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An Activity Driver Based Analysis of Hazardous Materials Usage at Wright-Patterson AFB

Charles D. Perham

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THESIS

Charles D. Perham, Captain, USAF

AFIT/GEEM/EN/96D-16

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY
AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

AFIT/GEEM/EN/96D-16

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Presented to the Faculty of the School of Engineering

Air Education and Training Command

In Partial Fulfillment of the

Requirements for the Degree of

Master of Science in

Engineering and Environmental Management

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Maj James R. Aldrich, PhD

Mark N. Goltz, PhD

Lt Col Steven T. Lofgren, PhD
Advisor

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Charles D. Perham

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LIST OF ACRONYMS

AF...Air Force

AFIT.....................Air Force Institute of Technology

AGC...............................Aerospace Ground Control

AGE.............................Aerospace Ground Equipment

AGS...........................Aircraft Generation Squadron

CES.............................Civil Engineering Squadron

DM-HMMS....Depot Maintenance-Hazardous Materials Management System

DoD..................................Department of Defense

EPA........................Environmental Protection Agency

EPCRA....Emergency Planning and Community Right-to-Know Act

HazMat...................................Hazardous Material

HSWA..................Hazardous and Solid Waste Amendments

MEK....................................Methyl Ethyl Ketone

MS...................................Maintenance Squadron

MSDS.............................Material Safety Data Sheet

NDI.............................Non-Destructive Inspection

ODC...............................Ozone Depleting Chemical

ODS..............................Ozone Depleting Substance

OI...................................Operating Instruction

OSHA..........Occupational Safety and Health Administration

NEPA......................National Environmental Policy Act

PPA...............................Pollution Prevention Act

RCRA................Resource Conservation and Recovery Act

SARA..........Superfund Amendments and Reauthorization Act

SGF................................Sortie Generation Flight

TLV..................................Threshold Limit Value

TRI.................................Toxic Release Inventory

WPAFB.......................Wright-Patterson Air Force Base

ABSTRACT

As the Air Force has progressed and succeeded in the realm of pollution prevention, the opportunities for further progress have become more challenging. With the "low-hanging fruit" now gone from the pollution prevention tree, new methods to identify opportunities must be adopted.

This research effort applied a subset of activity based costing, activity driver analysis, to reveal pollution prevention opportunities in regards to hazardous materials usage. A sample of base organizations (civil engineering and aircraft maintenance), and a sample of the hazardous chemicals (Class C or most hazardous) used by those organizations were investigated to determine the drivers behind usage.

The conclusion of this effort is that activity driver analysis can be used to reveal pollution prevention opportunities. The results of this sample revealed significant differences in drivers between civil engineering and aircraft maintenance. This was confirmed with a chi-squared test for homogeneity, rejected at the .05 α level. Additionally, the results brought to light the pollution prevention opportunities that may be available in each organization. A pareto analysis of the hazardous material drivers for civil engineering revealed that over 57% of the various materials were driven by "availability at issue."

This discovery distinguishes the civil engineering issue points as a ripe fruit for further examination.

The objective of this effort was a suggested method to assist base level environmental managers in employing activity driver analysis. Base level managers should be able to follow the six step process outlined and uncover new pollution prevention opportunities.

AN ANALYSIS OF HAZARDOUS MATERIALS USAGE AT WRIGHT-PATTERSON AFB THROUGH ACTIVITY DRIVER ANALYSIS

I. INTRODUCTION

Background

The Pollution Prevention Act(PPA) of 1990 declared that the national policy of the United States regarding pollution is that, "pollution should be prevented or reduced at the source whenever feasible" (Federal Register, 1993:31115). Executive Order 12856 required that all federal agencies comply with the provisions of the PPA. The Air Force fully embraced this, and implemented pollution prevention programs at its installations. The official policy of the Air Force is clear. "The Air Force is committed to environmental leadership and preventing pollution by reducing use of hazardous materials and releases of pollutants into the environment to as near zero as feasible" (Department of the Air Force, 1994).

Like industry, the Air Force has found it cheaper and more efficient to prevent pollution before a process begins rather than clean it up once it occurs. With their original pollution prevention efforts, the Air Force has been able to eliminate the use of many hazardous materials and ozone depleting substances (ODS) that are not essential to the operation or maintenance of our weapon systems (McCall, 1995). These initial efforts were relatively simple and successful because the AF was able to deal with this "low-hanging fruit" and reduce the use of hazardous materials.

Now that significant improvements have been made in the realm of pollution prevention, the AF must manage the program with more finely tuned controls. To do this, the Air Force has been eliminating hazards and reducing costs by using tools such as cost-benefit and life cycle analysis. These initiatives have been successful in reducing pollution (McCall, 1995).

The Air Force has also made significant progress in its management of hazardous materials by implementing the hazardous materials pharmacy concept. This concept directs installations to set up one office to handle the authorization, acquisition, distribution, and tracking of all hazardous substances on a base. The increased attention that hazardous materials acquisition has received through the pharmacy concept has directly led to the a reduction in hazardous materials used and thus a reduction of pollution generated (McComas, 1995:27).

As the Air Force continues its search for additional opportunities in pollution prevention, new avenues need to be identified. One method the Air Force has yet to employ is activity driver analysis. This method focuses on the activities which cause the generation of pollution, and what drives these activities. The driver behind an activity is the factor that causes the activity to occur, and the cost to be incurred (Sharman, 1994:14). Activity driver analysis reveals what causes activities, and in the process, questions the activities importance in relation to overall procedures.

Objective

The Air Force has used an array of methods for selecting pollution prevention opportunities. Past methods of selection included singling out the largest pollution generator, or the most expensive contributor (Hudson, 1995:4). These methods, though originally successful, are no longer as effective. The "low-hanging fruit" has been picked. The objective of this thesis is to explore the use of activity driver analysis as a new method in the selection of pollution prevention opportunities at base level. To achieve this objective, an activity driver analysis was performed at Wright-Patterson AFB. The following investigative questions were established to assist in the analysis:

1) What are the drivers of hazardous materials used at Wright-Patterson AFB?

2) Do the categorical driver results help to determine which areas have the greatest pollution prevention opportunities?

Scope

This thesis effort was conducted at Wright-Patterson AFB. In order to make this effort as applicable as possible Air Force wide, two activities were selected for analysis, which are common to virtually all Air Force installations. The two organizations selected for hazardous materials driver analysis were the 788th Civil Engineering Squadron and the 445th Maintenance Squadron. The number of class C materials analyzed (625) was those acquired within a six month window (1 Jan 96 to 1 Jul 96).

Approach and Limitations

Interviewing the 48 collective shop supervisors of the two selected squadrons was the method selected to obtain the hazardous material driver information. This method served as a limitation in itself because it automatically inserted the human element into the thesis. Personal opinions were used to generate the driver categories. The availability and reliability of those personnel interviewed was a critical factor. Time was another key constraint as it limited the number of organizations selected, the number of people interviewed, and the number of materials examined.

Thesis Organization

This thesis is divided into five chapters. Chapter I provides a brief overview of the problem, research purpose, scope, and approach and limitations of the research effort. Chapter II discusses the history and development of the pollution prevention concept, and describes in detail the concepts of activity based costing, activity based management, and activity driver analysis. Chapter III explains the research methodology used to answer the research questions. Chapter IV, Analysis and Findings, has two sections. The first presents and discusses the results of the data analysis performed on the hazardous material drivers. In the second section, a standard activity driver analysis methodology is suggested for Air Force installations. The conclusions drawn from the research effort and suggestions for further study are in chapter V. Appendices include the list of sampled materials by organization and their drivers, and the list of personnel interviewed at each organization.

II. Literature Review

Overview

This chapter provides background information about the relevant issues related to this thesis. Section one of this chapter will review the literature on the evolution of pollution prevention, the Pollution Prevention Act of 1990, and the benefits of pollution prevention. Section two of this chapter will review Air Force implementation of pollution prevention strategies, including hazardous materials management. The final section of this chapter will review activity based costing and activity based management, which will provide the necessary background for understanding the analysis of activity drivers.

Pollution Prevention

Evolution of Pollution Prevention

The environmental movement of the 1960's successfully brought to the public stage the problems human activity had created in our environment. Rachel Carson's publication of *Silent Spring* in 1962 brought to the world's attention the implications of pesticides and ecological issues and human health (Carson, 1962). As a result of this public awareness, hundreds of environmental regulations were established which permeated every aspect of society. The National Environmental Policy Act (NEPA), passed in late December 1969, ushered in what has been referred to as "... the decade of environmental concern" (Jain, 1993:43;Ruckelshaus, 1985:105). Not coincidentally, the Environmental Protection Agency (EPA) was established in early 1970, forever changing the nation's dealings with the environment. As the 1970's reflected a growing concern for the environment, the 1980's continued the trend as many additional laws were passed with the intent to preserve and enhance the environment. By 1988, there were over 10,000 pages of federal environmental laws and regulations (Freeman et al., 1992:622).

Logically, the EPA first focused on visible and significant acute effects from problems such as polluted waters and automobile emissions. It was not until these areas were headed in the right direction that the EPA recognized that the best way to protect our environment is to reduce pollution at the source. This led to the concept of pollution prevention. Not only does pollution prevention safeguard our environment, it also saves millions of dollars in treatment, compliance, and acquisition costs (EPA, 1993:34).

The roots of pollution prevention can be found in the Resource Conservation and Recovery Act (RCRA) of 1976. This act addressed the generation, storage, transportation, treatment, and disposal of hazardous wastes. Though it did not encourage or mandate hazardous waste reduction, RCRA laid the foundation for the Hazardous and Solid Waste Amendments (HSWA), passed in 1984 (Masters, 1991:185). These 1984 amendments to RCRA established the requirement for hazardous waste generators to create waste minimization programs. HSWA states, "The elimination or reduction of hazardous wastes at the source should take priority over the management of hazardous wastes" (Federal Register, 1993:31114). This is the concept of pollution prevention. It is clearly stated in section 1003 (b) of RCRA:

> It is to be the policy of the United States that, whenever feasible, the generation of hazardous waste is to be reduced or eliminated as expeditiously as possible. Waste that is nevertheless generated should be treated, stored, or disposed of so as to minimize the present and future threat to human health and the environment (Federal Register, 1993:31115).

HSWA was not, however, the only precursor to pollution prevention. In a 1992 article "Measuring Pollution Prevention Progress: How do we get There from Here?" Barbara Bush described several factors that moved government and industry toward pollution prevention (Bush, 1992:431). Including the HSWA guidance, these factors are presented in the following table.

Table 1.
Reasons for Implementing Pollution Prevention

1. An awareness of the technical limitations of end-of pipe and command and control approaches to environmental

protection and the rising incremental costs of waste treatment and disposal
2. A concern that pollutants are simply transferred from one medium to another under the single medium statute approach
3. The potential future liability for clean-up and damages from waste treatment and disposal
4. The focus on waste minimization established under HSWA of 1984

The growing recognition that the United States annually produces millions of tons of pollution and spends tens of billions of dollars per year controlling this pollution led to Congress passing the Pollution Prevention Act of 1990 (United States Congress, 1990)

Pollution Prevention Act

Congress passed the Pollution Prevention Act to emphasize the significant opportunities that exist for industry to reduce or prevent pollution at the source through cost-effective changes in production, operation, and raw materials use (United States Congress, 1990:13101). In that brief, but powerful document, Congress stated:

> The Congress hereby declares it to be the national policy of the United States that 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 (United States Congress, 1990:13101).

This new policy is known as the pollution prevention hierarchy.

It is important to distinguish source reduction at the top of the hierarchy in that it is genuinely pollution prevention from the other three tiers are now considered pollution control by the Air Force. This is clearly illustrated in the waste minimization management options hierarchy table from the Air Force *Hazardous Waste Management Guide*.

Table 2.
Waste Minimization Management Options Hierarchy

Method	Example Activities	Example Applications
Source Reduction (Highest Priority) *This is Pollution Prevention.*	Process Changes Input Material changes Technology Changes Improved Operating Practices (*usually the quickest and most cost effective*) Product Changes Source Elimination	Inventory Control Waste Segregation Established Procedures and Training Improved Equipment Substitution with Less Toxic Material in Process Modify Product to Avoid Solvent Use Modify Product to Extend Coating Life
Recycling *This is Pollution Control.*	Reuse Reclamation	Closed-Loop Recycling/Reuse Solvent Recycling (*off-site*) Metal Recovery from a Spent Plating Bath Volatile Organic Compounds (VOC) Recovery
Treatment *This is Pollution Control.*	Stabilization Encapsulation Neutralization Precipitation Evaporation Incineration Scrubbing Volume Reduction	Thermal Destruction of Organic Solvent Precipitation of Heavy Metal from Spent Plating Bath
Disposal *This is Pollution Control.*	Disposal at a Permitted Facility	Land Disposal

A further definition of the term source reduction was detailed in Section 13202 of the PPA. It is considered any practice which:

> (i) 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 (ii) reduces the hazards to public health and the environment associated with the release of such substances, pollutants, or contaminants (United States Congress, 1990:13202).

The PPA also provided specific direction in two areas. The Act required the EPA administrator to establish in the Agency an independent office to carry out the functions of the act. These functions include establishing an advisory panel of technical experts, establishing a training program on source reduction opportunities, and identifying opportunities to use Federal procurement to encourage source reduction (United States Congress, 1990:13202).

The major focus of the act was on industry. Industry was now required to submit annual reports on source reduction and recycling. These reports were to be filed by the facilities which already file toxic chemical releases under section 313 of the Superfund Amendments and Reauthorization Act (SARA) of 1986 (United States Congress, 1990:13206). Not only did the act require reporting quantities and percentage changes of toxic chemical releases from year to year, more importantly, it required reporting the source reduction practices used with respect to each chemical. The categories of source reduction practices are illustrated in the following table.

Table 3.
Source Reduction Practices Categories

1. Equipment, technology, process, or procedure modifications 2. Reformulation or redesign of products 3. Substitution of raw materials 4. Improvements in management, training, inventory control, materials handling, or other general operational phases of industrial facilities.

Reporting reduction practices allows the EPA to analyze the trends in industrial pollution prevention and make recommendations to the field.

Benefits of Pollution Prevention

There are strong incentives to reduce both the volume and toxicity of waste generated and hazardous materials used. The Air Force has created a comprehensive list of the benefits which can be derived from prudent pollution prevention management. They are listed in the following table.

Table 4.
Benefits of Pollution Prevention

1. Reduced overall waste treatment costs
2. Reduced manpower and equipment requirements for pollution control and treatment
3. Reduced transportation and disposal costs
4. Decreased record-keeping requirements
5. Reduced liability costs (reduce or eliminate fines for non-compliance)
6. Reduced operating costs through more efficient use of materials (decreased energy costs)
7. An improved image in the community
8. Reduced operating costs through the use of more efficient technologies
9. Reduced impact on public health and environment, which can help foster good relationships with regulators (Department of the Air Force, 1995:97)

The Air Force

Air Force Implementation of Pollution Prevention

The Air Force initiated source reduction through good management practices before it was required by Executive Order 12856 addressing pollution prevention. It is important to highlight the term *management*, because that was the focus of the 1989 DoD Directive 4210.15 titled Hazardous Material Pollution Prevention. The policy states:

> It is DoD policy that hazardous material shall be selected, used, and **managed** over its life cycle so that the Department of Defense incurs the lowest cost required to protect human health and the environment. The preferred method of doing this is to avoid or reduce the use of hazardous material. Where use of hazardous material may not reasonably be avoided, users shall follow regulations governing its use and **management** as required by appropriate DoD issuance. In

> the absence of regulations, users shall apply **management** practices that avoid harm to human health or the environment. Emphasis must be on less use of hazardous materials in processes and products, as distinguished from end-of-pipe **management** of hazardous waste (Department of Defense, 1989:1)

This directive was issued before the PPA was ever passed, and a full four years before President Clinton signed Executive Order 12856 titled Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements. It was not until this Executive Order was signed on 3 August 1993 that the Air Force was legally bound to comply with the provisions of the Pollution Prevention Act. It is important to note that Executive Order 12856 required each facility to comply with the Emergency Planning and Community Right-to-Know Act (EPCRA), which mandated all installations file Toxic Release Inventory (TRI)reports. As stated in the earlier section detailing the PPA, all facilities which file under the TRI are committed to file source reduction and recycling information to the EPA.

Executive Order 12856 also set the goal of a 50% reduction of total releases of toxic chemicals to the environment and off-site transfers of such chemicals for treatment and disposal by December 31, 1999 (Clinton, 1993:41983). The baseline for measuring reductions for purposes of achieving this goal was the first year in which the releases were publicly reported. The Air Force, in typical proactive fashion, established its baseline in 1992, two years before the required 1994 report. A metric was established for hazardous waste disposal in the 20 July 1994 Policy Directive titled *Environmental* Quality (Department of the Air Force, 20 July 1994:2). The proactive attitude of the Air Force is reinforced in Air Force Pamphlet 32-7043 which states:

> The Air Force has developed a proactive pollution prevention policy which calls for the reduction of hazardous material use and releases of pollutants into the environment to as near zero as feasible (Department of the Air Force, 1995:96).

The Air Force does not only look at hazardous waste, however, as all installations are additionally required to monitor the EPA's 17 priority pollutants, ozone depleting chemicals (ODC's), items containing recycled content, Emergency Planning and Community Right-to-Know Act chemicals, and municipal solid waste. The EPA's 17 priority pollutants and their primary Air Force uses are listed in table 5.

Table 5.
EPA Priority Pollutants and Associated AF Uses

Priority Pollutant	**Air Force Use**	**ID Number**
Benzene	Fuels	1
Cadmium and compounds	Plating/corrosion control	2
Carbon Tetrachloride	Bearing cleaning, PMEL	3
Chloroform	Bearing shop	4
Chromium and compounds	Plating and paints	5
Cyanides	Plating solutions	6
Dichloromethane	Cold wipedown cleaner	7
Lead and compounds	Batteries, paint, solder	8
Mercury and compounds	Laboratories	9
Methyl Ethyl Ketone	Degreaser/cleaner,aircraft	10
Methyl Isobutyl Ketone	Paints	11
Nickel and compounds	Plating/corrosion control	12
Perchloroethylene	Degreaser	13
Toluene	Paints	14
Trichloroethane	Parts cleaning, propellants	15
Trichloroethylene	Degreaser, parts cleaning	16
Xylene	Paints	17

It is interesting to note that six of the seventeen priority pollutants were among the top ten chemicals reported in the Department of Defense's 1994 TRI. These chemicals, and the others researched by this thesis, will be further discussed in chapter 3.

Hazardous Materials Management

It is important to define terms associated with hazardous materials management in an Air Force context. Air Force Instruction 32-7080, titled *Pollution Prevention Program,* provides the following definitions:

Hazardous Material--Any material that poses a threat to human health or the environment typically due to their toxic, corrosive, ignitable, explosive, or chemically reactive nature.

Hazardous Substance--Any substance or material that poses a threat to human health or the environment typically due to their toxic, corrosive, ignitable, explosive, or chemically reactive nature. More specific definitions may be found in various federal regulations which implement statutes (e.g. Hazardous Material Transportation Act, Comprehensive Environmental Response, Compensation and Liability Act).

Hazardous Waste--Any waste by-products of society that can pose a substantial or potential hazard to human health or the environment when improperly managed; possesses at least one of four characteristics (toxic, corrosive, ignitable, explosive, or chemically reactive) or are listed in Code of Federal Regulation, Part 40, Section 261.3 or applicable state or local waste management regulations.

The Air Force has directed installations to "develop procedures to centrally control the purchase and use of hazardous materials" (Department of the Air Force, 1994:4). This concept minimizes hazardous material/ozone depleting chemical use through:

- Centralized control of hazardous substances purchased.
- Centralized issuing and distribution of hazardous substances.
- Purchase of hazardous substance in smallest unit of issue required for customer service.

This direction has led most installations to adapt the HazMat (Hazardous Materials) Pharmacy concept which sets up one office to handle the authorization, requisition, distribution, and tracking of all hazardous substances on a base. The HazMat Cell at Wright-Patterson AFB, which is operating under this pharmacy guidance, was a source of data for this effort.

Activity Based Management

This section will describe the background, advantages, and disadvantages of activity based costing. There will be an example provided of an activity based costing environmental application. The focus will then shift to one distinct portion of activity based costing, activity driver analysis. This will lay the foundation for the activity driver analysis of hazardous materials, which can help to uncover pollution prevention opportunities at base level.

Activity Based Costing

Traditional accounting systems were typically developed for the purpose of providing financial accountability to a business. The difficulty with these traditional systems is they do not measure costs of associated processes. The systems are generally used for external financial reporting rather than internal management and control decisions (Kaplan, 1988:61; Presley and Sarkis, 1994:7). Accounting systems were developed during a period when labor was the primary factor related to costs. Labor was about 40% of total costs and raw materials around 35%, so only about 25% of costs had to be allocated in overhead (Brooks and others, 1993:41). In recent years reengineering and automation have reduced labor costs to between 5% and 10% of the total, while raw materials have held steady at 35% (Rao, 1995:62). This increases overhead to upwards of 60% of total costs. This shift in cost percentages has led to the convention that most systems simply "spread" the overhead costs over units of production. The problem is that overhead is consumed in vastly different amounts by different departments, but accounted for using the same old peanut butter "spread" approach (Rao, 1995:62). A prime example of a cost that companies lump into overhead is environmental compliance. Most environmental regulations were passed after the accounting systems were already in place. The problem occurs when there is a small step in a large process which costs a company an excessive amount in compliance. Because the compliance costs are lumped into overhead, management often does not recognize what is driving their high costs. It is this type of scenario which drove activity based management, and specifically activity based costing, into being.

Activity based costing recognizes that costs are incurred by activities. The objective of activity based costing is to appropriately allocate overhead costs to those activities which cause these costs (Wouters, 1994:75). In other words, activity based costing is a system that assigns costs to products and activities according to the demand each product or activity makes on a company's varied resources (Brooks and others, 1993:41). This ideology challenged the conventional accounting methods in that it was a more detailed approach that could be used as a management decision tool. The idea that a company should understand its cost drivers, and apply these drivers to the cost of products in proportions to the volume of activity that a product consumes, was modernistic at first (Keegan and Eiler, 1994:27). The concept, however, is simple. Rather than lump together all costs of running a department or functional area, the expenses are divided and allocated according to activity (Yoemans, 1994:64).

In the literature, the benefits of activity based costing are portrayed to far outweigh the negatives (Rao; Brooks and Others; Yoemans; Ness and Cucuzza; Noreen; White and Others; Estrin and Others; Sharman; Wouters; Keegan and Eiler). Notwithstanding the potential difficulties with setting up an activity based costing system, the installation of a new system will still force a company to scrutinize what it actually does and this can lead to efficiencies (Rao, 1995:62). Activity based costing is a tool that enables companies to take a hard look at the profitability of their existing plants and products. This system allows companies to break down their overhead costs and determine which products to eliminate, which raw materials to change, what processes to modify, and so on (Brooks and others, 1993:41). The benefit of activity based costing is that it "provides an outstanding way of benchmarking your existing processes and figuring out ways to improve them" (Yoemans, 1994:64). In fact, when activity based costing is employed as a component of activity based management, it makes possible dramatic, rather than incremental, improvements (Ness and Cucuzza, 1995:131). Activity based management is a concept that challenges managers to not only look at the financial costs associated with individual activities, but also the impacts of those activities on overall operations.

It is now possible to see how activity based costing can be used for pollution prevention. A common reason to switch to activity based costing systems is to reduce the cost of manufacturing products in the design stage by providing more accurate cost information concerning alternative design specifications (Noreen, 1991:159). Reducing the costs of manufacturing, i.e. being cost effective, is one of the primary goals of pollution prevention. Though preventing pollution is good for the environment and an organization's public image, the reality is that reducing the cost of doing business is a good management practice. By accounting for costs relating to increasingly important areas like environmental compliance and remediation using activity based costing, organizations can better manage their processes.

Traditional accounting has impeded support for pollution prevention projects in some firms because the environmental costs have been spread out in overhead. This has precluded such projects from systematic consideration (White and others, 1993: 247). The difficulty in justifying pollution prevention projects is a reason for implementing activity based management.

Activity based management, as previously stated, associates costs with activities. In the activity based management approach, activities are lumped together through common processes (Estrin and others, 1994:41). The next question that is asked in the analysis is: "what are the drivers of each of the activities and processes?" Drivers are factors that cause activities to occur, and cost to be incurred (Sharman, 1994:14). It is this question of causality which gets to the roots of the process. This question must be answered for the different activities and processes to be able to justify their existence. When companies can justify operations, then they can defend the costs associated with them. A process which consumes too great a cost to rationalize, may be difficult to justify. This approach has then uncovered a potential area to be improved. Improving upon the processes which incur the costs, whether they are internal or external, is the goal of activity based management.

The application of activity based management in this thesis focuses on activity driver analysis for hazardous materials used on Wright-Patterson AFB. Activity driver analysis is only a small portion of the overall activity based management concept, but is useful in this framework. It is anticipated that pollution prevention managers at base level may be able to apply this method to reveal pollution prevention opportunities in a new fashion.

III. Methodology

This chapter discusses the data requirements as well as the methodology used to investigate the objective and investigative questions. The primary objective of this effort is to develop a technique that will assist base level managers in identifying pollution prevention opportunities through hazardous material driver analysis. A standard technique was determined by investigating the hazardous material usage of both the 788th Civil Engineer Squadron and the 445th Maintenance Squadron at Wright-Patterson Air Force Base for the first 6 months of 1996. A 6 month window of time was selected for two reasons: first, it bounds the number of separate materials to a manageable number; second, a short, recent time period ensures that the users of the materials were available for interviews, and could recall pertinent data. Interviewing was the primary method used to obtain the hazardous material driver information. Statistical procedures were then applied to test for similarity of drivers between organizations, and to lend confidence to the projection of the sample data to a larger population.

Sample Selection

Choosing the Organizations

This section outlines the procedures used in selecting the 788th CES and the 445th MS as the sample. It was desired that the selection be both applicable Air Force wide and be representative of a large percentage of extremely hazardous materials used on typical installations.

To determine the relative percentage of extremely hazardous materials used by different organizations at WPAFB in this study, data from the HazMat Cell computer system was extracted for the first 6 months of 1996. The information included not only the number and type of different materials used, but also the pounds of each material ordered.

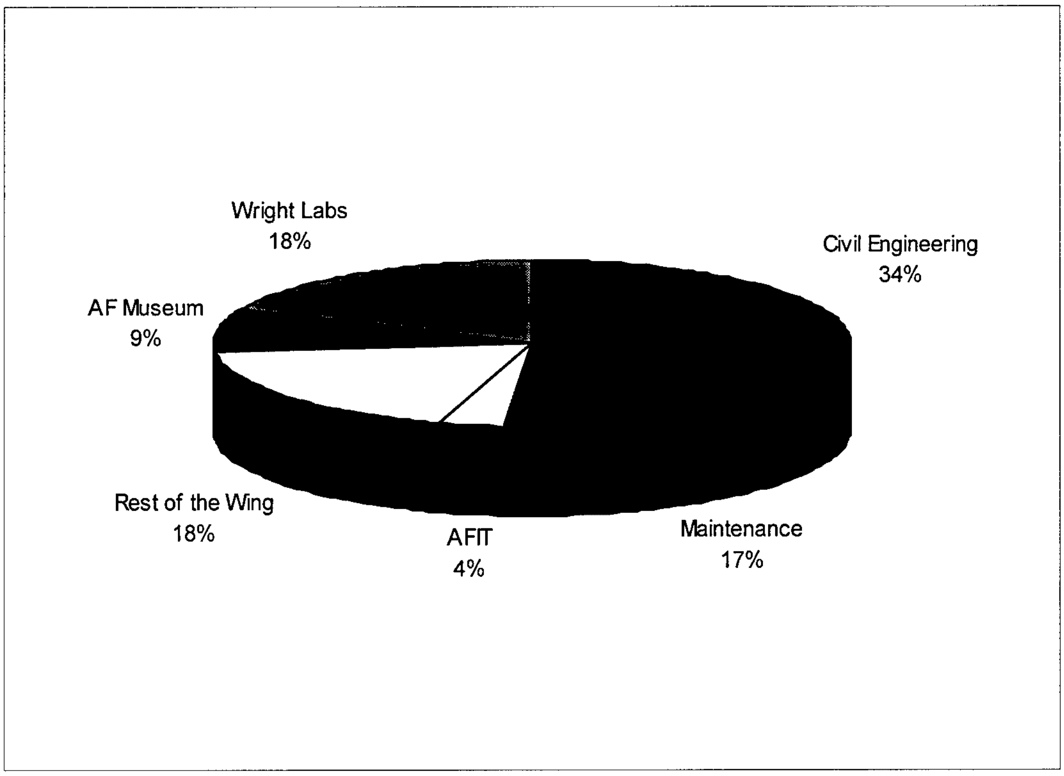

Figure 1. Class C Materials Issued (% total mass) on WPAFB from Jan 96 - 1 Jul 96

Figure 1 shows that 51% of the extremely hazardous materials issued in the first 6 months of 1996 at Wright-Patterson AFB were used by either the 788th CES or the 445th MS. Figure 2 depicts extremely hazardous materials use at a typical operational base assuming the Figure 1 percentages for Wright-Patterson AFB are applicable. Figure 2 removes the unique tenant organizations (Wright Labs, AFIT, AF Museum) at Wright-Patterson AFB to illustrate a more typical base. It is important to note that this represents only the Class C materials, the most hazardous, and not the complete hazardous materials percentages.

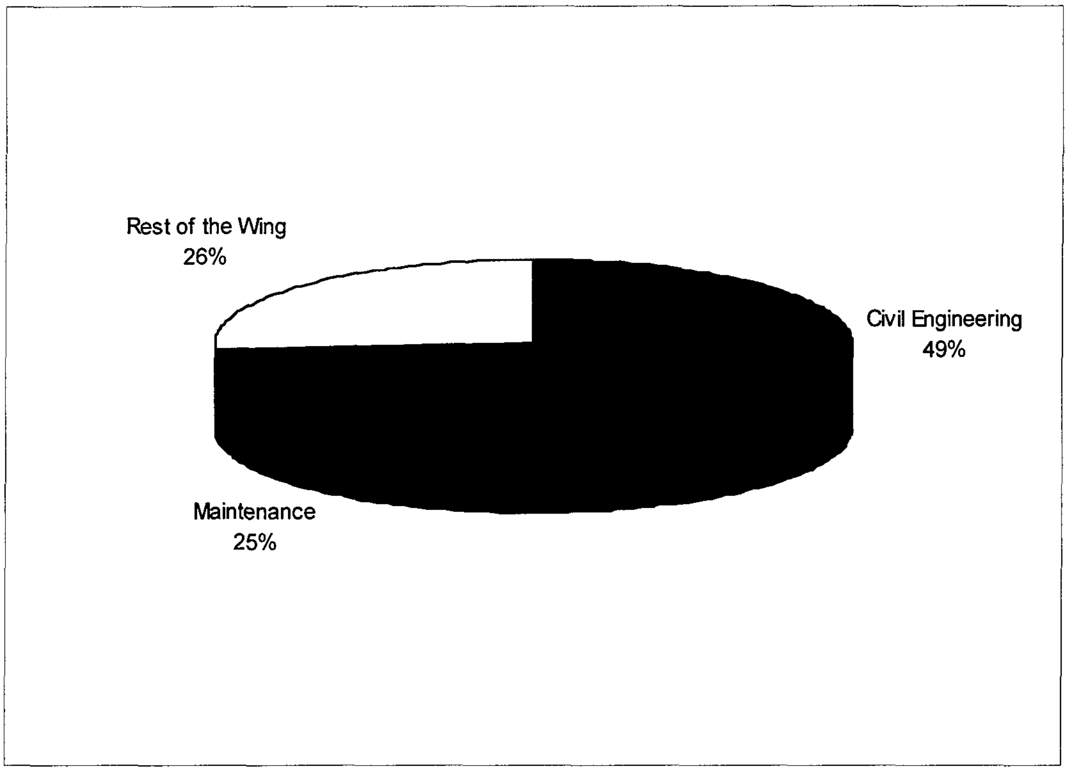

Figure 2. Class C Materials Altered for Typical Base Level Representation (% total mass)

Choosing the Materials

This section outlines the procedures used in selecting the materials analyzed in this thesis effort. There are literally thousands of hazardous materials that are used on Wright-Patterson AFB. The selection of the 788th CES and the 445th MS narrowed that number somewhat, but further bounds were required to make the amount manageable. Information gathered from the HazMat Cell and Bioenvironmental Engineering was used to further bound the sample size.

HazMat Cell. Wright-Patterson AFB has fully embraced the hazardous materials pharmacy concept, and uses a HazMat

Cell to manage hazardous materials acquisition on base. The program is based on three simple principles (88 ABW/EM-H, 1996: 1).

- No hazardous material is authorized on base without prior approval from the HazMat Cell.
- All requisitions for hazardous material must be processed through the HazMat Cell.
- All hazardous material containers must bear the Pharmacy label.

The Cell is run by a team comprised of bioenvironmental engineering, environmental directorate, supply, and dedicated HazMat Cell personnel. The computer system that the HazMat Cell employs is the Depot Maintenance Hazardous Material Management System (DM-HMMS).

Bioenvironmental Engineering. The bioenvironmental engineers on base serve as an integral member of the hazardous materials management team. AFI 48-101, Aerospace Medical Operations, delineates their responsibilities to include:

- Act as technical advisor for hazardous material use and management.
- Perform oversight for regulatory compliance and stipulate management practices.
- Participate in installation environmental management
- Support the installation's pollution prevention goals through hazardous material acquisition, control, and risk reduction analysis and consultation (AFI REFERENCE).

The significant contribution the bioenvironmental engineers make to the HazMat Cell is the coding of hazardous materials to classify all materials procured on base into separate health hazard categories.

The three codes that a material procured on base can possess are Hazcode A, B, or C. Hazcode A is reserved for any material procured on base which has been deemed non hazardous to human health after review by bioenvironmental engineering and environmental management. Examples of materials which are Hazcoded A include alkaline batteries and Windex. Hazcode B is reserved for potentially hazardous or minimally hazardous materials. Materials classified in this code include:

- Some SARA Title III materials (Toxic Release Inventory)
- Materials listed in the Threshold Limit Value (TLV) Booklet
- Materials where health exposure or an environmental standard has been set by OSHA or the EPA.
- Materials used to compile an Air Pollution Inventory.

Wright-Patterson AFB has used 6,372 different Hazcode B materials since tracking began with DM-HMMS (Parker, 1996). Examples of materials that are Hazcoded B are lithium batteries, and most of the motor oils used on base. Hazcode C is reserved for hazardous materials which pose a serious health risk or environmental threat. The characteristics that these materials can possess include:

- Suspected or known human carcinogen, mutagen, teratogen
- Radioactive material
- Acutely toxic material
- Materials where a short term exposure limit has been established
- Materials where a ceiling limit has been established
- Any of the EPA 17 Materials
- Materials requiring respiratory protective equipment

There have been 4,265 different materials procured by Wright-Patterson AFB which posses the Hazcode C classification (Parker, 1996). Examples of a Hazcode C material are lead-based paint, benzene, and toluene.

The materials selected for driver analysis in this effort were those labeled Hazcode C. This selection was based on the extreme human and environmental threat these materials possess, and the manageable number of materials the 788th CES and 445th MS use. For the six month window analyzed, there were 625 total Class C materials

Conducting the Interviews

This section outlines the procedures used in preparing for and conducting interviews with the personnel responsible for the hazardous materials usage. Included are both the process used to prepare for interviews and the general interview outline.

Interview Preparation

There are 27 and 21 different work places in the 788th Civil Engineering and the 445th Maintenance Squadron, respectively, that were analyzed in this effort. The immediate supervisor for each area was the person usually interviewed. Special exceptions were made in instances where the supervisor was unavailable. The individual areas are listed in Table 6.

Table 6.
Workplaces Interviewed

445th Workplaces	788th Workplaces
Metals Technology	Heat Plant Area B
Propulsion Section	Heat Distribution Area B
AGE	Liquid Fuels
Structural Repair	Water Treatment
NDI	HazMat and Waste
Inspection Dock	Electronics and Alarms
Fuel Systems	Locksmith
Aircraft Support Flight	Water Sewer and Gas A/C
Pneudraulics	Water Sewer and Gas B
AGC Shop	Power Production
Electro-Environmental	Exterior Electric
Survival Equipment	Hospital Maintenance
Aerospace Repair	Outside Plant Units
445th AGS	Asbestos Team
Aircraft Life Support Section	Pavement/Equipment
Communications-Navigation	CE Zone B
Systems Design	Fire Station #1
Survival Equipment Flight	KH Heat Plant
AGS Sortie Generation Flight	Grounds Area A & C
445th Logistics Group	Cathodic Protection
445th Element System	Major Vertical support
	CE Zone C
	Project Painters
	CE Zone A
	Grounds area B
	Pest Management
	Steam Distribution

These two lists of workplaces were obtained from Bioenvironmental Engineering, which maintains a separate case file on each workplace. The case files include six separate sections:

- Chronological workplace history
- Master summary and correspondence
- Physical agent exposure data
- Chemical exposure data
- Miscellaneous and special operations data
- Clinical occupational health data

The miscellaneous and special operations data section proved to be the most helpful as it contained narrative descriptions of the workplace activities, along with operating instructions (OI's), standard operating procedures (SOP's), and some technical orders (TO's) (Kauth, 1996). Studying the case files, specifically the miscellaneous and special operations data section, was a prerequisite for each interview. This provided an understanding of the workplace activities as well as a way to gain the confidence of the interviewee. For the areas in the 788th and 445th where case files were unavailable, the 1992 baseline pollution prevention survey proved to be equally helpful.

Interview questions

The format for each interview was semi-structured. A certain pattern of original questions was asked to gain the confidence and trust of the interviewee, and then a follow-up set of questions was asked about the hazardous materials drivers. Free discussion was encouraged throughout as useful information was often revealed during this conversation. The questions were developed after 4 pilot interviews, 2 from each organization, were conducted. The original question set is shown in Table 7.

Table 7.
Original Questionnaire

1. What is your view on the management of hazardous materials on base? i.e. historical perspective/evolution?
2. Do you understand the Hazcode ranking system used on base?
3. Do you know which materials you use which are Hazcoded class C?
4. What are the processes that you perform that use these hazardous materials?
5. Are any of the processes or materials used in the processes avoidable?
6. Are there any substitutes that you know of for any of the hazardous materials in question?

After the original set of questions was asked, the detailed portion of the interview followed. This is where the interviewee revealed the driver behind the material usage. Interviewees were first asked their opinion about what caused the materials to be used. After getting the interviewee opinion, follow-up questions were asked to further categorize the drivers. The follow-up questions were developed from an array of sources. Interviews with the issue point managers of the organizations provided keen insight into potential drivers. Additionally, the pilot study suggested some of the various drivers. It was important to obtain the interviewee opinion first, so that the follow-up questions did not lead them to a specific point. These questions were established to hone the interviewee responses into categories. The follow up questions are shown in Table 9.

Table 8.
Follow-Up Questions

1. Do you use this material because it is dictated in a technical order, regulation, standard operating procedure, or operating instruction?
2. Do you know of any available substitutions for the material that are less hazardous?
3. Do you use this material because it is the most efficient or takes the least amount of time?
4. Do you use this material because, "That is the way it has always been done?"
5. Do you use this material because of the AF mission (i.e. it has to be done/ordered to be done)?
6. Do you use this material because it was what was available at the issue point?
7. Do you know of any changes in the use of this material? (i.e. Is the process changing for the better?)

Once the driver was established for each of the Hazcode C materials issued to the 455th MS an the 788th CES, statistical analyses were performed.

Statistical Analysis

The statistical analysis consists of two separate questions. First, are the drivers of hazardous materials consistent between the organizations? Second, what is the confidence that each sample represents an accurate picture of the organization at Wright-Patterson AFB?

Analysis of Categorical Data

Analysis of the drivers for hazardous materials used by civil engineering and maintenance was performed using the analysis of categorical data (Devore, 1991). This was because the drivers, after being independently determined, were grouped into one of five categories.

This research effort is considered a multinomial experiment. A multinomial experiment has each trial result in one of k possible outcomes, where k is an integer greater than 2. This experiment consists of selecting n individuals from a population and categorizing each one, then p_i is the proportion of the population falling in the ith category. For this study, k represents the number of different driver categories (five). The previously defined p_i also represents the probability that any individual material will fall under category i. The n in this study is the sample number of Hazcode C materials totaling 625 (239 for civil engineering and 386 for maintenance).

Since the value of the unspecified parameter, P_i, is estimated from sample data, a chi-squared test can be performed to determine similarity between populations. The null hypothesis states that the p_i's are homogeneous for different populations (civil engineering and maintenance).

Confidence intervals

This section of the statistical analysis employed two separate methods to determine the confidence of how well each sample represented the population.

The maintenance squadron turned out to be binomial in that there were only 2 different drivers in the sample, so a large-sample confidence interval for a population proportion was used. A large-sample $100(1-\alpha)\%$ confidence interval for a population proportion p is from:

$$p_{hat} - z_{\left(\frac{\alpha}{2}\right)} \cdot \sqrt{\frac{p_{hat} \cdot q_{hat}}{n}} \quad \text{to} \quad p_{hat} + z_{\left(\frac{\alpha}{2}\right)} \cdot \sqrt{\frac{p_{hat} \cdot q_{hat}}{n}}$$

where $p_{hat}=x/n$, n is the sample size, x is the observed number of successes, and $q_{hat}=1-p_{hat}$.

Bonferroni intervals

There were four final driver categories for the civil engineering sample. To obtain a set of four confidence intervals with a family confidence of at least 95%, simultaneous intervals must be established. For 4 simultaneous intervals to sum to a 95% confidence level, each individual category must use an α value of .0125 corresponding to a 98.75% individual interval confidence. This is readily observed in equation format.

$$100(1-\alpha/4)\% = 100(1-.05/4))\% = 98.75\%$$

The four intervals run simultaneous, $(98.75)^4$, thus totaling to at least 95% family confidence.

IV. ANALYSIS AND FINDINGS

This chapter will discuss the findings of the investigative questions detailed in chapter 3. First, the interview results will be displayed in the various driver categories. Second, the statistical analysis will be performed on the categorical driver data including a chi-squared analysis, and confidence intervals.

Interview Results

The interviews with the 48 various shops in civil engineering and maintenance produced a tremendous amount of information. A consistent interview method of allowing the interviewee to state their opinion, followed by the secondary questionnaire about specific drivers, often revealed more than one possible driver for each hazardous material. For activity driver analysis to be performed, only one "primary" driver is allowed for each material. A "primary" driver category was established for each hazardous material during routine post-interview reviews. These reviews allowed for a thorough examination of the interview notes to assist in the decision of the "primary" driver. An example of this process is with a material from maintenance, methyl ethyl ketone (MEK). MEK is used because it is used because it is the most efficient chemical for various situations. The "primary" reason it is used, however, is because it is dictated in the technical orders. This rational order to the drivers made it relatively simple to determine most materials "primary" driver. For those materials that were "on the fence," judgment was exercised by the interviewer.

The driver information reduced to five general categories as potential drivers of hazardous materials usage. It is important to note that these categories were generated by the interviewee responses, not a predetermined plan. The categories are numbered 1 through 5 to make the results presentable. They are listed in table 9.

Table 9.
Hazardous Material Usage Driver Categories

Category 1	Material usage driven by **efficiency** (i.e. used because that is what takes the least amount of time)
Category 2	Material usage driven by **tradition** (i.e. that is the way it has always been done)
Category 3	Material usage driven by the **mission** (i.e. has to be done/ordered to be used) (but NOT by a category 5 situation)
Category 4	Material usage driven by what was **available at the issue point** (i.e. "We used what they gave us at issue)
Category 5	Material usage driven by **technical orders,** regulations, standard operating procedures, or operating instructions

Category 1 deals with materials driven by efficiency. Examples of materials residing in this category include most of the herbicides, and a petroleum based leak detector. Category 2 is for materials which are driven by tradition. An example of a material used by civil engineering which was used because of tradition is a sealer lacquer. Category 3 is for materials driven by the mission. This category was the most difficult to define because all of the materials in question are used to support the mission. It included materials which had to be used, or were ordered to be used, but not those required by technical orders. This category was selected as "primary" driver for materials like solder. Solder has to be used to support the mission, but is not specifically listed in any civil engineering technical order. Category 4 was reserved for those materials that were selected because that was what was available at the issue point. This revealing driver proved to be a popular answer for civil engineering. Category 5 is for materials which are driven by technical orders. This was the most cut and dry of the categories, and ranked primary if it was pertaining.

The research into the 6 month window of hazardous material usage of civil engineering and maintenance addressed 625 total materials. Each material was independently addressed. The results, broken down by category, are illustrated in table 10.

Table 10.
Total Categorical Results

Organization	Category					Individual Material Totals
	1	2	3	4	5	
Civil Engineering	24	6	72	137	0	239
Maintenance	0	0	1	0	385	386
Material Totals	24	6	73	137	385	625

The most interesting aspect of the total categorical results is that none of the materials used by civil engineering resided in category 5 (TO, regulations, SOP, or OI). Conversely, 99.74% of the materials used in maintenance reside in that same category. This illustrates the differences between the organizations. Analysis of categorical data will be used to statistically examine the results presented in Table 10.

Analysis of Categorical Data

To perform a chi-squared analysis of the data, a table of expected values had to be calculated. The expected population values are calculated using the sample values and assuming there would be a homogeneous proportion between the organizations in each driver category. The expected totals per category were calculated by summing the total number of materials for both organizations in a category, then dividing that same number of materials proportional to the overall total (i.e. 38.24% to CE and 61.76% to MS). An example calculation for the first category in the Civil Engineering row is illustrated here:

$$(24)(239)/(625) = 9.1776$$

The table of expected values is shown in Table 11.

Table 11.
Expected Totals Per Category

Organization	Expected Totals Per Category					
	1	2	3	4	5	totals
Civil Engineering	9.178	2.294	27.533	52.389	147.22	239
Maintenance	14.822	3.706	45.085	84.611	237.78	386

The null hypothesis of homogeneity states that the proportion of individuals in each driver category is the same for both of the organizations. The χ^2 statistic for comparison is 9.488 using an α value of .05 (signifying 95% confidence) and 4 degrees of freedom. The χ^2 statistic calculated from the table of expected values utilized the following formula:

$$\left[\sum_{x=1}^{5} \left[\frac{(\text{observed} - \text{estimated})^2}{\text{estimated}} \right] \right]$$

The χ^2 total for the sample taken was 625.9. Because 625.9 $\geq$ 9.488, the hypothesis of homogeneity is rejected at level .05 in favor of the conclusion that there are significant differences in the drivers behind hazardous materials used in civil engineering and maintenance. What this difference means is that pollution prevention opportunities at base-level should not be approached in the same manner for civil engineering and maintenance.

For maintenance organizations at base level to improve with respect to pollution prevention, they must address the management of the materials. This is because the materials selection process is dictated to them through technical orders. To minimize hazardous materials use, base level pollution prevention managers should encourage meticulous acquisition and management of the hazardous materials. Unfortunately, this offers limited opportunities at best. The best opportunities for improvement of hazardous materials usage by maintenance will occur at a level above the base. Bases can merely question the requirements stated in TO's. At the Air Force level, changes can be made to TO's that will affect the entire Air Force.

Civil engineering, on the other hand, due to its distribution of hazardous material drivers, offers significantly higher opportunities for improvement.

Civil engineering hazardous material drivers broken down in a pareto analysis are presented in Figure 3.

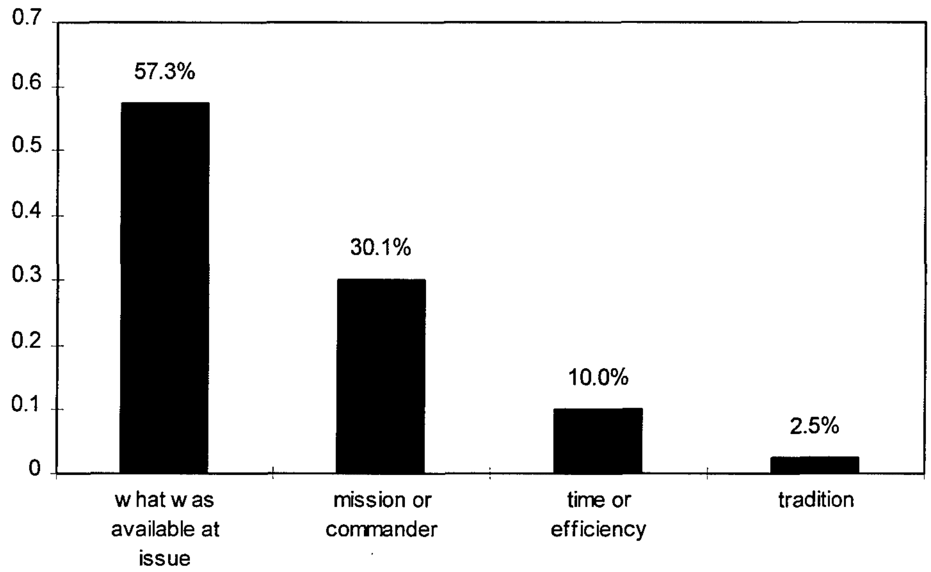

Figure 3. Pareto Analysis of Civil Engineering (% of 239 total Materials)

Figure 3 illustrates that significant opportunities for improvement may be available at the issue point. Figure 3 represents the percentages of 239 materials from civil engineering that fall into each category. Because Figure 3 shows the number of materials and not the distribution by mass, the data used to calculate Figure 2 was reexamined. Figure 2 reveals that approximately 17.84% (by mass) of materials used by civil engineers at a typical Air Force installation are used because it was what was available at the issue point.

Does this mean that all of these materials could be replaced with less hazardous materials? Certainly not. However, this does reveal that there may be pollution prevention opportunities available at base level which could be found by investigating the issue points. This could include examining such things as the training level of the issue point managers, and the interface between issue point managers and the HazMat Pharmacy.

Confidence in Results

This section of the statistical analysis employed two separate methods to determine how well the samples from civil engineering and maintenance represented their respective populations. The fact the driver proportions obtained are from a sample implies that they are point estimates. Though they would represent the best guess for the true value of the actual proportions, they will almost never equal it. Because of this, some measure of how close the point estimate is likely to be to the true value is required (Devore, 1991:275). This is done using confidence intervals.

The maintenance squadron was determined using the large sample confidence interval for the population proportion at a level of 95% confidence. This was used because the maintenance squadron turned out to be a binomial analysis, meaning only two possible outcomes. The results of this analysis conclude that, with a 95% confidence, between 99.23% and 100% of the materials used by maintenance are driven by technical orders.

The civil engineering squadron represents a more challenging analysis. Using individual confidence intervals of 98.75%, a family confidence level of at least 95% is obtained. This is the premise of the Bonferroni. The individual confidence intervals are illustrated in Table 12.

Table 12.
95% Confidence Interval Percentages for Civil Engineering

Category	Driver	Original 98.75% Confidence	95% Family Confidence	
			lower bound	upper bound
4	Available at issue	57.3	50.1	64.5
3	Mission or commander	30.1	23.5	36.8
2	Time or efficiency	10	14.4	5.7
1	Tradition	2.5	0.2	4.5

This illustration validates the previously stated comment that a large portion of hazardous materials used at base-level are ripe for pollution prevention opportunities. It can be stated with a 95% confidence that between 50.1% and 64.5% of the materials used by civil engineering at base level are driven by the issue point availability.

Summary

The results presented in this chapter represent civil engineering and aircraft maintenance at Wright-Patterson AFB. The success this sample had in illustrating pollution prevention opportunities was the basis for the general method suggested in Chapter 5.

V. Conclusions and Recommendations

The objective of this effort was to investigate the use of activity driver analysis as a means to reveal pollution prevention opportunities at the base level. Based upon the successes of the Wright-Patterson example, a general method for base level environmental management to investigate the drivers of hazardous materials in order to identify pollution prevention opportunities can be suggested. This general method is not intended to be the panacea for the problem of identifying opportunities, but simply an additional method for bases to uncover possibilities.

General Methodology

This section of the thesis will suggest a standard approach that Air Force installations can use to reveal pollution prevention opportunities by employing activity driver analysis. The approach suggested includes six steps. These steps were developed after investigative questions one and two of this effort were completed. The six steps are listed in Table 13.

Table 13.
Six Steps for Activity Driver Analysis

Step 1	Choosing the organizations
Step 2	Choosing the materials
Step 3	Determining the sample
Step 4	Determining the driver
Step 5	Breaking down the drivers into categories
Step 6	Analyzing the data and identifying opportunities

This research shows that activity based management can be useful in the realm of hazardous materials management. Does this mean that the Air Force should switch to an activity based accounting system? Certainly not. What this thesis reveals is that by utilizing a subset of the activity based management theory, activity driver analysis, bases can reveal prevention possibilities.

The first step that needs to be taken in this process is to choose where activity driver analysis should be applied, meaning what organizations should be looked at. In this thesis, organizations were chosen for two reasons. The fact that most bases have aircraft maintenance, and all bases have civil engineers, led to the selection of those two organizations. Additionally, the significant volume of hazardous materials that those two organizations represent was a prime factor in their selection. This method, though valid for this thesis effort, does not have to be the standard method. The organizations selected for activity driver analysis need only to be the organizations which the base wants to improve. The organization that uses the largest volume of hazardous materials is a good starting place, but not required.

The second step in the process is to choose the materials which are targeted for improvement. This is a difficult step to provide specific guidance on because most installations code their materials, and specifically their hazardous materials, in different ways. WPAFB uses the coding system established by DM-HMMS which is now utilized at 24 military installations. Regardless of installation, the selection of materials will be crucial for two primary reasons. First, it will determine the amount of effort required to perform the analysis. Second, driver analysis may vary depending upon the level of hazard material. The research in this thesis focused on the most hazardous materials, those coded C, so as to bound the study to a reasonable amount and also consider those most threatening to human health.

After the organizations and materials are selected, the sample needs to be determined in the third step. This step will vary depending upon the first two steps in the process. The consequential element of this step is choosing a sample that is representative of the population. For some efforts, the results of the first two steps will lead to a small, finite quantity of materials that can be completely sampled. For other larger efforts, the first two steps may lead to a large amount of materials to be analyzed. In this case statistical methods will have to be employed to ensure a representative sample is selected.

The fourth step is the crux of the effort, determining the drivers of the material used. Interviews were successfully used in this thesis effort to determine hazardous material drivers. Unless there is a person knowledgeable of each material in a sample, interviews will be the most successful method of obtaining the driver information. Unfortunately, the interview process is not cut and dry. Selecting who should be interviewed, along with selecting the interview technique, is critical in the outcome of this step. In this thesis, the supervisors of the shops responsible for the specific materials were interviewed. This was done in the interest of time, as the supervisors were tied to the individual materials by name in the DM-HMMS system. The interview technique used in this thesis was semi-structured. It worked well in the Air Force setting because it was a non-attribution environment, and free discussion was encouraged. The discussions provided key information in the determination of the hazardous material drivers. In general, the interview technique should be determined considering both the interviewer, and more importantly, the interviewee's levels of experience.

The fifth step in the process is time consuming and tedious, but crucial to the success of the effort. This is where the drivers are broken down into categories. A general knowledge of how activity driver analysis works is a prerequisite to conduct this step. Each activity can have more than one driver, but ultimately a "primary" driver must be selected for each activity. This is where human judgment comes into play. The person performing the analysis must use a consistent method in determining the driver for each hazardous material using activity.

The sixth and final step of the process is the reason bases should perform the analysis. Analyzing the results and determining where pollution prevention efforts should be focused is the whole point behind this methodology. This thesis revealed some important differences between civil engineering and aircraft maintenance. Additionally, the analysis yielded significant insight into which areas could be most ripe for improvement within the individual organizations.

Conclusions

The first investigative question dealt with determining the drivers of hazardous materials and grouping them into analyzable categories. Based on the interviews conducted, and the synthesis of that information, five overall driver categories were determined for 625 extremely hazardous materials. The defining words for the five categories each material could fall into were: efficiency, tradition, mission, availability at issue, and technical orders. Interestingly, none of the materials from civil engineering fell into the 5th category (technical orders). Conversely, 99.74% of the materials used in aircraft maintenance fell into that category. This disparity was proven statistically.

The second investigative question dealt with evaluating the results statistically to compare organizations and determine which areas have the greatest pollution prevention opportunities at base level. The civil engineering squadron was shown to have significantly more opportunities for improvement in the area of pollution prevention at the base level. The caveat "at the base level" is the key in this observation as the 445th maintenance squadron is required to use 99.74% of its materials by technical orders.

Improvements in the realm of pollution prevention for maintenance at the base level would be slow at best. The base level organizations can merely suggest changes to the technical orders in which the decision ultimately rests at higher levels of authority. For civil engineering, the focus should be on the issue points. This does not infer that the issue points are operating haphazardly, just that the driver behind material usage pointed to using "what was available at issue." Investigation into the methods used by issue point managers to select and manage the materials used by civil engineers could reveal many areas for improvement.

Recommendations

Air Force level Environmental Management should review the results of this research and consider applying activity driver analysis to hazardous materials usage with the intent of revealing pollution prevention opportunities. This type of analysis could be conducted at any level in the Air Force and applied accordingly. Additionally, if guidance were prepared for installations based on this research, then the base-level environmental managers could apply it at their own discretion.

Follow-on Research Opportunities

This thesis effort has just scratched the surface of possibilities of applying activity based theory to the Air Force. Follow-on research opportunities could branch in many directions. Efforts could be made to determine drivers for other common Air Force operations such as medical or vehicle maintenance. Determining specific hazardous material drivers by Major command is also a potential area for further research.

Investigating the management of the issue points in civil engineering could be the next building block on top of this effort. A detailed look into the selection, approval, and tracking procedures could possibly reveal excellent opportunities for pollution prevention based initiatives.

To step further back in the activity based methodology and determine how the Air Force could apply an activity based accounting system is another possible avenue of future research. The Air Force could certainly benefit from a system that considers all the costs associated with activities.

APPENDIX A

ORG_SYM	Workplace	Issue Pt	ZONE	MATERIAL	MSDS #	LBS OUT	Driver
CEG/CE00	Outside	IPC27A1	C170A1	56707 PST H TEMP ANTI-GALLING	139253	0.12	1
	Plant Units	IPC27A1	C170A1	SO-SURE GLOSS GREEN 14062 (24-	89925	0.59	3
		IPC27A2	C170A1	CHAMPION GRAPHITE	149123	0.75	4
		IPC27A2	C170A1	O-S-598	95233	104.43	3
		IPC27A2	C170A1	SO-SURE BLUE 15102 (14-152)	117962	0.95	3
		IPC27A2	C170A1	SO-SURE ENAM ID 24-190 G, GLOS	89893	1.00	3
		IPC27A2	C170A1	STAY CLEAN LIQUID FLUX #21;PN3	139122	0.25	3
		IPC27A2	C170A4	SO SURE GLOSS BLACK 17038 (14-	106599	0.87	3
CEG/CECX	Drafting	IPC27A2	FACC11A	SO SURE FLUORESCENT RED 1A RED	126280	0.62	2
CEG/CEFO	Fire Station #1	IPC27A1	C163A1	CONCEPT TB DISINFECTANT DEODOR	133114	0.90	4
CEG/CEOBD	Heat	IPC27A1	B36A13	112244-31,(335 A)"GROUP A"(SMA	185908	50.05	1
	Distribution	IPC27A1	B36A13	6Y648 SLIP PLATE AEROSOL	148832	0.75	3
		IPC27A1	B36A13	SO-SURE FLUORESCENT ORANGE IC	126285	1.00	4
		IPC27A2	B36A13	17FC BRAZING ROD	150130	4.00	4
		IPC27A2	B36A13	7018 XLM	131019	10.00	1
		IPC27A2	B36A13	916, PVC CLEAR MEDIUM BODIED C	148039	0.80	3
		IPC27A2	B36A13	FLEETWELD 5P	102261	50.01	1
		IPC27A2	B36A13	SO SURE WHITE 37875 14-370	114092	0.95	4
		IPC27A2	B36A13	SO-SURE GLOSS WHITE 17875 (24-	89945	0.93	4
		IPC27A2	B36A13	SO-SURE ORANGE 12197 (14-120)	114065	0.62	4
CEG/CEOIEP	Power	IPC27A1	C22F1	FOAMY ENGINE BRITE DEGREASER (	150047	1.12	4
	Production	IPC27A1	C22F1	SO SURE ZINC CHROMATE GREEN CO	123346	0.73	2
		IPC27A2	C22F1	SO SURE GLOSS BLACK 17038 (14-	106599	0.87	2
		IPC27A2	C22F1	SO SURE LACQUER OLIVE DRAB 140	114076	1.00	2
CES/CEOA	KH Heat	IPB4CA1	K1240A1	CLEANING SOLVENT/PART 755-59	149611	1.01	3
	Plant	IPC27A2	K1240A1	EN ALKYD SEMI-GLOSS LO VOC CT	117445	11.20	3
		IPC27A2	K1240A1	THINNER, PAINT TYPE III - ODOR	149320	5.92	3
		IPC27A2	K1240A1	TOUCH N FOAM EXPANDING HOLE FI	50680	0.83	4
CES/CEOAD	Steam	IPC27A1	C22W1	SO SURE GRAY 16440 14-183	121452	0.62	4
	Distribution	IPC27A2	C22W1	01922, RIDGID DARK THREAD CUTT	187988	7.72	1
		IPC27A2	C22W1	60AP SMAW CARBON STEEL	149826	50.01	3
		IPC27A2	C22W1	7018 XLM	131019	10.00	3
		IPC27A2	C22W1	CODE-ARC 7018 MR ELECTRODES	94451	50.01	3
		IPC27A2	C22W1	FLEETWELD 5P	102261	50.01	3
		IPC27A2	C22W1	LOCTITE (R)QUICK METAL(R) 660/	149609	0.11	3
		IPC27A2	C22W1	SO SURE GRAY 16187 14-181	117991	0.97	4
		IPC27A2	C22W1	SO-SURE CLEAR 24-100 (G/O)	89516	1.00	4
		IPC27A2	C22W1	SO-SURE ENAM ID 24-190 G, GLOS	89893	1.00	4
		IPC27A2	C22W1	SO-SURE FLAT BLACK 37038 SPRAY	89520	1.00	4
		IPC27A2	C22W1	TOUCH N FOAM EXPANDING HOLE FI	50680	0.83	1
		IPC2A2	C22W1	SO SURE CORROSION PREVENTIVE C	125660	0.86	4
		IPC2A2	C22W1	SO-SURE YELLOW 13655-14B133 (G	92362	1.00	4
CES/CEOE	HazMat	IPC27A1	C19C2	9983 CARLON ALL WEATHER QUICKS	18091	1.94	1
CES/CEOGA	Pest	HMRESAL	A278A1	6R210	135789	2.86	1
	Management	IPB36A1	B745D3	TT-E-487E & AMD, 1 CLR NO 1618	111752	9.60	1
		IPC27A1	A278A1	"HYVAR" X-L HERBICIDE/PART CWE	149685	9.95	1
		IPC27A1	A278A1	PT3-6-10, AEROSOL INSECTICIDE	186921	1.80	1
		IPC27A1	A876B1	"HYVAR" X-L HERBICIDE/PART CWE	149685	9.95	1
		IPC27A1	B745D3	SO SURE FLUORESCENT ORANGE 1C	126286	0.96	3

788th Civil Engineering

ORG_SYM	Workplace	Issue Pt	ZONE	MATERIAL	MSDS #	LBS OUT	Driver
CES/CEOGA	Pest	IPC27A1	A278A1	"HYVAR" X-L HERBICIDE/PART CWE	149685	9.95	1
	Management	IPC27A1	A278A1	21581 OFTANOL 2 INSECTICIDE	150594	21.21	1
		IPC27A1	A278A1	D-TRANS ALLETHRIN RESMETHRIN	133227	0.72	1
		IPC27A1	A278A1	DURSBAN TC TERMITICIDE CONCENT	143527	9.20	1
		IPC27A1	A278A1	TEMPO 20 WP, TEMPO 20% WETTABL	187557	0.03	1
		IPC27A2	A278A1	SO-SURE ORANGE 12197 (14-120)	114065	0.62	4
		IPC2A2	A278A1	PWC POLYURETHANE AEROSOL COLO	17715	1.00	4
CES/CEOHV	Vertical	IPB36A1	C22B2	INSTANT SUPER CLEANER/DEGREASE	73011	3.37	4
	Support	IPC27A2	C22B1	22C870, SO-SURE GLOSS WHITE 17	149392	0.49	3
		IPC27A2	C22B1	SO-SURE ENAM ID 24-190 G, GLOS	89893	1.00	3
		IPC27A2	C22B1	SO-SURE ENAMEL CLEAR	89517	2.00	3
		IPC27A2	C22B2	AIRCO EASY ARC #7014	150167	50.01	3
		IPC27A2	C22B2	FLEETWELD 5P	102261	50.01	3
		IPC27A2	C22B2	SO SURE GRAY 16187 14-181	117991	0.97	3
		IPC27A2	C22B2	SO SURE GRAY 16440 14-183	121452	0.97	3
		IPC27A2	C22B3	SO-SURE OLIVE GREEN 14064 (14-	114079	0.94	3
CES/CEOIC	Cathodic	IPC27A2	C22P1	916, PVC CLEAR MEDIUM BODIED C	148039	0.80	4
	Protection	IPC27A2	C22P1	C371, OATELY CLEANER	148090	0.40	4
		IPC27A2	C22P1	PARABOND C-70	40276	0.80	4
		IPC27A2	C22P1	PARABOND P-10	70992	0.91	4
		IPC27A2	C22P1	ROSIN CORE SOLDER,WRA,WRMA,WR	104202	1.00	3
		IPC27A2	C22P1	SOLDER	73180	1.00	3
CES/CEOIE	Exterior	IPB36A1	C22J1	F-M1364 ADHESIVE CLEAR MMMA 10	103872	0.13	3
	Electric	IPC27A1	C22J1	ENAMEL, FLOOR AND DECK, 16187	18017	9.70	3
		IPC27A1	C22J1	FAST DRY FIELD MARKING PAINT	150437	1.46	3
		IPC27A2	C22J1	EPOXY ADHESIVE HARDENER	118616	0.06	3
		IPC27A2	C22J1	PARABOND P-10	70992	0.91	3
		IPC27A2	C22J1	PSI-690 PRIMER	121725	0.05	3
CES/CEOP	Pavement	IPC27A2	A876C1	SO-SURE YELLOW 13655-14B133 (G	92362	1.00	4
	/Equipment	IPC27A1	A876C1	ENAMEL, OLIVE DRAB, 14064	114080	0.69	4
		IPC27A2	A876C1	SO-SURE ENAM ID 24-190 G, GLOS	89893	1.00	4
CES/CEOUF	Liquid	IPC27A1	C29A1	GAS LEAK DETECTOR	110245	0.52	1
	Fuels	IPC27A2	C29A1	22C870, SO-SURE GLOSS WHITE 17	149392	0.49	4
		IPC27A2	C29A1	6300 PETROLEUM BASED RUST PREV	73881	5.00	1
		IPC27A2	C29A1	SO SURE WHITE 37875 14-370	114092	0.95	4
CES/CEOUT	Water	IPB36A1	C19D1	SO SURE ZINC CHROMATE GREEN CO	123346	0.90	3
	Treatment	IPB36A1	C19D1	TT-E-489H LOW VOC 15045 BLUE	107542	72.82	3
		IPC27A1	C19D1	82C833, SO SURE YELLOW PRIMER	147771	0.70	3
		IPC27A1	C19D1	BUFFER SOLUTION HARDNESS #1	120058	0.27	3
		IPC27A1	C19D1	CHLORINE	149356	150.04	3
		IPC27A1	C19D1	ENAMEL, FLOOR AND DECK, 16187	18017	9.70	3
		IPC27A1	C19D1	SO SURE ZINC CHROMATE GREEN CO	123346	0.73	3
		IPC27A2	C19D1	22C870, SO-SURE GLOSS WHITE 17	149392	0.49	3
		IPC27A2	C19D1	3005, 1 SHOT ART & SIGN POSTER	80196	0.25	3
		IPC2A2	C19D1	CHLORINE	149356	150.04	3
CES/CEZFA1	Zone A	HMRESAL	CE A1-F	STAIN, OIL TYPE, WOOD INTERIOR	94679	1.74	4
		IPC27A1	CE A1-E	AEROSOL FOOD GRADE SILICONE	148647	0.67	1
		IPC27A2	CE A1-E	BB-C-120,CHLORINE,TECHNICAL	104954	11.19	3
		IPC2A2	CE A1-J	PSI-690 PRIMER	121725	0.05	4
		IPC27A1	CE A2-E	202-6, NU-BRITE	149328	25.05	4

ORG_SYM	Workplace	Issue Pt	ZONE	MATERIAL	MSDS #	LBS OUT	Driver
CES/CEZFA1	Zone A	IPC27A1	CE A2-E	GAS LEAK DETECTOR	110245	0.00	4
		IPC27A1	CE A2-J	704012 SEALER SANDING LACQUER	116402	8.35	2
		IPC27A1	CE A2-J	GSA GENERAL PURPOSE ADHESIVE S	125685	1.17	4
		IPC27A1	CE A2-J	PSI-690 PRIMER	121725	0.05	4
		IPC27A1	CE A2-J	SO SURE RUBBER ADHESIVE, AEROS	125680	0.85	4
		IPC27A1	CE A2-J	TOUCH N FOAM EXPANDING HOLE FI	50680	0.87	4
		IPC27A1	CE A2-O	B-20 (ON CAN NO. 5550), BREWER	149129	41.74	1
		IPC27A2	CE A2-J	2213,FRANKLIN TITEBOND WOOD GL	97303	8.72	4
		IPC27A2	CE A2-P	KWIK SEAL TUB & TILE CAULK	38751	0.52	1
		IPC27A2	CE A2-P	SOLDER	73180	1.00	3
		IPC27A1	CE A3-J	CONTACT CEMENT	118978	6.24	1
		IPC27A1	CE A3-J	NEOPRENE RUBBER/PHENOLIC RESIN	118979	6.24	4
		IPC27A1	CE A3-N	B54 T104 ULTRADEEP BASE	151541	8.35	2
		IPC27A2	CE A3-I	NICKEL-SAFE ICE MACHINE CLEANE	147485	0.59	4
		IPC27A2	CE A3-J	RA-12 (ACE HARDENER), FRANKLIN	18168	0.66	4
		IPC27A2	CE A3-J	SO SURE WHITE 37875 14-370	114092	0.95	4
		IPC27A2	CE A3-J	SO-SURE CLEAR 24-100 (G/O)	89516	1.00	4
		IPC27A2	CE A3-J	TOUCH N FOAM EXPANDING HOLE FI	50680	0.83	1
		IPC27A2	CE A3-N	CONTACT CEMENT	118978	6.24	4
		IPC27A2	CE A3-P	916, PVC CLEAR MEDIUM BODIED C	148039	0.80	4
		IPC27A2	CE A3-P	C371, OATELY CLEANER	148090	0.40	4
CES/CEZFB1	Zone B	IPB36A1	CE B1-E	SO SURE ALUMINUM 17178 14-160	118008	0.85	4
		IPC27A1	CE B1-G	916, PVC CLEAR MEDIUM BODIED C	148039	0.80	4
		IPC27A1	CE B1-I	SO-SURE ENAM ID 24-190 G, GLOS	89893	1.00	4
		IPC27A1	CE B1-K	SHUR STIK 90 DRYWALL ADH.	17762	1.81	4
		IPC27A1	CE B1-L	PARABOND M-250	187955	6.78	4
		IPC27A2	CE B1-E	CLEANING SOLVENT/PART 755-59	149611	0.75	4
		IPC27A2	CE B1-K	22C870, SO-SURE GLOSS WHITE 17	149392	0.49	4
		IPC27A2	CE B1-K	SO-SURE ENAM ID 24-190 G, GLOS	89893	1.00	4
		IPC27A2	CE B1-K	TOUCH N FOAM EXPANDING HOLE FI	50680	0.83	4
		IPC27A2	CE B1-L	TOUCH N FOAM EXPANDING HOLE FI	50680	0.83	4
		IPB36A1	CE B3-P	TOUCH N FOAM EXPANDING HOLE FI	50680	0.87	4
		IPC27A1	CE B3-I	GAS LEAK DETECTOR	110245	0.52	4
		IPC27A2	CE B3-E	00203, MASTER GASKET(R) SEALAN	148011	0.10	4
		IPB36A1	CE B4-H	30783-8OZ OATEY PURPLE PRIMER/	40139	1.00	3
		IPB36A1	CE B4-H	C371, OATELY CLEANER	148090	0.41	3
		IPB36A1	CE B4-J	RA-12 (ACE HARDENER), FRANKLIN	18168	0.72	4
		IPB36A1	CE B4-J	TOUCH N FOAM EXPANDING HOLE FI	50680	0.87	4
		IPC27A1	CE B4-N	CONTACT CEMENT	118978	6.24	4
		IPC27A1	CE B4-N	SO-SURE ENAM ID 24-190 G, GLOS	89893	1.00	4
		IPC27A2	CE B4-J	TOUCH N FOAM EXPANDING HOLE FI	50680	0.83	4
		IPC27A2	CE B4-K	PSI-690 PRIMER	121725	0.05	4
		IPC27A2	CE B4-N	NEOPRENE RUBBER/PHENOLIC RESIN	118979	7.47	4
		IPC27A2	CE B4-N	SO-SURE CLEAR 24-100 (G/O)	89516	0.66	4
		IPC27A2	CE B4-P	SOLDER	73180	2.00	3
		IPC2A2	CE B4-I	SO-SURE ENAM ID 24-190 G, GLOS	89893	1.00	4
CES/CEZFC1	Zone C	IPC27A1	CE C1-E	GAS LEAK DETECTOR	110245	0.52	4
		IPC27A1	CE C1-G	56707 PST H TEMP ANTI-GALLING	139253	0.12	4
		IPC27A1	CE C1-H	916, PVC CLEAR MEDIUM BODIED C	148039	0.80	3
		IPC27A1	CE C1-J	WET/DRY SURFACE PLASTIC ROOF C	149372	46.01	3
		IPC27A1	CE C1-K	PSI-690 PRIMER	121725	0.05	3
		IPC27A1	CE C1-N	CONTACT CEMENT	118978	6.24	1
		IPC27A2	CE C1-E	NICKEL-SAFE ICE MACHINE CLEANE	147485	0.59	4
		IPC27A2	CE C1-E	SO SURE GRAY 16440 14-183	121452	0.97	4
		IPC27A2	CE C1-H	C371, OATELY CLEANER	148090	0.40	4

ORG_SYM	Workplace	Issue Pt	ZONE	MATERIAL	MSDS #	LBS OUT	Driver
CES/CEZFC1	Zone C	IPC27A2	CE C1-N	SO-SURE ENAMEL CLEAR	89517	1.00	4
		IPC27A2	CE C1-P	SCOTCH-GRIP 847-L RUBBER & GAS	113472	1.84	4
		IPC27A1	CE C2-E	202-6, NU-BRITE	149328	25.05	4
		IPC27A1	CE C2-P	916, PVC CLEAR MEDIUM BODIED C	148039	0.80	3
		IPC27A2	CE C2-E	C371, OATELY CLEANER	148090	0.40	4
		IPC27A2	CE C2-E	SOLDER	73180	3.00	3
		IPC27A2	CE C2-I	202-6, NU-BRITE	149328	50.09	4
		IPC27A2	CE C2-J	INSTA-SEAL FOAM SEALANT, 12 OZ	30891	0.97	3
		IPC27A2	CE C2-P	VC9923 PVC SOLVENT CEMENT	124889	0.91	4
		IPC27A1	CE C3-I	CON-COIL	149036	43.95	3
		IPC27A2	CE C3-G	SO SURE GRAY 26134 (14-284)	118034	0.97	4
		IPC27A2	CE C3-I	INSTANT SUPER CLEANER/DEGREASE	73011	1.65	4
		IPC27A2	CE C3-J	SO-SURE BLUE 15102-14B152(G/0)	117961	1.00	4
		IPC27A2	CE C3-P	4699, NIBCO PURPLE PRIMER	148911	0.01	4
		IPC27A2	CE C3-P	5198, HERCULES CPVC PLASTICS P	154031	0.97	4
CES/CEZFH	Paint	IPB4CA1	C22A2	ENAMEL HEAT RESISTING	17929	3.45	4
	Shop	IPB4CA1	C22A2	PWC243, PWC POLYURETHANE AEROS	148100	0.81	4
		IPC27A1	C22A2	04320 TAC SPRAY ADHESIVE	149164	1.34	4
		IPC27A1	C22A2	1D492/6587, SPREAD ULTRA EXTER	149459	8.00	1
		IPC27A1	C22A2	3010, PRO-TYPE STAIN KILLER (O	153255	2.97	4
		IPC27A1	C22A2	4030, 80 4030 M O N STAIN MAR	149217	7.20	4
		IPC27A1	C22A2	706052, NEUTEC LIQUID PAINT &	185691	6.80	4
		IPC27A1	C22A2	706053,NUTEC SEMI PASTE PAINT	185670	6.80	4
		IPC27A1	C22A2	ENAMEL HEAT RESISTING	17929	6.91	4
		IPC27A1	C22A2	ENAMEL, FLOOR AND DECK, 16187	18017	9.70	4
		IPC27A1	C22A2	ENAMEL,ALKYD,GLOSS 16187	106165	8.32	4
		IPC27A1	C22A2	LATEX REDWOOD STAIN, 33	149292	8.40	4
		IPC27A1	C22A2	PAINT, TRAFFIC, HIGHWAY-WHITE	123427	65.22	3
		IPC27A1	C22A2	PRO-TYPE STAIN KILLER (OIL-BAS	149416	2.15	4
		IPC27A1	C22A2	QUICK DRY LACQUER CLEAR LAB #	149985	0.69	4
		IPC27A1	C22A2	SO-SURE FLUORESCENT ORANGE IC	126285	1.00	4
		IPC27A1	C22A2	SO-SURE FLUORESCENT RED IA RED	126279	0.92	4
		IPC27A1	C22A2	WOODSEALER,SANDING,LOW LUSTER	148104	7.88	4
		IPC27A1	C22A4	600 INDUSTRIAL ENAMEL 13538, B	111801	8.80	4
		IPC27A1	C22A4	THINNER DOPE & LACQUER-CELLULO	94051	32.97	4
		IPC27A1	C22A4	TT-S-190F SANDING SEALER, CODE	116398	8.16	4
		IPC27A1	C22A4	WHITE 37875	114096	0.93	4
		IPC27A2	C22A1	152L,1 SHOT LETTERING ENAMEL	137916	0.74	4
		IPC27A2	C22A2	04320 TAC SPRAY ADHESIVE	149164	1.08	4
		IPC27A2	C22A2	1782T INT PAINT BLACK CONCENTR	152455	2.09	4
		IPC27A2	C22A2	1810, KILZ	148057	2.00	4
		IPC27A2	C22A2	3580 SPRED HOUSE MASONRY & STU	30672	8.00	4
		IPC27A2	C22A2	4520 GLID-GUARD ALKYD INDUSTRI	26639	8.00	4
		IPC27A2	C22A2	4537-5PFR, GLID-GUARD ALKYD IN	148979	7.80	4
		IPC27A2	C22A2	6900 PAINT, LATEX, LIFEMAS PR	14661	11.76	4
		IPC27A2	C22A2	BLACK GLOSS ALKYD VC65087	111813	8.64	4
		IPC27A2	C22A2	DRYLOK DOUBLE DUTY SEALER WHIT	65883	40.01	3
		IPC27A2	C22A2	GREEN CP-3890-1000 AEROSOL	126294	1.00	3
		IPC27A2	C22A2	LIFEMASTER PRO HI-BUILD 5440 S	148016	40.01	1
		IPC27A2	C22A2	SO-SURE CLEAR 24-100 (G/O)	89516	1.00	4
		IPC27A2	C22A2	SO-SURE ENAM ID 24-190 G, GLOS	89893	1.00	4
		IPC27A2	C22A2	THINNER, PAINT TYPE III - ODOR	149320	5.92	4
		IPC27A2	C22A2	TT-E-487E & AMD, 1 CLR NO 1618	111758	48.01	4
		IPC27A2	C22A2	TT-P-115F, TYPE I WHITE	123428	68.02	3
		IPC27A2	C22A4	4575, 1918 GLID-GUARD ALKYD IN	150089	8.00	4
		IPC27A2	C22A4	INSTANT SUPER CLEANER/DEGREASE	73011	1.65	4

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ORG_SYM	Workplace	Issue Pt	ZONE	MATERIAL	MSDS #	LBS OUT	Driver
CES/CEZFH	Paint	IPC27A2	C22A4	SO SURE ALUMINUM 17178 14-160	118008	0.85	4
	Shop	IPC27A2	C22A4	TT-E-489H ENAMEL, ALKYD, GLOSS	107546	8.32	4
		IPC27A2	C22A4	TT-S-190F SANDING SEALER, CODE	116398	7.04	4
		IPC29A1	C22A4	RUSTMASTER ENAMEL 1225 SERIES-	149943	0.68	3
CES/CEZFS	Asbestos	IPC27A1	A862A1	SO SURE RUBBER ADHESIVE, AEROS	125680	0.85	3
	Team	IPC27A1	A862A1	SO-SURE ENAM ID 24-190 G, GLOS	89893	1.00	3
		IPC27A2	A862A1	60AP SMAW CARBON STEEL	149826	50.01	3
		IPC27A2	A862A1	CHIL-PERM CP-30	63316	9.60	3
		IPC27A2	A862A1	PSI-690 PRIMER	121725	0.05	3
CES/CEZM	Hospital	IPC27A1	A830F10	56707 PST H TEMP ANTI-GALLING	139253	0.12	4
	Maintenance	IPC27A1	A830F3	7400206 DEPEND ACTIVATOR	137814	0.06	3
		IPC27A1	A830F3	7500206 DEPEND NO-MIX ADHESIVE	137815	0.05	3
		IPC27A1	A830F3	AMERCOAT, HIGH PERFORMANCE EPO	151457	2.09	3
		IPC27A1	A830F3	AMERCOAT, HIGH PERFORMANCE EPO	151471	8.35	3
		IPC27A1	A830F3	CONTACT CEMENT	118978	6.24	4
		IPC27A1	A830F4	916, PVC CLEAR MEDIUM BODIED C	148039	0.80	4
		IPC27A1	A830F6	SO-SURE ENAM ID 24-190 G, GLOS	89893	0.64	4
		IPC27A1	A830F7	DL1543-55, FORMULA	188033	475.19	3
		IPC27A1	A830F7	PRECISION BLUE LAYOUT FLUID #5	113954	0.75	4
		IPC27A1	A830F7	SO SURE PRIMER, GRAY PRIMER, I	115504	0.66	4
		IPC27A1	A830F7	SO-SURE GRAY 36306 (104-380)	93906	1.00	4
		IPC27A2	A830F6	SO-SURE GLOSS WHITE 17875 (24-	89945	0.93	4
		IPC27A2	A830F7	SO-SURE ENAM ID 24-190 G, GLOS	89893	1.00	4
		IPC2A2	A830F3	TT-S-190F SANDING SEALER, CODE	116398	7.04	4
		IPC2A2	A830F7	00203, MASTER GASKET(R) PRIMER	148007	0.09	4
		IPC2A2	A830F7	00203, MASTER GASKET(R) SEALAN	148011	0.05	4
CES/CEOUA	Water	IPC27A1	C22I1	916, PVC CLEAR MEDIUM BODIED C	148039	0.80	4
	Sewe/Gas	IPC27A2	C22I1	C371, OATELY CLEANER	148090	0.40	4
		IPC27A2	C22I1	PARABOND P-10	70992	0.91	4
					Total	2440.95	

445th Maintenance Squadron

ORG_SYM	Workplace	Issue Pt	ZONE	MATERIAL	MSDS #	LBS OUT	Driver
445 LGMPE	Propulsion	IPC105A1	C13L1	PWC EPOXY PRIMER/PART PWC201	149495	1.06	5
	Sections	IPC13A2	C13L1	190 0273 INDUSTREX FIXER AND R	182243	0	5
		IPC13A2	C13L1	190 0273 INDUSTREX FIXER AND R	182242	0	5
		IPC13A2	C13L1	3M 90 HIGH STRENGTH ADHESIVE 1	139497	1.32	5
		IPC13A2	C13L1	A-1177-B-1 PART A	135012	1.22	5
		IPC13A2	C13L1	A-1177-B-2 PART B	135013	0.74	5
		IPC13A2	C13L1	ALOX 22028CM-3	112801	0	5
		IPC13A2	C13L1	BREAK-FREE CLP, LIQUID	132447	1.14	5
		IPC13A2	C13L1	BREAK-FREE CLP,LIQUID	132446	1.09	5
		IPC13A2	C13L1	CLEANING AND LUBRICATING COMP	87896	0	5
		IPC13A2	C13L1	CS 1900 PART A	118101	1.11	5
		IPC13A2	C13L1	MOLYBDENUM (IV) SULFIDE	120537	0.55	5
		IPC13A2	C13L1	MOLYSULFIDE (MOLYBDENUM DISUL	120536	0.71	5
		IPC13A2	C13L1	PARABOND M-250	187955	0	5
		IPC13A2	C13L1	PERMA-SLIK G AEROSOL 10-117	142067	1.28	5
		IPC13A2	C13L1	PRO-SEAL 870, CLASS A, BASE	88040	0	5
		IPC13A2	C13L1	ROYCO 463	132442	0	5
		IPC13A2	C13L1	RUBBER ADHESIVE	94670	1.96	5
		IPC13A2	C13L1	SO SURE LACQUER,FLAT BLACK 370	113877	0.9	5
		IPC13A2	C13L1	SO-SURE GRAY 16099-24-180(0) E	89908	1	5
		IPC13A2	C13L1	SO-SURE LACQUER ID14B160 (O) A	118006	0.33	5
		IPC13A2	C13L1	SO-SURE OLIVE DRAB 24084(34-24	114847	0.94	5
		IPC13A2	C13L1	SO-SURE ORANGE 12215-121 (G/O)	117900	0.55	5
		IPC13A2	C13L1	SO-SURE PRIMER ID 234-382 G, G	115506	0.54	5
		IPC13A2	C13L1	TAPFREE	145991	0	5
		IPC4026A	C13L1	BREAK-FREE CLP, LIQUID	132447	0.77	5
		IPC4026A	C13L1	MOLYSULFIDE (MOLYBDENUM DISUL	120536	0.62	5
		IPC4026A	C13L1	PERMA-SLIK G AEROSOL 10-117	142067	1.27	5
445 LGMSA	Aerospace	IPC13A2	C13W1	22C870, SO-SURE GLOSS WHITE 17	149392	0.94	5
	Repair	IPC13A2	C13W1	24087 OLIVE DRAB	114849	0.44	5
		IPC13A2	C13W1	A-1177-B-1 PART A	135012	0.99	5
		IPC13A2	C13W1	AEROSHELL GREASE 22;SHELL COD	125893	1.55	5
		IPC13A2	C13W1	GSA GENERAL PURPOSE ADHESIVE	125685	0.96	5
		IPC13A2	C13W1	LL-610, PRODUCTION LACQUER-GLO	187831	1.54	5
		IPC13A2	C13W1	LL-610, PRODUCTION LAGQUER-GLO	187832	1.84	5
		IPC13A2	C13W1	PERMA-SLIK G AEROSOL 10-117	142067	1.27	5
		IPC13A2	C13W1	PRO-SEAL 870 B-2	153161	0.61	5
		IPC13A2	C13W1	PRO-SEAL 870 B-2	153162	0.11	5
		IPC13A2	C13W1	ROYCO 463	132442	0.36	5
		IPC13A2	C13W1	SO SURE LACQUER,FLAT BLACK 370	113877	0.88	5
		IPC13A2	C13W1	SO-SURE OLIVE DRAB 14064-204-1	93926	1	5
		IPC13A2	C13W1	TECTYL 502C	91603	0.46	5
		IPC4026A	C13W1	BREAK-FREE CLP, LIQUID	132447	1.08	5
		IPC4026A	C13W1	CORROSION PREVENTIVE COMPOUN	154606	1.1	5
		IPC4026A	C13W1	MOLYSULFIDE (MOLYBDENUM DISUL	120536	0.53	5
		IPC4026A	C13W1	PERMA-SLIK G AEROSOL 10-117	142067	1.27	5
		IPC4026A	C13W1	PR-1436-G B-2, PART A	139087	0.44	5
		IPC4026A	C13W1	PR-1436-G B-2, PART B	139088	0.18	5
		IPC4026A	C13W1	SILICONE 7	5967	1.43	5
		IPC4026A	C13W1	TECTYL 502C	91603	0.77	5
		IPC4026A	C13W2	MOLYSULFIDE (MOLYBDENUM DISUL	120536	0.69	5
		IPC4026A	C13W2	PERMA-SLIK G AEROSOL 10-117	142067	1.27	5
445 MAAG	Aircraft Support	IPC4026A	C4028C2	PERMA-SLIK G AEROSOL 10-117	142067	1.25	5
445 MS	Inspection	IPC4026A	C4026D1	1B15 H AEROSOL	127837	0.74	5
	Dock	IPC4026A	C4026D1	22C870, SO-SURE GLOSS WHITE 17	149392	0.71	5
		IPC4026A	C4026D1	3M 90 HIGH STRENGTH ADHESIVE 1	139497	1.35	5

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ORG_SYM	Workplace	HDSC	ZONE	MATERIAL	MSDS #	LBS OUT	Driver
445 MS	Inspection	IPC4026A	C4026D1	600 INDUSTRIAL ENAMEL 11136	112053	2.03	5
	Dock	IPC4026A	C4026D1	BREAK-FREE CLP, LIQUID	132447	0.57	5
		IPC4026A	C4026D1	CONTACT CEMENT, MA-162	89089	1.32	5
		IPC4026A	C4026D1	CS3300 (PART B)	153159	0.11	5
		IPC4026A	C4026D1	LA-132	107518	0.44	5
		IPC4026A	C4026D1	METHYL ETHYL KETONE	104888	1.04	5
		IPC4026A	C4026D1	MOLYSULFIDE (MOLYBDENUM DISUL	120536	0.72	5
		IPC4026A	C4026D1	PERMA-SLIK G AEROSOL 10-117	142067	1.25	5
		IPC4026A	C4026D1	PR-1422-G B-1/2,2 PART B	110886	1.74	5
		IPC4026A	C4026D1	PR-1436-G B-2, PART A	139087	0.44	5
		IPC4026A	C4026D1	PR-1436-G B-2, PART B	139088	0.18	5
		IPC4026A	C4026D1	PR-1436-G, CLASS B, PART B	110326	2.19	5
		IPC4026A	C4026D1	PR-1826 ADHESION PROMOTER	151877	0.19	5
		IPC4026A	C4026D1	PR1826 B-1/2 EPOXY RESIN COMPO	151875	0.29	5
		IPC4026A	C4026D1	PR1826 B-1/2 POLYTHIOETHER POL	151876	0.19	5
		IPC4026A	C4026D1	PRO-SEAL 870 B-1/2,PART B	139084	0.14	5
		IPC4026A	C4026D1	SO SURE LACQUER, CLEAR 14B100	111464	0.67	5
		IPC4026A	C4026D1	SO SURE LACQUER,FLAT BLACK 370	113877	1.04	5
		IPC4026A	C4026D1	SO-SURE LACQUER, ID 14B130 (G/	117943	0.9	5
		IPC4026A	C4026D1	SO-SURE PRIMER ID 234-382 G, G	115506	0.37	5
		IPC4026A	C4026D1	SO-SURE RED 11136 (14B111)(G/0	92381	0.67	5
		IPC4026A	C4026D1	SO-SURE STENCIL INK BLACK 3703	9616	0.8	5
		IPC4026A	C4026D1	TRICHLOROETHANE,TEC O-T-620C T	152057	2.98	5
445/LGMAP	Pneudraulics	IPC13A2	C13K1	INSULATOR 9526054	113365	0.08	5
		IPC13A2	C13K1	ADHESIVE MA-212	116630	1.05	5
		IPC13A2	C13K1	PRO-SEAL 870 CLASS A, ACCELERA	88078	0.5	5
		IPC13A2	C13K1	PRO-SEAL 870, CLASS A, BASE	88076	0.67	5
445/LGMAF	Aircraft	IPC4026A	C4020B1	AP 654, PR1826 B-1/4	144588	0.2	5
	Fuel Systems	IPC4026A	C4020B1	AP 654, PR1826 B-1/4 - ACCELER	144587	0.26	5
		IPC4026A	C4020B1	CS 1900 PART A	119891	0.04	5
		IPC4026A	C4020B1	PR-1440 A-1/2, ACCELERATOR	181046	0.27	5
		IPC4026A	C4020B1	PR-1440 A-1/2, BASE	181047	0.27	5
		IPC4026A	C4020B1	PR-1440, A1/2, PART B	118836	0.51	5
		IPC4026A	C4020B1	PR-1826 ADHESION PROMOTER	144589	0.2	5
		IPC4026A	C4020B1	PR-1826 ADHESION PROMOTER	144615	0.19	5
		IPC4026A	C4020B1	PR1826 B -1/4	148052	0.09	5
		IPC4026A	C4020B1	PR1826 B-2 - ACCELERATOR	150842	0.19	5
		IPC4026A	C4020B1	PR1826 B-2 BASE COMPOUND PART	150843	0.19	5
		IPC4026A	C4020B1	PRC P/N 1426, PART B	110396	0.25	5
		IPC4026A	C4020B1	AP 654, PR1826 B-1/4	144588	0.2	5
		IPC4026A	C4020B1	AP 654, PR1826 B-1/4 - ACCELER	144587	0.2	5
		IPC4026A	C4020B1	EPOXY TABS--TYPE "O"	152014	0.04	5
		IPC4026A	C4020B1	LEAK DETECTION POWDER 491 (AER	136432	2.65	5
		IPC4026A	C4020B1	PR-1440, A1/2, PART B	118836	0.11	5
		IPC4026A	C4020B1	PR-1826 ADHESION PROMOTER	144589	0.2	5
445 TH	Aerospace	IPC4026A	C4021E1	SN40WACP6 0.125 1LB ACID CORED	96256	0.5	5
	Ground	IPC4026A	C4026E1	22C870, SO-SURE GLOSS WHITE 17	149392	0.72	5
	Equipment	IPC4026A	C4026E1	EXTINGUISHER,FIRE,VAPORIZING L	134250	5	5
		IPC4026A	C4026E1	MA-412 ADHESIVE	104265	0.36	5
		IPC4026A	C4026E1	METHYL ETHYL KETONE	104888	11.82	5
		IPC4026A	C4026E1	PR-1826, B 1/2, PART B	144600	0.56	5
		IPC4026A	C4026E1	SO SURE LACQUER,FLAT BLACK 370	113877	0.67	5
		IPC4026A	C4026E1	PAINT, TRAFFIC	187889		3
445 TH	Inspection Dock	IPC4026A	C4026D1	CONTACT CLEANER AND LUBE;ETN 1	87870	1	5
		IPC4026A	C4026D1	TIN/LEAD ALLOY (60% TIN, 37%LE	113108	1	5

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ORG_SYM	Workplace	HDSC	ZONE	MATERIAL	MSDS #	LBS OUT	Driver
445/LGMAE	Electro	IPC13A2	C4012K1	ALOX 22028CM-3	112801	0.31	5
	Environmental	IPC13A2	C4012K1	SO SURE CORROSION PREVENTIVE	112795	1.15	5
		IPC4026A	C4012K1	CONTACT CLEANER AND LUBE;ETN 1	87870	0.6	5
		IPC4026A	C4012K1	LA-132	107518	0.37	5
		IPC4026A	C4012K1	MA-412 ADHESIVE	104265	0.58	5
		IPC4026A	C4012K1	TIN/LEAD ALLOY (60% TIN, 37%LE	113108	1.05	5
		IPC4026A	C4012K1	TRICHLOROETHANE,TEC O-T-620C T	152057	2.48	5
445/LGMC	Com-Nav	IPC4026A	C4012L1	CONTACT CLEANER AND LUBE;ETN 1	87870	1.09	5
445/LGMFC	Structural	IPC105A1	C13O1	"SCOTCHGARD" BRAND FABRIC PRO	91515	1.11	5
	Repair	IPC105A1	C13O1	03-R-26 CATALYST,RED 11136	110599	1.81	5
		IPC105A1	C13O1	03GY49 BASE,MIL-C-83286B,GRAY,	96026	2.6	5
		IPC105A1	C13O1	03W127ACAT CAT,MIL-C-85285B 17	142955	8	5
		IPC105A1	C13O1	15044-BLUE	107616	2	5
		IPC105A1	C13O1	266C,COMPOUND THINNING LIQUID.	94032	6.52	5
		IPC105A1	C13O1	3:1, CAT, MIL-C-85285, 36173,	147080	2.59	5
		IPC105A1	C13O1	3:1, CAT, MIL-C-85285, G/S, 34	146704	1.26	5
		IPC105A1	C13O1	3:1, MIL-C-85285B, 36118, PC 0	145266	9.71	5
		IPC105A1	C13O1	3:1, MIL-C-85285B, 36173 PC03G	147079	9.87	5
		IPC105A1	C13O1	463-07-0027 EPOXY-POLYAMIDE PR	132139	2	5
		IPC105A1	C13O1	724112-COMP B	92588	1.12	5
		IPC105A1	C13O1	724112-COMP B	125340	2.15	5
		IPC105A1	C13O1	724222-COMP A	92587	1.58	5
		IPC105A1	C13O1	724222-COMP A	125339	3.01	5
		IPC105A1	C13O1	742-622,TT-E-489F,COMP L CLA,#	114607	2	5
		IPC105A1	C13O1	786112 LACQUER-C/N GLOSS BROWN	101842	2	5
		IPC105A1	C13O1	791716 LAC ACRYLIC N/C GLOSS W	111885	8	5
		IPC105A1	C13O1	A-A-857, THINNER,PAINT PRODUCT	94035	6.59	5
		IPC105A1	C13O1	ACCELERATOR FOR 600-SER PU CA1	149463	1.86	5
		IPC105A1	C13O1	ACETONE	98083	0.79	5
		IPC105A1	C13O1	B66W103G, DTM ACRYLIC GLOSS CO	148745	14.34	5
		IPC105A1	C13O1	BROWN 10080	106171	7.79	5
		IPC105A1	C13O1	CAAPCOAT AS-P108 CATALYST	110090	0.17	5
		IPC105A1	C13O1	CAAPCOAT B-274 BLACK POLYURETH	110085	7.49	5
		IPC105A1	C13O1	CAAPCOAT POLYURETHANE ACCELE	110086	0.28	5
		IPC105A1	C13O1	CAAPCOAT POLYURETHANE CURING	110087	0.63	5
		IPC105A1	C13O1	CAT, MIL-C-85285B, 15044 PC 03	146392	1.88	5
		IPC105A1	C13O1	CAT, MIL-C-85285B, 17925, 0PC0	144330	2.37	5
		IPC105A1	C13O1	CAT, MIL-C-85285B, 36118 PC 03	145267	2.11	5
		IPC105A1	C13O1	CATALYST,WHITE 17925,ISOCYANAT	12506	2.38	5
		IPC105A1	C13O1	CELL SOAK 380 N.F.COMPOUND	59199	209.48	5
		IPC105A1	C13O1	CID-A-A-2210, WOOD FILLER, X-7	105222	3.18	5
		IPC105A1	C13O1	ENAMEL ALKYD GLOSS BLACK 17038	111829	2	5
		IPC105A1	C13O1	LACQUER C/N GLOSS 11 BLACK 170	101856	2	5
		IPC105A1	C13O1	METHYL ETHYL KETONE	8481	3.15	5
		IPC105A1	C13O1	METHYL ETHYL KETONE	104886	7.59	5
		IPC105A1	C13O1	MIL-C-83286, 16473, 03GY049	96029	1.68	5
		IPC105A1	C13O1	MIL-C-85285B, 17925 PC03W127A	144329	3.34	5
		IPC105A1	C13O1	MIL-R-81294 C OR B PAINT STRIP	95793	4.29	5
		IPC105A1	C13O1	MIL-T-81772B,TYPE I, POLYURET	18018	8.27	5
		IPC105A1	C13O1	N3	98495	8	5
		IPC105A1	C13O1	NAPHTHA, ALIPHATIC	99528	7.01	5
		IPC105A1	C13O1	OMEGA 3812 SN 313-2	95787	9.36	5
		IPC105A1	C13O1	P-832/LACQUER	100137	8	5
		IPC105A1	C13O1	PAINT ALUMINUM HEAT RESISTING	116812	1.98	5
		IPC105A1	C13O1	PIGMENTED EPOXY RESINCOMPON	132129	2	5
		IPC105A1	C13O1	POLYAMIDE RESIN COMPONENT B	132130	2	5
		IPC105A1	C13O1	POLYURETHANE	110598	2	5

ORG_SYM	Workplace	HDSC	ZONE	MATERIAL	MSDS #	LBS OUT	Driver
445/LGMFC	Structural	IPC105A1	C13O1	POLYURETHANE PAINT WHITE 17925	7845	11.78	5
	Repair	IPC105A1	C13O1	POLYURETHANE SPRAY ENAMEL PW	30327	0.81	5
		IPC105A1	C13O1	PRECIPITATION NAPHTHA	98496	6.55	5
		IPC105A1	C13O1	PWC EPOXY PRIMER/PART PWC201	149495	0.93	5
		IPC105A1	C13O1	PWC POLYURETHANE AEROSOL COL	17715	0.87	5
		IPC105A1	C13O1	PWC POLYURETHANE AEROSOL COL	17733	0.71	5
		IPC105A1	C13O1	PWC POLYURETHANE AEROSOL COL	17743	0.98	5
		IPC105A1	C13O1	RR 990,RAIN REPELLANT,WINDSHIE	92287	0.44	5
		IPC105A1	C13O1	SCOTCHCAL BRAND EDGE SEALER 3	125614	0.62	5
		IPC105A1	C13O1	SO SURE ZINC CHROMATE GREEN C	123346	0.95	5
		IPC105A1	C13O1	SO-SURE 74-293-P	95748	0.69	5
		IPC105A1	C13O1	SO-SURE BLUE 15080-14B150(G/0)	117970	0.66	5
		IPC105A1	C13O1	SO-SURE BROWN 30109 (244-314)	89511	0.9	5
		IPC105A1	C13O1	SO-SURE ENAM ID 24-190 G, GLOS	89893	0.66	5
		IPC105A1	C13O1	SO-SURE GLOSS BLACK 17038-24-1	89894	1	5
		IPC105A1	C13O1	SO-SURE GRAY 16099-24-180(0) E	89908	1	5
		IPC105A1	C13O1	SO-SURE GREEN 14062-14B140 (F/	92370	0.45	5
		IPC105A1	C13O1	SO-SURE LACQUER, WHITE 17875-1	106588	0.49	5
		IPC105A1	C13O1	SO-SURE OBLITERATING COMPOUND	113857	0.81	5
		IPC105A1	C13O1	SO-SURE PRMR ZINC CRMT GRN CLR	123344	1	5
		IPC105A1	C13O1	SO-SURE STENCIL INK RED 31136(	149522	0.5	5
		IPC105A1	C13O1	SO-SURE STENCIL INK YELLOW 335	148385	0.66	5
		IPC105A1	C13O1	SOLVENT, T306C#1	94077	6.35	5
		IPC105A1	C13O1	SYNTHETIC RESIN THINNER	94076	8	5
		IPC105A1	C13O1	TROLUOIL	99526	5.89	5
		IPC105A1	C13O1	TT-E-489H LOW VOC 15045 BLUE	107542	72.82	5
		IPC105A1	C13O1	TT-L-32A (15102 BLUE)	17896	16	5
		IPC105A1	C13O1	TTR-251J,TYPE III,CLASS A	149569	8.88	5
		IPC105A1	C13O1	X-422, CATALYST FOR 463-07-002	132140	1.6	5
		IPC105A1	C13O3	(3:1) CAT, MS-461, 36231, PC 0	146399	1.48	5
		IPC105A1	C13O3	(3:1) MS-461, 36231, PC 03GY33	146398	7.35	5
		IPC105A1	C13O3	DEOXIDINE 605 KIT 120 BRUSH ON	119444	2.32	5
		IPC105A1	C13O3	PWC POLYURETHANE AEROSOL COL	17743	0.78	5
		IPC105A1	C13O3	PWC POLYURETHANE AEROSOL COL	17737	0.43	5
		IPC105A1	C4021F1	ANE AEROSOL COLORS,YELLOW	17736	1.01	5
		IPC105A1	C4021F1	"SCOTCHGARD" BRAND FABRIC PRO	91515	1.14	5
		IPC105A1	C4021F1	020-707 SOLVENT	89302	6.64	5
		IPC105A1	C4021F1	03-GN-176 BASE,GREEN 24176,POL	150469	7.49	5
		IPC105A1	C4021F1	03-GN-52 CATALYST,GREEN 24052,	150470	2.61	5
		IPC105A1	C4021F1	03R064 POLYURETHANE 11136	142938	9.58	5
		IPC105A1	C4021F1	03R064CAT ALIPHATIC ISOCYANATE	142939	8.57	5
		IPC105A1	C4021F1	13538, TYPE 1, 03Y091 MIL-C-85	142978	9.25	5
		IPC105A1	C4021F1	215, PWC POLYURETHANE AEROSOL	147912	0.92	5
		IPC105A1	C4021F1	3:1, CAT, MIL-C-85285, 36173,	147080	2.59	5
		IPC105A1	C4021F1	3:1, MIL-C-85285B, 36118, PC 0	145266	8.42	5
		IPC105A1	C4021F1	3:1, MIL-C-85285B, 36173 PC03G	147079	8.47	5
		IPC105A1	C4021F1	724112-COMP B	92588	1.12	5
		IPC105A1	C4021F1	724112-COMP B	125340	1.48	5
		IPC105A1	C4021F1	724114, POLYAMIDE RESIN	188434	1.09	5
		IPC105A1	C4021F1	724222-COMP A	92587	1.55	5
		IPC105A1	C4021F1	724222-COMP A	125339	1.98	5
		IPC105A1	C4021F1	724226, PRIMER COATING:EPOXYCH	148663	6.66	5
		IPC105A1	C4021F1	724400 PRIMER COATING EPOXYCHE	181719	3.3	5
		IPC105A1	C4021F1	724400,PRIMER COATING EPOXYCHE	188430	1.52	5
		IPC105A1	C4021F1	820X311, SUPER DESOTHANE CLEAR	152854	2.37	5
		IPC105A1	C4021F1	88L-C-85285B, 34092, G/S PC 03	146699	8.41	5
		IPC105A1	C4021F1	A-A-857, THINNER,PAINT PRODUCT	94035	7.64	5
		IPC105A1	C4021F1	ACCELERATOR FOR 600-SER PU CA1	149463	1.94	5
		IPC105A1	C4021F1	ACETONE	98083	1.04	5

ORG_SYM	Workplace	HDSC	ZONE	MATERIAL	MSDS #	LBS OUT	Driver
445/LGMFC	Structural	IPC105A1	C4021F1	ACETONE,TECHNICAL	98081	0.87	5
	Repair	IPC105A1	C4021F1	B667104	17717	8.56	5
		IPC105A1	C4021F1	B66W103G, DTM ACRYLIC GLOSS CO	148745	31.01	5
		IPC105A1	C4021F1	BRUSH-ON ALODINE 1200 (1201 LI	119443	1.14	5
		IPC105A1	C4021F1	CAT, 13538, TYPE I 03Y091	142979	7.4	5
		IPC105A1	C4021F1	CAT, MIL-C-83286, 16473, 03GY0	96030	2.26	5
		IPC105A1	C4021F1	CAT, MIL-C-85285B, 17925, 0PC0	144330	2.37	5
		IPC105A1	C4021F1	CAT, MIL-C-85285B, 34092, G/S,	146700	2.58	5
		IPC105A1	C4021F1	CAT, MIL-C-85285B, 36118 PC 03	145267	2.59	5
		IPC105A1	C4021F1	CATALYST,WHITE 17925,ISOCYANAT	12506	2.39	5
		IPC105A1	C4021F1	GC-3001	116623	1	5
		IPC105A1	C4021F1	GENERAL PURPOSE ADHESIVE SPRA	125684	1.38	5
		IPC105A1	C4021F1	METHYL ETHYL KETONE	8481	2.35	5
		IPC105A1	C4021F1	METHYL ETHYL KETONE	104884	7.36	5
		IPC105A1	C4021F1	METHYL ETHYL KETONE	149584	6.17	5
		IPC105A1	C4021F1	MIL-C-83286, 16473, 03GY049	96029	3.05	5
		IPC105A1	C4021F1	MIL-C-85285B, 17925 PC03W127A	144329	3.33	5
		IPC105A1	C4021F1	MIL-C-85285B,17925,TYPE I	148349	3.24	5
		IPC105A1	C4021F1	MIL-R-81294 C OR B PAINT STRIP	95793	2.6	5
		IPC105A1	C4021F1	MIL-T-81772B,TYPE I, POLYURET	18018	16.14	5
		IPC105A1	C4021F1	N5217 BLACK A/D ENAMEL 17038	111814	9.85	5
		IPC105A1	C4021F1	NAPHTHA, ALIPHATIC	99528	4.71	5
		IPC105A1	C4021F1	OMEGA 3812 SN 313-2	95787	10.36	5
		IPC105A1	C4021F1	PIGMENTED EPOXY RESINCOMPON	132129	3.18	5
		IPC105A1	C4021F1	POLYAMIDE RESIN COMP B ID 7241	125343	2.24	5
		IPC105A1	C4021F1	POLYAMIDE RESIN COMPONENT B	132130	2.18	5
		IPC105A1	C4021F1	POLYURETHANE SPRAY ENAMEL PW	30327	1.01	5
		IPC105A1	C4021F1	PR-1560-MC, PART B	89304	2.52	5
		IPC105A1	C4021F1	PRECIPITATION NAPHTHA	98496	6.63	5
		IPC105A1	C4021F1	PWC 10-76	23783	1.1	5
		IPC105A1	C4021F1	PWC 201, EPOXY PRIMER	17692	0.36	5
		IPC105A1	C4021F1	PWC EPOXY PRIMER/PART PWC201	149495	1.07	5
		IPC105A1	C4021F1	PWC POLYURETHANE AEROSOL COL	17726	1	5
		IPC105A1	C4021F1	PWC POLYURETHANE AEROSOL COL	17715	0.83	5
		IPC105A1	C4021F1	PWC POLYURETHANE AEROSOL COL	17740	0.86	5
		IPC105A1	C4021F1	PWC POLYURETHANE AEROSOL COL	17733	1.05	5
		IPC105A1	C4021F1	PWC POLYURETHANE AEROSOL COL	17743	1.06	5
		IPC105A1	C4021F1	PWC POLYURETHANE AEROSOL COL	17737	1.04	5
		IPC105A1	C4021F1	PWC-218 POLYRETHANE AEROSOL O	149082	1.04	5
		IPC105A1	C4021F1	PWC211 PWC POLYURETHANE AER	17732	1.03	5
		IPC105A1	C4021F1	PWC242, PWC POLYURETHANE AER	148334	1.01	5
		IPC105A1	C4021F1	SCOTCHCAL BRAND EDGE SEALER 3	125614	0.6	5
		IPC105A1	C4021F1	SCOTCHGARD(TM) BRAND PROTECT	91514	1.14	5
		IPC105A1	C4021F1	SD AL POLY ACTIVATOR	152857	2.16	5
		IPC105A1	C4021F1	SO SURE GRAY PRIMER (234-382)	115508	0	5
		IPC105A1	C4021F1	SO SURE LACQUER,FLAT BLACK 370	113877	0.9	5
		IPC105A1	C4021F1	SO SURE RUBBER ADHESIVE, AEROS	125680	0.85	5
		IPC105A1	C4021F1	SO SURE ZINC CHROMATE GREEN C	123346	1.09	5
		IPC105A1	C4021F1	SO-SURE BROWN 30109 (244-314)	89511	0.92	5
		IPC105A1	C4021F1	SO-SURE CLEAR 24-100 (G/O)	89516	0.74	5
		IPC105A1	C4021F1	SO-SURE LACQUER, WHITE 17875-1	106588	0.58	5
		IPC105A1	C4021F1	SO-SURE STENCIL INK YELLOW 335	148385	0.74	5
		IPC105A1	C4021F1	SPRAY STENCIL INK-BLACK	110298	1.3	5
		IPC105A1	C4021F1	TECTYL 502C	91603	0.87	5
		IPC105A1	C4021F1	THINNER C/N DOPE BLUSH RETARDI	94314	5.91	5
		IPC105A1	C4021F1	TTR-251J,TYPE III,CLASS A	149569	2.32	5
		IPC105A1	C4021F1	TURCOAT, LIQUID ACCELAGOLD	89441	2	5
		IPC105A1	C4021F2	03-GN-176 BASE,GREEN 24176,POL	150469	7.46	5
		IPC105A1	C4021F2	03-GN-52 CATALYST,GREEN 24052,	150470	2.6	5

ORG_SYM	Workplace	HDSC	ZONE	MATERIAL	MSDS #	LBS OUT	Driver
445/LGMFC	Structural	IPC105A1	C4021F2	724400 PRIMER COATING EPOXYCHE	181719	1.38	5
	Repair	IPC105A1	C4021F2	820X311, SUPER DESOTHANE CLEAR	152854	1.38	5
		IPC105A1	C4021F2	CAT, MIL-C-85285B, 17925, 0PC0	144330	1.27	5
		IPC105A1	C4021F2	METHYL ETHYL KETONE	104884	5.14	5
		IPC105A1	C4021F2	MIL-C-85285B, 17925 PC03W127A	144329	1.63	5
		IPC105A1	C4021F2	POLYAMIDE RESIN COMP B ID 7241	125343	0.95	5
		IPC105A1	C4021F2	PRECIPITATION NAPHTHA	98496	6.54	5
		IPC105A1	C4021F2	PWC POLYURETHANE AEROSOL COL	17733	0.8	5
		IPC105A1	C4021F2	SD AL POLY ACTIVATOR	152857	1.49	5
		IPC105A1	C4021F2	SO SURE ZINC CHROMATE GREEN C	123346	0.47	5
		IPC13A2	C13O1	A-1177-B-1 PART A	135012	1.85	5
		IPC13A2	C13O1	A-1177-B-2 PART B	135013	1.51	5
		IPC13A2	C13O1	CADOX M-50	135896	0.84	5
		IPC13A2	C13O1	CS 1900 PART A	118101	1.05	5
		IPC13A2	C13O1	CURING AGENT U	121581	1.14	5
		IPC13A2	C13O1	PR-1422-G A-2, PART A	109611	2.27	5
		IPC13A2	C13O1	PR-1422-G A-2, PART B	109612	0.29	5
		IPC13A2	C13O1	PR-1432-GP PART A	108100	0.9	5
		IPC13A2	C13O1	PR-1432-GP PART B	108101	11.69	5
		IPC13A2	C13O1	PRO-SEAL 870 B-2	153161	0.64	5
		IPC13A2	C13O1	PRO-SEAL 870 B-2	153162	0.11	5
		IPC13A2	C13O1	PRO-SEAL 872 CLASS B, PART B	135814	0.23	5
		IPC13A2	C13O3	CS 1900 PART A	118101	0.89	5
		IPC13A2	C13O3	EA 9330 PART B	136907	0.53	5
		IPC13A2	C13O3	EA 9330, PART A	136906	1.82	5
		IPC13A2	C13O3	PRO-SEAL 872 CLASS B, PART B	135814	0.22	5
445 TH	Metal	IPC13A2	C4021F1	PR-1422-G A-2, PART A	109611	0.77	5
	Technology	IPC13A2	C4021F1	PR-1422-G A-2, PART B	109612	0.35	5
		IPC4026A	C4021F1	PR-1422-G B-1/2,2 PART B	110886	1.59	5
		IPC13A2	C13V1	ALUMTAP	187588	1.15	5
		IPC13A2	C13V1	CORROSION PREVENTIVE COMPOUN	125659	0.75	5
		IPC13A2	C13V1	GSA GENERAL PURPOSE ADHESIVE	125685	1.17	5
		IPC13A2	C13V1	MOBILGREASE 28	125160	20.52	5
		IPC13A2	C13V1	SO SURE CORROSION PREVENTIVE	112795	1.14	5
		IPC13A2	C13V1	SO SURE LACQUER,FLAT BLACK 370	113877	0.41	5
		IPC13A2	C13V1	TAPFREE	145991	1.12	5
445/LGMFC	Structural	IPC13A2	C4021F1	3M 90 HIGH STRENGTH ADHESIVE 1	139497	0.8	5
	Repair	IPC13A2	C4021F1	A-1177-B-1 PART A	135012	2.3	5
		IPC13A2	C4021F1	A-1177-B-2 PART B	135013	1.61	5
		IPC13A2	C4021F1	CADOX M-50	135896	0.92	5
		IPC13A2	C4021F1	PERMA-SLIK G AEROSOL 10-117	142067	1.27	5
		IPC13A2	C4021F1	POLYLITE POLYESTER RESIN 31-00	115835	7.2	5
		IPC13A2	C4021F1	PR-1422-G B-1/2,2 PART B	110886	2.09	5
		IPC13A2	C4021F1	PR-1432-GP PART A	108100	0.78	5
		IPC13A2	C4021F1	PR-1432-GP PART B	108101	9.31	5
		IPC13A2	C4021F1	PR-1436-G, CLASS B, PART B	109326	0.13	5
		IPC13A2	C4021F1	PRO-SEAL 870 CLASS A, ACCELERA	88078	0.14	5
		IPC13A2	C4021F1	PRO-SEAL 870, ACCELERATOR	111554	1.75	5
		IPC13A2	C4021F1	PRO-SEAL 870, B-2 BASE	111553	8.49	5
		IPC13A2	C4021F1	PRO-SEAL 872 CLASS B, PART B	135814	0.47	5
		IPC13A2	C4021F1	PRODUCT CODE: 3010370	9769	1.23	5
		IPC4026A	C13O1	METHYL ETHYL KETONE	104888	11.82	5
		IPC4026A	C13O1	NAPHTHA, ALIPHATIC	99528	6.91	5
		IPC4026A	C13O1	PR-1826 ADHESION PROMOTER	151877	0.19	5
		IPC4026A	C13O1	PR1826 B-1/2 EPOXY RESIN COMPO	151875	0.44	5
		IPC4026A	C13O1	PR1826 B-1/2 POLYTHIOETHER POL	151876	0.19	5
		IPC4026A	C13O1	PRO-SEAL 870, CLASS A, BASE	88040	0.22	5

ORG_SYM	Workplace	HDSC	ZONE	MATERIAL	MSDS #	LBS OUT	Driver
445/LGMFC	Structural Repair	IPC4026A	C13O1	PROSEAL 870 ALL CLASS & TYPES,	88041	1.31	5
		IPC4026A	C4021F1	CS 1900 PART A	119891	0.22	5
		IPC4026A	C4021F1	METHYL ETHYL KETONE	104888	5.62	5
		IPC4026A	C4021F1	METHYL ETHYL KETONE	149584	7.53	5
		IPC4026A	C4021F1	PR-1422-G B-1/2,2 PART B	110886	1.38	5
		IPC4026A	C4021F1	PR-1436-G B-2, PART A	139087	0.44	5
		IPC4026A	C4021F1	PR-1436-G B-2, PART B	139088	0.18	5
		IPC4026A	C4021F1	PR-1440, A1/2, PART B	118836	0.03	5
		IPC4026A	C4021F1	PR-1826 ADHESION PROMOTER	151877	0.19	5
		IPC4026A	C4021F1	PR1826 B-1/2 EPOXY RESIN COMPO	151875	0.29	5
		IPC4026A	C4021F1	PR1826 B-1/2 POLYTHIOETHER POL	151876	0.19	5
		IPC4026A	C4021F1	PRO-SEAL 870 B-1/2,PART B	139084	0.14	5
		IPC4026A	C4021F1	SO-SURE PRIMER ID 234-382 G, G	115506	1.08	5
		IPC4026A	C4021F1	SPRAY STENCIL INK-BLACK	110298	0.35	5
445/LGMFN	NDI	IPC13A2	C13U1	ISOPROPYL ALCOHOL	122225	32.51	5
		IPC13A2	C13U1	ZC-7B, SKC-NF CLEANER/REMOVER	148384	34.18	5
		IPC13A2	C13U2	190 0273 INDUSTREX FIXER AND R	182243	2.73	5
		IPC13A2	C13U2	190 0273 INDUSTREX FIXER AND R	182242	14.32	5
		IPC13A2	C13U2	818 5100, INDUSTREX DEVELOPER	182247	1.9	5
		IPC13A2	C13U2	818 5100;KODAK INDUSTREX DEVEL	182246	0.6	5
		IPC13A2	C13U2	MAGNE-TECH SY8000A/1 AEROSOL	121628	0.82	5
		IPC13A2	C13U2	ZC-7B, SKC-NF CLEANER/REMOVER	148384	0.77	5
445/LGMFS	Survival Equipment	IPC4026A	C4035A1	3M 90 HIGH STRENGTH ADHESIVE 1	139497	1.32	5
		IPC4026A	C4035A1	CELLULOSE ACETATE BUTYRATE DO	149976	7.24	5
		IPC4026A	C4035A1	LA-132	107518	0.58	5
		IPC4026A	C4035A1	MA-412 ADHESIVE	104265	0.55	5
		IPC4026A	C4035A1	TOLUENE,TECHNICAL	104654	1.98	5
445AGSMAA	Aircraft Support Flight	IPC4026A	C4028C1	3M 90 HIGH STRENGTH ADHESIVE 1	139497	1.33	5
		IPC4026A	C4028C1	AEROSOL SPRAY PAINT YELLOW 135	117946	0.36	5
		IPC4026A	C4028C1	BREAK-FREE CLP, LIQUID	132447	1.14	5
		IPC4026A	C4028C1	LA-132	107518	0.58	5
		IPC4026A	C4028C1	PERMA-SLIK G AEROSOL 10-117	142067	1.27	5
		IPC4026A	C4028C1	SO SURE LACQUER, CLEAR 14B100	111464	0.35	5
		IPC4026A	C4028C1	SO SURE LACQUER,FLAT BLACK 370	113877	0.58	5
		IPC4026A	C4028C1	SO-SURE LACQUER, ID 14B130 (G/	117943	0.9	5
		IPC4026A	C4028C1	SO-SURE PRIMER ID 234-382 G, G	115506	1.08	5
		IPC4026A	C4028C1	SO-SURE RED 11136 (14B111)(G/0	92381	0.95	5
		IPC4026A	C4028C1	SPRAY STENCIL INK-BLACK	110298	0.49	5
445MS/LGMG	AGE	IPC105A1	C4021E1	POLYURETHANE SPRAY ENAMEL PW	30327	1.03	5
		IPC4026A	C4021E1	CONTACT CLEANER AND LUBE;ETN 1	87870	1	5
		IPC4026A	C4021E1	PR-1422-G B-1/2,2 PART B	110886	2.26	5
		IPC4026A	C4021E4	MOLYSULFIDE	120535	0.7	5
		IPC4026A	C4021E4	PERMA-SLIK G AEROSOL 10-117	142067	0.63	5
					Total	1237.7	

Civil Engineer Class C Chemicals

Workplace	Bio File	Supervisor	phone #	Issue Point IPC27A1	Issue Point IPC27A2
Heat Plant Area B	y	William Livesay	256 7412		2
Heat Distribution Area B	y	Roger Shaffer	255 7332	3	5
Liquid Fuels	y	Hugh Sumner	257 6995	1	2
Water Treatment	n	James Bundy	257 1928	7	6
Hazmat and Waste	y	Alton Wilson	257 3904	1	1
Electronics and Alarms	y	Gary Beverly	257 3327	2	
Locksmith	y	Robert Ligas	257 5020	1	
Water Sewer and Gas A/C	y	Darin Dull	257 6320	1	2
Water Sewer and Gas B	y	Robert Hollingsworth	255 5914		
Power Pro	y	David Evans	257 4160	2	3
Exterior Electric	y	Thomas Calderone	257 7730		3
Hospital Maintenance	n	Thomas Dabbelt	257 4511	10	2
Outside Plant Units	y	Jeffrey Gifford	257 3706	2	6
Asbestos Team	n	Willis Leonard	257 2250	3	3
Pavement/Equipment	n	Doyle Jackson	257 7233	3	2
CE Zone B	n	Gregory Beers	255 5158	7	13
Fire Station #1	n	Darrel Wilcoxon	257 3033	1	
KH Heat Plant	y	Anthony Day	257 7360	3	7
Grounds Area A & C	n	Dannie Smith	257 4776	1	
Cathodic Protection	n	Alfred Daum	257 9958		6
Major rep vert support	y	Roger Guernsey	257 2500		9
CE Zone C	n	Thomas David	257 7732	11	18
Project Painters	y	James Wilson	257 6266	21	22
CE Zone A	n	Thomas David	258 4408	11	10
Grounds area B	y	Darrell Rayburn	255 6886		4
Pest Management	y	William Webb	257 3593	8	1
Steam Distribution	y	John Mullins	257 6650	1	12
				100	139
				Grand Total 239	

445th Class C Chemicals

Workplace	Bio File	Supervisor	phone #	Issue Point IPC13A2	Issue Point IPC4026A1	Issue Point IPC105A1
Metals Technology	y	Richard Deacon	257 7381	7		
Propulsion Section	y	Darrell Cooper	257 2065	25	3	1
AGE	y	Charles Burger	257 4538		5	1
Structural Repair		Richard Deacon	257 0279	30	21	141
NDI	y	Schrewsbury	257 4537	10		
Inspection Dock	y	Raymond Grass	257 0075		29	
Fuel Systems	y	Randel Cunigan	257 4070		24	
Aircraft Support Flight	y	Michael Keene	257 2543		12	
Pneudraulics		John Wolfram	257 0276	6		
AGCs Shop		David Ferguson	257 7127			5
Electro-Environmental		Craig Davidson	257 3169	2	5	
Survival Equipment	y	Charles Chevalier	257 4557	2		
Aerospace Repair	y	Stephen Collopy	257 2585	11	10	
445th AGS	y	Richard Deacon	257 0279		3	
Aircraft Life Support Section	y	Vernon Massey	257 3319	2		
Com/Nav	y	Robert Kemphues	257 7128		7	
Systems Design		Thomas Ludwig	257 7521			6
Survival Equipment Flight		Keith Staffan	257 6581		5	
AGS Sortie Generation		John Berry	257 6228		10	
445th LG		Don Wien	257 0076		2	
445th Element System		mike Bridewell	257 4362		1	
				95	137	154
				Grand Total 386		

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APPENDIX B

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Vita

Charles D. Perham[redacted] He graduated from Forest Hills High School in West Palm Beach, Florida in 1988. Attending the University of New Hampshire, he majored in Civil Engineering while pursuing a commission in the Air Force through ROTC. After graduation from UNH in 1992, his first assignment with the Air Force was at Shaw AFB, an Air Combat Command (ACC) base in Sumter, SC. During his time in Sumter, he worked the Simplified Acquisition of Base Engineering Requirements (SABER) program, and also served as the Chief of the Readiness Flight. In June of 1995, he entered the Graduate Engineering and Environmental Management program at the Air Force Institute of Technology. His follow on assignment will be with another ACC base, Davis Monthan, in Tucson, Arizona.

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An Activity Driver Based Analysis of Hazardous Materials Usage at Wright Patterson Air Force Base

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13. ABSTRACT *(Maximum 200 words)*

This research effort applied a subset of activity based costing, activity driver analysis, to reveal pollution prevention opportunities in regards to hazardous materials usage. A sample of base organizations (civil engineering and aircraft maintenance), and a sample of the hazardous chemicals (Class C or most hazardous) used by those organizations were investigated to determine the drivers behind usage. The conclusion of this effort is that activity driver analysis can be used to reveal pollution prevention opportunities. The results of this sample revealed significant differences in drivers between civil engineering and aircraft maintenance. This was confirmed with a chi-squared test for homogeneity, rejected at the .05 α level. Additionally, the results brought to light the pollution prevention opportunities that may be available in each organization. A pareto analysis of the hazardous material drivers for civil engineering revealed that over 57% of the various materials were driven by "availability at issue." This discovery distinguishes the civil engineering issue points as a ripe fruit for further examination. The objective of this effort was a suggested method to assist base level environmental managers in employing activity driver analysis. Base level managers should be able to follow the six step process outlined and uncover new pollution prevention opportunities.

14. SUBJECT TERMS

environment, environmental, activity driver, activity based costing, management,

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