon	On Board Charger (120V/20A)
Electricity (Solar Assisted Recharge)	1993 Chev. S-10 Compact Pickup	On Board Charger (120V/20A)
Solar	1993 Hand-crafted "Race" Car	On Board Solar Cells
Biodiesel	1991 Chev. Cheyenne Full Size Pickup	500 Gallon Above Ground Tank

*Reference 2

TABLE III*
SUBJECTIVE DRIVER EVALUATIONS

ALTERNATIVE FUEL	OPERATOR COMMENTS
Liquefied Natural Gas (LNG)	There is no difference between my vehicle and the LNG vehicle, but the refueling procedure needs to be improved.
Liquid Propane	Good acceleration, good power, & good performance. Refueling is as easy as gasoline. Above average vehicle.
Electricity	Needs more power and range. Needs faster recharging. Perfect vehicle for driving around the base.
Electricity with Solar Recharge	Needs more power and range. Needs faster recharging. Perfect vehicle for driving around the base.
Solar	This particular vehicle was not intended for practical applications at Tinker AFB.
Biodiesel	Handles just like other pickup trucks. Easy to refuel. Cannot tell the difference between biodiesel and diesel.

*Reference 2

The various alternative fuels were also evaluated using a V2000 Vericom Performance computer. During a series of full throttle accelerations the computer measured acceleration and computed speed, distance, and power. From the data generated by the computer, correlation's were derived between net horsepower and velocity. A typical performance test for this study was a series of full throttle accelerations from zero to 40 miles per hour. To minimize the effects of wind and road grade, performance test runs were made in both directions. Plots of the net horsepower available for vehicle acceleration versus velocity for the test vehicles are presented in Figure 1. Based on the subjective driver evaluations and Figure 1, liquefied natural gas and liquid propane were determined to be acceptable alternative fuels at Tinker AFB.

Finally, the Federal Test Procedure, which follows EPA protocol for certification, was used to evaluate vehicle emissions (Table III). Electric and solar vehicles were not evaluated using the Federal Test Procedure because these alternative fuel vehicles have zero tailpipe emissions. Although electric vehicles have a non-combustion powertrain, some offset should be included for the "smokestack" emissions produced in generating the electricity at the local utility plant. The emissions for the electric vehicles presented in Table IV are in reference to the "smokestack" emissions that are produced at the electric utility plant.

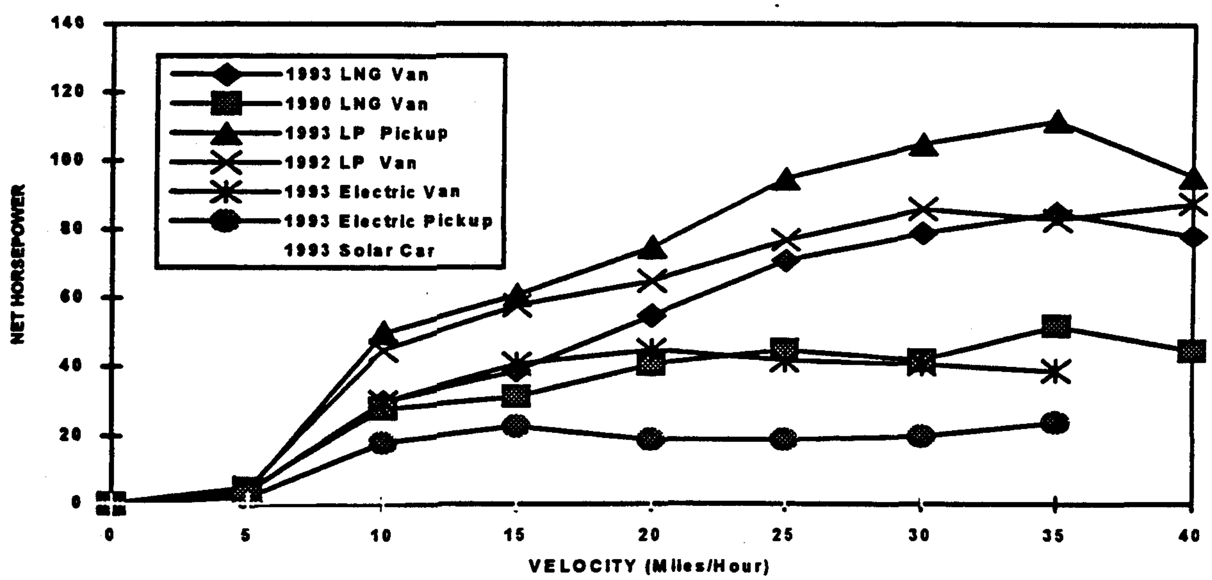


Figure 1. Net Horsepower Versus Velocity for Alternative Fueled Vehicles (Reference 2)

TABLE IV*
EMISSIONS FOR LIQUEFIED NATURAL GAS, LIQUID PROPANE, BIODIESEL, AND ELECTRICITY

	TOTAL YDROCARBON (average)	PARTICULATES (average)	CARBON MONOXIDE (average)	NITROGEN OXIDE (average)
Liquefied Natural Gas 1993 Van (grams/mile)	0.66	Not Applicable	4.28	1.53
Liquefied Natural Gas 1990 Van (grams/mile)	1.32	Not Applicable	9.84	1.34
Liquid Propane 1993 Pickup (grams/mile)	0.38	Not Applicable	3.44	0.67
Biodiesel 1991 Pickup (grams/mile)	0.32	0.15	1.04	3.42
Biodiesel 1991 Pickup (grams/mile)	0.17	0.10	1.02	5.13
Electricity 1993 Van (grams/mile)	0.04	Not Applicable	0.27	3.55
Electricity 1993 Pickup (grams/mile)	0.01	Not Applicable	0.08	1.07

Reference 2

Based strictly on the alternative fuel vehicles evaluated in this study, the apparent impact of the specific fuel chosen on the emission performance ranges from complete elimination of tailpipe emissions for the electric and solar vehicles to little or no change in tail pipe emissions for the biodiesel fuel. However, the results in Table III should only be considered as indicators of relative emissions performance for several types of vehicles because these are limited tests with non-optimized engines. For example, a more optimized liquefied natural gas vehicle would probably include a methane-specific catalyst and a dedicated engine.

Before choosing an alternative fuel, other requirements should also be given careful consideration. Fuel economy and infrastructure are two extremely important factors to consider. For example, natural gas has 1.2 million miles of infrastructure across the continental United States, and electric infrastructure can be located in practically every city, town, or home in the United States. Even though the infrastructure for electricity is clearly available, expensive battery replacement costs will still be incurred approximately every two years.

CONCLUSIONS

The results from the evaluation have been used to formulate Tinker's Alternative Fuels Program for the future. Although compressed natural gas and liquid propane have significantly reduced vehicle emissions, Tinker AFB is now looking to eliminate vehicle emissions all together via electric and solar vehicles. Even though tailpipe emissions are eliminated, several disadvantages currently exist with the technologies. Electric vehicles are limited in range and power and require costly battery replacement every few years, where as solar vehicles are impractical due to the large surface areas required to generate power with the present low efficiency cells. However, Tinker AFB, in conjunction with Oklahoma Gas & Electric and the University of Oklahoma, has formed a technology advancement coalition to improve current solar and electric technology. The coalition is presently focused on transitioning innovative solar and electric technology and applying it to electric vehicles.

REFERENCES

1."***Monitoring the Tinker Air Force Base Alternative Fuel Fleet***,"Technical Progress Report No. 3, ITT Research Institute, BDM Federal (National Institute for Petroleum and Energy Research), June 15, 1993.

2."***Alternative Fuels Demonstration***," Final Report, Battelle, February 24, 1994.

Alternative Fuels in Mobile Applications - Compliance With the 1990 CAAAs and EPACT

Presented to the 3rd Annual Air Force Pollution Prevention Conference & Exhibition

Richard L. Bechtold, P.E.
Sr. Project Manager
EA Engineering, Science & Technology, Inc.
8401 Colesville Rd.; Suite 500
Silver Spring, Maryland 20910
Tel (301) 565-4216
Fax (301) 587-4752

I. Why Use Alternative Fuels?

There are two main reasons to use alternative fuels: to reduce dependence on petroleum fuels and to reduce air pollution caused by vehicles using petroleum fuels. The Energy Policy Act of 1992 (EPACT) and the Clean Air Act Amendments of 1990 (CAAAs) require fleets to use alternative fuels to achieve these desirable objectives. Those who must use alternative fuels today face uncertainties that include evolving vehicle technologies, vehicle availability, and the availability of fuel delivery and refueling infrastructure. This paper briefly discusses alternative fuel vehicle technology at this stage of development and provides some insight into the effect various alternative fuel vehicles might have on fleet operations and cost.

II. State-of-the-Art Alternative Fuel Vehicle Technology and Emission Characteristics

The following presents information about the most typical alternative fuels: natural gas, LP Gas, methanol, ethanol, and electricity. More advanced alternative fuels such as hydrogen are not included because they are not ready for typical fleet use.

Natural Gas: There are two primary methods of storing natural gas on transportation vehicles: compressed (CNG) and liquefied (LNG). The natural gas engine fuel and emission systems are the same whether the natural gas is stored as CNG or LNG (the low temperature of LNG has some potential for increasing engine volumetric efficiency, but to date this potential has not been exploited). Natural gas vehicle (NGV) emission characteristics include very low carbon monoxide (CO) emissions, low non-methane emissions, zero evaporative emissions, about ten percent lower carbon dioxide (CO_2) emissions relative to petroleum fuels, and typically higher oxides of nitrogen (NO_x) emissions. Optimization of emission catalyst technology has allowed Chrysler to develop dedicated natural gas vehicles with very low NO_x and methane emissions, qualifying as Low Emission and Ultralow Emission vehicles (LEV and ULEV).

Light duty NGVs will have a small power loss compared to gasoline fuel vehicles with similar displacement engines, typically in the range of five to ten percent. This is because the natural gas enters the cylinder as a gas which displaces air otherwise used for combustion whereas gasoline enters as a combination of liquid and vapor with lower combined volume. This situation is reversed for converted diesel engines where power output can be increased because the air in the cylinder is used in its entirety compared to diesel combustion where there is always excess air present.

CNG is stored onboard the vehicle using high-pressure (2400 or 3000 psi) cylindrical tanks. CNG has about one-fifth the energy storage density of gasoline, meaning that five times the volume of CNG must be stored to provide the same driving range as gasoline. The most common cylinder material is steel, though reinforced aluminum is very popular and reinforced composite cylinders are becoming popular for vehicle use because they weigh much less (though they cost more). CNG vehicles will be heavier than conventional fuel vehicles by a small amount to several hundred pounds. Packaging of sufficient CNG cylinders on the vehicle to give the same operating range as when using gasoline or diesel fuel can be very difficult, especially for passenger cars. For this reason, most CNG passenger cars are bi-fuel, i.e., they retain the conventional fuel system and add the CNG fuel system, but can only operate using one at a time. Bi-fuel vehicles tend to result in compromises in terms of performance and emissions, being neither optimum for natural gas or the conventional fuel.

LNG is stored in highly insulated containers to keep it below methane's boiling point of -259° F. The insulation while being very good, is not perfect, and vaporized natural gas will have to be vented periodically unless the fuel is used by the vehicle. Venting times vary by fuel tank design, and are as short as a few days or as long as 10 to 14 days. LNG has about two-thirds the energy content of gasoline, so approximately 50 percent more must be stored to provide equal driving range. LNG tanks are lighter than CNG tanks but more costly.

<u>LP Gases</u>: The vehicle fuel system technology and emission characteristics of LP Gas vehicles are very similar to natural gas vehicles. The major difference in emissions is that unburned hydrocarbons are primarily propane instead of methane. LP Gas fuel tanks are similar in size and weight to LNG tanks, but are much less costly than LNG or CNG tanks. Like natural gas, engine power is reduced slightly, and vehicles can be dedicated or bi-fuel.

<u>Methanol</u>: There are two primary approaches to using methanol as a fuel, one for spark ignition engines and one for compression ignition engines. For spark ignition engines, 15 percent gasoline is added to the methanol (M85) to give it sufficient vapor pressure to allow cold starts to the same low temperatures as gasoline alone. Other than changes to address material compatibility and increase the fuel flow rate to compensate for the decreased energy content of methanol, no other engine changes are needed. Because of methanol's high octane rating, an increase in compression ratio is possible, with its

resultant advantages, but this modification would be for dedicated engines only. Most current methanol engines are light duty and are "flexible fuel", i.e., they are capable of using methanol, gasoline, or any blend in between in the same fuel tank (no separation is required - just add the fuel that is available). Flexible fuel vehicles (FFVs) have a sensor in the fuel line to the engine that can measure the percentage of methanol vs. gasoline being delivered to the engine, and provide compensation of spark timing and fuel injection quantity/timing correspondingly.

The only drawback to FFV technology is that engine design is constrained by the need to operate on gasoline. Advanced methanol engines have demonstrated very low emissions and very high efficiency, without the need for gasoline addition. These advanced engines are many years away from production but illustrate the emissions potential for methanol as a fuel. Methanol vehicles have similar mass emissions to gasoline, but the advantage is that methanol is less reactive than gasoline hydrocarbons. The range and number of toxic emissions are reduced when using methanol, but methanol produces formaldehyde emissions. Advanced methanol engine emissions have the potential for reduced CO, CO_2, and NO_x emissions.

The compression ignition engines modified to use methanol are to date all converted from heavy duty diesel engines. The only commercially available engine is the Detroit Diesel Corporation (DDC) 6V-92TA engine that uses neat (100 percent pure) methanol as fuel (with the addition of a small amount of additive). The DDC 6V-92TA uses a combination of glow plugs and combustion system design to achieve ignition under all engine operating conditions. This engine is the cleanest heavy duty diesel engine ever certified by the Environmental Protection Agency. Diesel engines can also be readily retrofitted to use methanol as a fuel by adding an ignition improver additive and modifying the fuel injection system to be methanol compatible and to provide the necessary fuel flow rate. Methanol compression ignition engines have very low particulate emissions and can also have very low NO_x emissions depending on design and calibration.

<u>Ethanol</u>: There are three primary methods that ethanol could be used as a transportation fuel: 1) as a blend with gasoline, typically ten percent and commonly known as "Gasohol"; 2) as a component of reformulated gasoline both directly but probably more likely transformed into a compound such as ethyl teritary butyl ether (ETBE); or 3) used directly as a fuel, probably with 15 percent gasoline known as "E85." Ethanol, by itself, has a very low vapor pressure, but when blended in small amounts with gasoline, it causes the resulting blend to have a disproportionate increase in vapor pressure. For this reason, there is great interest in using fuels such as ETBE as reformulated gasoline components because ETBE does not increase the vapor pressure of the resulting fuel blend.

The primary emission advantage of using ethanol blends is that CO emissions are reduced through the "blend-leaning" effect that is caused by the oxygen content of ethanol. The presence of oxygen in the fuel decreases the amount of air needed for complete combustion. Because this additional oxygen is being added through the fuel, the engine fuel and emission systems are "fooled" into operating leaner than designed, with the result being lower CO emissions and typically slightly higher NO_x emissions. The blend-leaning effect is most pronounced in older vehicles that do not have feedback control systems. However, even the newest technology vehicles typically show some reduction in CO emissions.

The vehicle technology to use E85 is virtually the same as that to use M85; thus, there will be very little difficulty developing E85 vehicles. The emission characteristics of E85 vehicles are not well known, but it is expected that they will be comparable to the latest vehicles using reformulated gasoline and M85 vehicles with the exception that E85 produces acetaldehyde instead of formaldehyde when combusted.

<u>Electricity</u>: Electricity is a form of energy but is considered an alternative fuel in the case of EPACT and the CAAAs. Electric vehicles have no emissions and are known as "zero emission vehicles" or ZEVs.

III. Alternative Fuel Vehicle Costs and Range

Because alternative fuel vehicle technology is evolving rapidly, it is difficult to generalize about costs. However, Table 1 summarizes the current situation with respect to incremental vehicle costs that can be expected. Note that these are just vehicle costs - maintenance and fuel costs are in addition.

IV. Alternative Fuel Vehicle Operating Concerns

<u>Emissions</u>: At present there are emission regulations for light duty methanol vehicles, heavy duty methanol engines, and for light duty vehicles and heavy duty engines fueled with natural gas and LP Gas. No regulations exist for ethanol vehicles and engines. Many states have not addressed how alternative fuel vehicles should be treated in terms of Inspection/Maintenance emission tests. This is of particular concern for converted and bi-fuel vehicles.

<u>Range</u>: All these alternative fuels have less energy per gallon than gasoline or diesel fuel. If the vehicle is bi-fuel, it usually has the same range when operated on the conventional fuel, plus the range it can travel on the alternative fuel. Dedicated alternative fuel vehicles generally have lower operating range than their conventional fuel counterparts. In general, light duty CNG vehicles will have half to two-thirds the range of their gasoline counterparts. Medium and heavy duty CNG vehicles can easily have near-equivalent range because they typically have sufficient room to place the required number of CNG cylinders. LNG and LP Gas vehicles do not have as much difficulty finding room for the number and size of fuel tanks that will give them near-equivalent range as when operating on conventional fuels. Light duty methanol FFVs

have about 60 percent the range of the same vehicle using gasoline, unless an auxiliary fuel tank is added. Light duty ethanol FFVs should have about 75 percent the range of the same vehicle using gasoline, unless an auxiliary fuel tank is added. Both methanol and ethanol heavy duty vehicles can usually add sufficient fuel tank capacity to have essentially equal range as when operating using diesel fuel.

Table 1. Typical Alternative Fuel Vehicle Incremental Costs

TYPE OF ALTERNATIVE FUEL VEHICLE	TYPICAL INCREMENTAL COST, DOLLARS
Light Duty CNG	$3,500+
Medium and Heavy Duty CNG	$5,000[1]+
Light Duty LNG	$5,000+
Medium and Heavy Duty LNG	$6,000+
Light Duty LP Gas	$2,000+
Medium and Heavy Duty LP Gas	$3,000+
Methanol FFV	0 to $2,000[2]
Ethanol FFV	0 to $2,000[3]
Heavy Duty Methanol	$10,000[4]+
Heavy Duty Ethanol	$10,000[5]+

Notes:
1. Assumes conversion of existing engine; costs for dedicated heavy duty natural gas engines not established; some CNG transit buses cost $30,000 to $50,000 more.
2. Ford and General Motors initially charged $2,000 extra for their FFVs, but more recently they have been offered without an incremental charge.
3. Assumes that ethanol FFVs would use the same technology as methanol FFVs.
4. Costs for methanol heavy duty engines not well-established and likely to come down as volume grows.
5. Same engines as for methanol heavy duty vehicles - other changes similar.

Complexity: Bi-fuel vehicles are inherently more complex because there are two fuel systems onboard. However, the fuel systems to use alternative fuels are also inherently more complex than those for gasoline or diesel fuel because of the differences in materials, operating principles, pressures, safety precautions, and fuel temperatures. Implementation of alternative fuel vehicles will require significant retraining of existing maintenance staff. Operator training will also be necessary for refueling AFVs because while the mechanical steps involved will be similar, the hazards are different. All personnel using or working on AFVs should receive health and safety training.

V. Compliance with the 1990 CAAAs and EPACT

There are some differences between the requirements to use alternative fuels under the 1990 CAAAs and EPACT. Fortunately, both can be satisfied using the same vehicles where overlap occurs. The following discusses the requirements for each.

The 1990 CAAAs: Requires fleets of 10 or more, capable of being centrally refueled, in ozone nonattainment areas to use clean fuels by purchasing new vehicles or converting existing vehicles. Clean fuels are defined as all the alternative fuels discussed in this paper plus reformulated gasoline. Starting in 1998, 30 percent of new cars and trucks under 8,500 GVW must be clean fuel vehicles or use clean fuels. The purchase requirement increases to 50 percent in 1999 and 70 percent in 2000. For heavy-duty vehicles, the purchase requirement is 50 percent in 1998 and thereafter. Emission credits are accrued by exceeding the vehicle purchase requirements or by purchasing vehicles cleaner than called for. The emission credits can be used to offset future purchase requirements, or may be sold in the open market when markets for such emission credits are developed. Currently, emission credit markets have been developed only for stationary sources. Equivalency factors may be developed to allow trading of emission credits between stationary and mobile sources.

EPACT: EPACT differs from the CAAAs in several ways. First, it covers only fleets of 20 or more that can be centrally refueled and it applies only to vehicles smaller than 26,000 GVW. EPACT does not include reformulated gasoline as an alternative fuel (note that the 1990 CAAAs use the term "clean fuels" while EPACT uses "alternative fuels") though provisions exist for DOE to possibly include it in the future. The purchase percentage requirements for EPACT have not yet been determined. EPACT provides tax incentives for vehicle purchases and for installation of refueling facilities. Credits may also be given for early purchases or purchases in excess of the minimum requirement.

Other Incentives: In addition to the 1990 CAAAs and EPACT, several states have incentives for using clean and alternative fuel vehicles. Some fuel providers such as utilities offer incentives to use alternative fuels.

VI. Other Alternative Fuel Vehicle Considerations

This paper has concentrated on alternative fuel vehicles themselves - however, there are many other considerations when deciding whether to implement alternative fuel vehicles. These concerns include: Are alternative fuels readily available commercially, or must dedicated refueling facilities be established? What will be the delivered cost of the alternative fuel? Will there be a resale market for alternative fuel vehicles? How will alternative fuel vehicle affect my operations? It will be many years until all these questions can be answered with some certainty. Until then, implementing alternative fuel vehicles will require careful planning to avoid costly mistakes.