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An Organizational Guide to Pollution Prevention

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An Organizational Guide to Pollution Prevention

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NOTICE

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FOREWORD

The U.S. Environmental Protection Agency is charged by Congress with protecting the Nation's land, air, and water resources. Under a mandate of national environmental laws, the Agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. To meet this mandate, EPA's research program is providing data and technical support for solving environmental problems today and building a science knowledge base necessary to manage our ecological resources wisely, understand how pollutants affect our health, and prevent or reduce environmental risks in the future.

The National Risk Management Research Laboratory (NRMRL) is the Agency's center for investigation of technological and management approaches for preventing and reducing risks from pollution that threaten human health and the environment. The focus of the Laboratory's research program is on methods and their cost-effectiveness for prevention and control of pollution to air, land, water, and subsurface resources; protection of water quality in public water systems; remediation of contaminated sites, sediments and ground water; prevention and control of indoor air pollution; and restoration of ecosystems. NRMRL collaborates with both public and private sector partners to foster technologies that reduce the cost of compliance and to anticipate emerging problems. NRMRL's research provides solutions to environmental problems by: developing and promoting technologies that protect and improve the environment; advancing scientific and engineering information to support regulatory and policy decisions; and providing the technical support and information transfer to ensure implementation of environmental regulations and strategies at the national, state, and community levels.

This publication has been produced as part of the Laboratory's strategic long-term research plan. It is published and made available by EPA's Office of Research and Development to assist the user community and to link researchers with their clients.

E. Timothy Oppelt, Director
National Risk Management Research Laboratory

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Science Applications International Corporation (SAIC) compiled and prepared the information used for this *Guide* under the management of Lisa K. Kulujian. The authors were Dr. Robert B. Pojasek, Pojasek & Associates, and Cam Metcalf, Executive Director, Kentucky Pollution Prevention Center. Custom Editorial Productions (CEP) of Cincinnati, Ohio, prepared the final document for publication.

The seeds for this document were planted by a Focus Group comprised of invited pollution prevention practitioners from US EPA, Regional and State programs, industry, and academia. This Focus Group was conducted in Cincinnati, Ohio, in conjunction with the National Pollution Prevention Roundtable in the Spring of 1998. It was further shaped by an Engineering Conference conducted in Crested Butte, Colorado, in the Fall of 1998. The final draft of this *Guide* was distributed to more that two hundred pollution prevention practitioners. The following people (in alphabetical order) spent valuable time reviewing and commenting on this publication, providing significant input that helped the authors in making it a more complete and accurate informational *Guide*:

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Pete and Lynnann H. Paris (Chief, Technology Transfer Branch) provided the scenic picture from Maine that has been used for the cover art of the *Guide* and the companion CD-ROM.

ABSTRACT

This *Pollution Prevention (P2) Guide* provides information to help organizations get P2 programs started or to re-evaluate existing P2 programs. It presents an alternative method for working on P2 projects and four approaches to implementing a P2 program in an organization. This *Guide* was not written to provide a "one-size-fits-all" formula for starting or improving a P2 Program. The intention is to spark some ideas and provide tools that can be used to successfully complete an organization's P2 mission.

Also, the *Guide* is *not* intended to be an exhaustive review of case studies and company examples. It does not include information on state P2 planning requirements. In order to keep this document a reasonable length, these examples have been cited in the references section, and supplemental information is provided on the CD-ROM that accompanies this *Guide*. There are many U.S. Environmental Protection Agency (EPA) programs that support the practice of P2, including Environmental Accounting Project, Design for Environment, P2 Resource Exchange, Environmentally Preferable Purchasing, Sustainable Industry Project, Performance Track Program, and other initiatives across the Agency. Internet links to these programs and other information are provided on the CD-ROM.

An Organizational Guide to Pollution Prevention is organized into three basic sections:

1.	**Basic P2 Concepts and Tools (Chapters 1-4)**	Introduction to P2, Getting Started, P2 Program Elements, and P2 Tools
2.	**P2 Program Implementation Approaches (Chapters 5-8)**	Traditional Approach, EMS Approach, Quality Approach, and Finding Your Own Way to Implement P2
3.	**Companion CD-ROM**	Supporting P2 Information

The EPA acknowledges the efforts of the principal authors of this *Guide*–Dr. Robert Pojasek (President, Pojasek & Associates) and Mr. Cam Metcalf (Executive Director, Kentucky Pollution Prevention Center). This *Guide* was prepared in fulfillment of Contract Number 68-C7-0011, Work Assignment #3-20, by Science Applications International Corporation, under the sponsorship of the EPA. Ms. Emma Lou George was the EPA Project Officer.

ACRONYMS

ACC = American Chemistry Council

BAT = best available technology

BMP = best management practice

CSI = Common Sense Initiative

DfE = Design for Environment

EHS = environment, health, and safety

EMAS = eco-management and audit scheme

EAP = Environmental Accounting Project

EMP = environmental management program

EMS = environmental management system

EPA = Environmental Protection Agency

EPP = Environmentally Preferable Purchasing

FDA = Food and Drug Administration

ISO = International Organization for Standardization

JIT = just-in-time

MSDS = material safety data sheet

MSWG = Multi-State Working Group

NGO = non-government organization

OSHA = Occupational Safety and Health Administration

P2 = pollution prevention

P2Rx = P2 Resource Exchange

PCB = polychlorinated biphenyl

PSM = process safety management

QA/QC = quality assurance/quality control

SGP = Strategic Goals Program

SOP = standard operating procedure

TQM = total quality management

VOC = volatile organic chemical

WBCSD = World Business Council for Sustainable Development

XL = eXcellence and Leadership

CONTENTS

EXECUTIVE SUMMARY

An Organizational Guide to Pollution Prevention provides information to help organizations get P2 programs started or to re-evaluate existing P2 programs. It presents an alternative method for working on P2 projects and four approaches to implementing a P2 program in an organization. This *Guide* was not written to provide a “one-size-fits-all” formula for starting or improving a P2 Program. The intention is to spark some ideas and provide tools that can be used to successfully complete an organization’s P2 mission.

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E.1 Introduction to P2

P2 has evolved substantially in its first decade. In 1988, the EPA published the *Waste Minimization Opportunity Assessment Manual* (EPA/625/7-88/003). This publication was revised and reissued in 1992 as the *Facility Pollution Prevention Guide* (EPA/600/R-92-088). Large numbers of these publications were distributed in the United States and internationally, and the information was well received. These publications have been included on the CD-ROM.

P2 programs provide many benefits to the organizations that use them. These include:

- Reduced operating costs
- Improved worker safety
- Reduced compliance costs
- Increased productivity
- Increased environmental protection
- Reduced exposure to future liability costs
- Continual improvement
- Resource conservation
- Enhanced public image

There are a number of impediments that P2 programs must address. These include:

- Capital requirements
- Specifications
- Regulatory issues
- Product quality issues
- Customers' acceptance
- Immediate production concerns
- Organization image concerns
- Available time/technical expertise

A five-step model is presented showing an alternative approach using the P2 tools discussed later in this *Guide* (Chapter 4). This is contrasted to the traditional approach to P2.

E.2 Getting Started With P2

Chapter 2 provides information on getting started with the P2 program process. First, set the boundaries around the program by deciding how P2 will be defined. Definitions from the EPA, United Nations Environment Program, and the World Business Council for Sustainable Development are presented. The user can choose to add elements from cleaner production and eco-efficiency to create a unique P2 definition that is broader than EPA's definition.

It is possible to use the P2 program to help an organization attain a goal of sustainable development. In addition, it is possible to integrate P2 into core business practices like six sigma, zero waste, and other company programs such as:

- Environmental management systems (EMS)
- Quality management initiatives
- Preventive maintenance
- Health and safety programs
- Insurance/risk management

Although a commitment to the P2 program should begin with management (i.e., top-down approach), line employees can often suggest valuable improvements in operations and procedures (i.e., bottom-up approach). The P2 tools presented in this *Guide* are well suited for encouraging employee participation as well as management recognition.

There is a substantial body of literature that describes, analyzes, and evaluates P2 efforts in the United States and internationally. It is clear that, like quality, P2 is a mindset that needs to permeate into the culture of the organization. Some have said that P2 is a way of life, not a new program. P2 requires many changes in behavior that cannot be simply demanded. Empowering employee teams to fully implement the new P2 behaviors is central to successful change management.

E.3 P2 Program Elements

P2 program planning should begin with the preparation of a *vision statement*, a *mission statement*, and a *statement of goals*. If your organization already has formal statements, it is important to align the P2 program with these statements. These statements and goals will help provide a good foundation for the P2 plan that your organization develops. Next, it is important to see how the P2 program aligns with the organization's guiding principles (also known as the core values). These items will help ensure that the program is understood and compatible with other initiatives in the organization.

The EPA has found that P2 programs often have similar program elements. They have published in the *Federal Register* six important elements that would be found in many programs of this nature. These elements include the following:

1. Provide top management support
2. Characterize the process
3. Perform periodic assessments
4. Maintain a cost allocation system
5. Encourage technology transfer
6. Conduct program evaluations

There may be other elements that can be included in the organization's P2 program. One good source is the American Chemistry Council's Responsible Care® Program's P2 Code. In addition, the organization must be certain to include the planning requirements that may be specified in its state environmental regulations.

To be truly successful, P2 requires a systematic, integrated, consistent, and organization-wide approach. This approach can be achieved through comprehensive P2 planning. Although you can learn from others' P2 success stories, real P2 success comes from the persistent application of the P2 philosophy and guiding principles in each organization's specific environment. Success is measured differently in each organization. It cannot be achieved simply by copying others.

E.4 P2 Tools

P2 teams can use a variety of specialized tools. These tools provide visual aids that are essential for communicating P2 information to management, other workers, and other interested parties. Tools also help P2 teams gather information and provide problem-solving and decision-making guidance. Finally, by using the tools, the P2 team is in a better position to construct an action plan for each P2 project included in the program. This allows for consistent tracking by the P2 oversight committee.

P2 tools are Systems Approach tools. The Systems Approach looks at the whole organization, and the parts, and the connections among the parts. These tools help point out how things can be changed to conserve the use of a resource or prevent the waste from occurring. This is fundamentally different from having an external assistance provider suggesting a way to change the process without considering the system.

These P2 tools are derived from quality programs and are widely used throughout the world. The application of the quality improvement tools used in the Systems Approach is a powerful force in eliminating environmental inefficiencies and preventing pollution.

The P2 tools are:

- Process characterization with hierarchical process mapping
- Resource accounting using the process maps as a template
- Selection of P2 opportunities using a Pareto diagram with appropriate cost information
- Analysis of the root cause of the problem using a cause-and-effect diagram
- Generation of alternative solutions using brainwriting
- Selection of an alternative for implementation using bubble-up/bubble-down
- Implementation of the alternative using an action plan

Checklists are also useful to help the P2 teams review the process and ensure that their work is complete.

Tools take time to master, but they help foster skills that the P2 team needs to characterize the process, solve problems, and make decisions. Making P2 a way of life takes more than words; it requires action. Action plans provide documentation for accomplishing the goals decided upon by using the tools. It makes it easier to track P2 progress over time.

E.5 Traditional Approach to P2 Implementation

The P2 approach provided in the previous EPA publications is presented along with process maps depicting each of the steps. This traditional approach has a “top-down” focus. It starts with getting management approval with pre-set program goals. This is communicated to the workforce using a policy statement. A P2 task force is organized and conducts a preliminary P2 assessment.

From this information, a P2 program plan is prepared with clear objectives and a firm schedule. Now a detailed P2 assessment is conducted to start the implementation phase. Checklists and worksheets are provided to help the team collect data and information. This assessment team will review the data and visit the sites where the P2 activity is planned to take place.

The team will derive P2 options (called *alternatives* in this *Guide*) and screen them with a criteria matrix. A feasibility analysis is performed to make a final determination based on technical, environmental, and economic factors. At this point, the traditional approach requires the preparation of a formal, written P2 assessment report to present the analysis to management for a decision.

Once the work begins, it is reviewed and adjusted to make sure it meets the objectives. The final step in the traditional program is to measure P2 progress. Data is acquired from the implementation phase and analyzed.

Previous P2 publications provide guidance on how to maintain the P2 program. Five activities are detailed as follows:

- Integrating the P2 program into other formal corporate initiatives
- Providing the proper amount of P2 education
- Communicating and soliciting of suggestions
- Providing for proper incentives for participating
- Implementing public outreach and education

P2 practitioners found this approach to be useful for very small organizations. Another method, called *Nothing to Waste*, has also been shown to be very effective with very small organizations and uses the tools presented in Chapter 4.

E.6 EMS Approach to P2 Implementation

The international voluntary standard for environmental management systems (EMS), known as ISO 14001, is an effective tool for implementing P2 alternatives. It is the intent of this standard to establish and maintain a systematic management plan designed to continually identify and reduce the environmental impacts resulting from an organization's activities, products, and services. An EMS promotes important planning and improvement elements needed in the design of multimedia source reduction and recycling programs.

As an initial step in developing a comprehensive EMS, most organizations find it helpful to complete an objective gap analysis of their existing environmental system. This enables the organization to compare its systems against ISO 14001 and highlight areas that require attention under the EMS development phase.

The preparation of the EMS includes the following steps:

- Environmental policy, management commitment, and scope of the EMS
- Communication of the EMS policy
- EMS planning
- EMS implementation
- Monitoring and measurement

An EMS establishes specific objectives, targets, and time frames for implementing P2 initiatives, improving environmental performance, and maintaining compliance, including compliance with state P2 planning requirements. Environmental management programs (EMP) are used to achieve the EMS objectives and targets.

Organizations are discovering that their investment in an EMS is leading to improved environmental performance and compliance with benefits for the environment and the community. An EMS provides a good method for establishing and implementing a P2 program. To achieve maximum environmental benefits, the EMS should embody the "plan, do, check, and act" model for continual improvement.

E.7 Using a Quality Model to Implement P2

P2 results are the *outcomes* of the *performance* of the P2 program and **not** a measure of the performance itself. Furthermore, P2 results by themselves offer little diagnostic value. They do not indicate whether an organization could have done better or if they really exceeded expectations. A model that focuses on measuring performance has been developed in the United States and is known as the Malcolm Baldrige National Quality Award. It measures six performance categories (i.e., leadership, strategic planning, other interested party involvement, information and analysis, employee participation, and process management). A seventh category captures the results. The Green Zia Program (New Mexico Environment Department) has adapted this quality model to measure environmental excellence. From the perspective of the organizations using this model, it is a prevention-focused, performance-driven EMS. Performance can be measured on a 1,000-point scale. This is a unit-less number and does not need to be normalized like other environmental metrics. Results are measured in three parts: environmental results, results of the interested party involvement, and financial results.

In order to increase the performance score, organizations must demonstrate how they leverage the various performance activities with other performance criteria. The organization also needs to find a way to integrate each of the eleven guiding principles with the proper criteria in the model. This facilitates the integration of the P2 program into the organization.

A five-step process is offered to improve or develop a P2 plan using the quality model concepts. The steps are as follows:

1. Plan and develop your P2 program
2. Develop your facility's P2 opportunities
3. Implement your P2 program alternatives
4. Maintain your P2 program
5. Measure your progress toward zero waste and emissions

The use of the Systems Approach and the quality model provides a means of creating a sustainable P2 plan for your organization. Your ISO 14001, Global Reporting Initiative, CERES Principles, Responsible Care® Program, balanced scorecard, six sigma, ISO 9000, and other environmental and quality initiatives will help the organization score points in each of the criteria. All these programs help contribute to environmental excellence. This quality model simply provides a means of providing a common thread on how they are related and allows you to see just how effective they are at driving environmental performance in your organization.

The P2 plan should be integrated with the core business practices. "Oh, that is something that the environmental coordinator is doing!" – such an attitude can only limit results. By making the P2 plan more businesslike, the possibilities for P2 within the organization are significantly enhanced.

E.8 Finding Your Own Way to Implement P2

Three approaches to implementing a P2 program have been presented in Chapters 5–7. This chapter discusses some of the items that are covered in these approaches to provide you with some ideas for planning and implementing a P2 program that is specific to your organization's requirements and culture. The following categories are presented that a P2 program could choose to address:

- Extent of planning
- Leadership
- P2 goal setting
- Focus on results
- Information and analysis
- Process management
- Employee participation
- Focus on interested parties
- Guiding principles or core values
- P2 program elements

E-9. CD-ROM

This *Guide* has been issued with a companion CD-ROM. It provides supporting information on all the topics and additional materials that may be required to plan and implement a P2 plan for your organization.

All the referenced material is accessible using the CD-ROM, including the previous EPA P2 publications and associated checklists. Information on a large number of EPA and state P2 activities is also included. The CD-ROM is divided into the following sections:

- P2 checklists
- Links to information on the P2 tools
- Information on EMS to support P2 implementation
- Information on the quality (Green Zia) model to support P2 implementation
- Other P2 manuals
- Other sources of useful P2 information

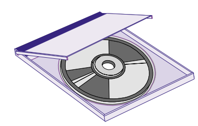
CHAPTER 1

Introduction

Includes:
- ☐ Evolution of Pollution Prevention (P2)
- ☐ Benefits of P2
- ☐ Impediments to P2 Use
- ☐ P2 in Steps
- ☐ Organization of This *Guide*
- ☐ References

EVOLUTION OF POLLUTION PREVENTION (P2)

Pollution prevention (P2) has evolved substantially in its first decade. In 1988, the U.S. Environmental Protection Agency (EPA) published the *Waste Minimization Opportunity Assessment Manual* (EPA/625/7-88/003). It contained over 34 pages of checklists and worksheets and focused on hazardous waste minimization. The first revision, *Facility Pollution Prevention Guide* (EPA/600/R-92/088), was released in 1992. It contained only 10 pages of checklists and worksheets, and added new topics, including energy conservation and the design of environmentally compatible products. The EPA distributed many copies of these publications to requestors in the United States and internationally, and the information was well-received by the environmental community. The EPA prepared many successful project reports and case studies based on this approach. Copies of these publications are available on the CD-ROM that accompanies this *Guide*, and the "traditional" P2 approach that they describe is covered in Chapter 5 of this *Guide*.



This *Guide* presents an alternative approach to implementing P2 in your organization. As you will see, it documents how P2 is moving from a specialized environmental initiative to a mainstream business activity. Employees can now become increasingly involved in P2 and reduce their reliance on "outside experts" using defined checklists and databases of "proven solutions" that may overlook P2 opportunities. Employees can use process mapping to better understand the organization's main and supporting processes and widely accepted problem-solving and decision-making tools to find new P2 opportunities and prepare cogent, written action plans. Many business managers are already familiar with these tools since they are already used to improve operations. No matter what method is selected to implement P2 activities, these tools should help improve communication within an organization and communication with other interested parties. This *Guide* is intended to assist any organization in developing, implementing, and maintaining a P2 program. It should help your organization decide which program elements to include and the general approach for sustaining this important business practice.

This Guide *presents an alternative approach to implementing P2 in your organization.*

P2 is moving from a specialized environmental initiative to a mainstream business activity.

During the evolution of P2, some environmental professionals have continued to focus on regulatory compliance. This has been a reactive focus, as compliance activity is usually undertaken in response to a new or changed regulation at the Federal, state, or local level. Prevention, on the other hand, is anticipatory. Action is taken not on the waste or use of a regulated material, but on the circumstances and conditions that may generate waste or a regulated material. The focus in P2 is on

The focus in P2 is on the organization's main and supporting processes, not on the resulting waste or use of a regulated material.

the organization's main and supporting processes, not on the resulting waste or use of a regulated material.

Many states have enacted P2 and toxics use reduction planning legislation. This legislation has had the unintended effect of making P2 a regulatory compliance effort and has done little to integrate P2 into core business practices. It is important to understand the organization's main and supporting processes and all of the individual work steps so that when the process is changed, the regulatory requirement is not triggered. By seeking to avoid the need for regulatory compliance (i.e., compliance through P2), environmental professionals become important resources to the organization's work function; managers of organizations are beginning to recognize the value of these environmental professionals as they reduce the costs associated with compliance activities.

Lean generally focuses on "the elimination of all waste from all business practices."

This Guide *focuses on the integration of P2 into core business practices.*

An organization's management is always searching for the newest trend to enhance its value and financial viability. Many organizations use a version of a management practice called lean manufacturing. Lean generally focuses on "the elimination of all waste from all business practices." Much has been written on seven types of organizational wastes: over-production, waiting time, transport, variable process, inventory, motion, and defective goods. Environmental wastes are rarely included in these programs because many organizations rely on the environmental function to manage these wastes in accordance with regulations. Many organizations with a strong focus on quality have weak P2 programs because the environment and quality programs have not been sufficiently integrated. This *Guide* focuses on the integration of P2 into core business practices. It will present P2 as a necessary component of many common organizational management programs and show you how to use the same problem-solving and decision-making tools used in these programs.

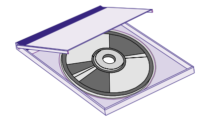
Many advocates for sustainability seek not merely to reduce waste but to eliminate the generation of waste altogether.

Having a strong P2 program is a vital aspect of any program that is set on eliminating wastes from the organization.

Many advocates for sustainability have called for a shift to biologically-inspired production models. They seek not merely to reduce waste but to eliminate the generation of waste altogether. As a result, there is a growing trend for organizations to set goals of zero wastes and/or zero emissions. Organizations like DuPont, Xerox, Collins Pine, and Interface have joined these ranks. The zero-waste trend stems from a long-standing tradition of setting zero defects, zero injuries, and zero incidents goals. Having a strong P2 program is a vital aspect of any program that is set on eliminating wastes from the organization. However, integrating a strong P2 program with many other programs in the organization is still essential to realizing these goals. Some organizations are implementing programs that direct them toward a sustainable performance level. Elimination of wastes and conservation of resources are important first steps in such programs.

This *Guide* is not intended to be an exhaustive review of case studies and company examples. In order to keep this *Guide* to a reasonable length, examples have been cited in the references section of each chapter and links have been provided in the CD-ROM that accompanies this *Guide*. In addition, many EPA and other programs support P2 efforts; e.g., Environmentally Preferable Purchasing (EPP), Design for Environment (DfE), Environmental Accounting Project (EAP), P2 Resource Exchange (P2Rx) and a number of other voluntary programs. Links to these programs are provided on the CD-ROM. This CD-ROM will also provide more detailed supporting information on many of the concepts described in the *Guide*.

This Guide *is not intended to be an exhaustive review of case studies and company examples.*



BENEFITS OF P2

The benefits of practicing P2 have long been noted. Despite the clear advantages, however, some managers are still reluctant to recognize the P2 efforts that are underway in their organizations. To provide better focus on the benefits, environmental coordinators are now showing how P2 is enhancing other management initiatives by linking P2 to the core values of the organization. It may be best to think of the following categories of benefits in this new light.

- Reduced operating costs
- Improved worker safety
- Reduced compliance costs
- Increased productivity
- Increased environmental protection
- Reduced exposure to future liability costs
- Continual improvement
- Resource conservation
- Enhanced public image

Reduced operating costs. P2 activities usually save an organization money in the long term. Many P2 projects have good returns on investment and short payback periods. Even if an organization is not subject to complicated regulations, P2 can still result in cost savings by reducing energy and water use while increasing materials productivity. Organizations may also save money in solid waste disposal costs, new material costs, and improved operating efficiency. Unfortunately, too few P2 professionals communicate the economic benefits of P2 progress to management.

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Improved worker safety. Reducing the use of toxic materials in the workplace should be a major component of P2. By reducing or eliminating toxic substance use, the safety of the work environment can be improved and the use of personal protective equipment requirements decreased. Also, reducing the likelihood of leaks, spills, and harmful releases can decrease worker, visitor, and contractor exposure to those

By reducing or eliminating toxic substance use, the safety of the work environment can be improved and the use of personal protective equipment requirements decreased.

substances. These steps will produce cost savings through material loss prevention and may result in reduced insurance rates as medical claims and disability leaves decrease. Better labor relations can also result from improved worker safety. Unfortunately, there have been cases where P2 activities have *inadvertently* decreased worker safety hazards (e.g., substituting the flammable solvent isobutyl alcohol for the halogenated solvent 1,1,1-trichloroethane which is non-flammable but a worker health issue). It is important that P2 does not trade off environmental improvement with workplace health and safety. Ergonomics can also be influenced by P2 efforts.

Undertaking P2 projects can reduce regulatory exposure and, in some cases, eliminate the need for permits, manifesting, monitoring, and reporting.

Reduced compliance costs. Undertaking P2 projects can reduce regulatory exposure and, in some cases, eliminate the need for permits, manifesting, monitoring, and reporting. This is referred to as *avoiding the need for regulatory compliance.* Keeping up with regulatory requirements and submitting the required reports can be an expensive and time-consuming process that, if eliminated, saves money. For example, the U.S. Air Force has initiated a program known as Compliance Through Pollution Prevention (Reference 1-1). The Air Force is trying to achieve and remain in compliance by using P2 instead of classical environmental engineering and regulatory compliance techniques. Some organizations have been able to change their regulatory compliance status (e.g., move from a large quantity generator of hazardous waste to a small quantity generator) through the use of P2 activities.

P2 can improve an organization's material productivity through more efficient use of raw materials due to improved processes and operations.

Increased productivity. P2 can improve an organization's material productivity through more efficient use of raw materials due to improved processes and operations. For example, an organization that produces large quantities of wastes (discharges, emissions, spills, and leaks) might be using old technologies to produce its products, or its processes might be poorly controlled and inefficiently operated. Sometimes small process improvements involving material substitutions and changes in operating procedures can result in increased product yield and better quality.

Increased environmental protection. Many waste disposal and treatment methods are less protective of the environment than previously estimated. These methods may only move environmental contaminants from one medium to another. They may cause problems in the future that are not yet apparent. P2 reduces the generation of wastes (discharges, emissions, spills, and leaks) at the source, resulting in less toxic waste, and thus assures improved environmental protection.

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Reduced exposure to future liability costs. Reduction of potential long-term liability from waste disposal, emissions, and discharges has become an important concern in recent years. Some past disposal practices, although legal, have caused environmental damage for which organizations have been held liable, creating a large liability expense and damaging their public images. P2 can help reduce long-term liability by reducing the amount and toxicity of waste generated.

Continual improvement. Successful implementation of a P2 program can be an integral part of a company's continual improvement or quality improvement program. Reducing wastes and improving efficiency are goals of both P2 and continual improvement. Many organizations use continual improvement to constantly change certain work processes in order to improve them. To clarify the use of the term "continual improvement," the following distinction is made:

Successful implementation of a P2 program can be an integral part of a company's continual improvement or quality improvement program.

> "Continuous improvement—happening all the time, everything moving forward at once; often used in quality programs"
>
> "Continual improvement—happening all the time, but not everything moving forward at the same time and rate; often used by auditors of Environmental Management Systems and in other environmental programs."

The term continual improvement is used throughout this text.

Resource conservation. P2 will lead to the use of less energy and water. All resources, materials use, and waste reduction can be monitored in the same program. Traditionally, most organizations had separate programs (e.g., water conservation or energy efficiency) for resource conservation and P2. However, these programs are related in many ways; both are necessary to improve efficiency and to meet the organization's goal of sustainability.

P2 will lead to the use of less energy and water.

Enhanced public image. P2 can help an organization gain a favorable image with the community by showing that they are willing to make changes to improve the environment and move towards sustainability. Some organizations have used their "green" image to successfully distinguish themselves in the marketplace, thus adding to their intangible goodwill market value.

IMPEDIMENTS TO P2 USE

A number of impediments commonly hinder successful implementation of a P2 program. It is important to recognize these impediments and address each of them during implementation. Management's commitment to addressing these issues is a key element of the success of the P2 program.

- Capital requirements
- Specifications
- Regulatory issues
- Product quality issues
- Customers' acceptance
- Immediate production concerns
- Organization image concerns
- Available time/technical expertise
- Inertia

Capital justification protocols may not recognize the "hidden" costs that are avoided and the reduction in the organization's financial overhead burden resulting from P2 measures.

Capital requirements. Implementation of P2 measures might require capital investment. Such projects may need to be justified economically and are subject to the availability of capital in the organization. Capital justification protocols may not recognize the "hidden" costs that are avoided and the reduction in the organization's financial overhead burden resulting from P2 measures.

Specifications. Specifications can be both an incentive and an impediment. For instance, specifications may stipulate certain materials be used in the manufacture of a product, or that virgin materials be used rather than recycled. This can lead to the use of materials that are damaging to the environment, or the unnecessary use of virgin materials where recycled would suffice.

Unfortunately, P2 changes may occur faster than the government can respond.

Regulatory issues. It may be necessary to obtain a new or modified permit or other governmental approval before implementing a process change or material substitution. This can be time-consuming and costly. For example, if a process is regulated by the Food and Drug Administration (FDA), all process changes require submittal of an application for approval, and new equipment must be inspected and approved by the FDA. In some cases, clinical trials of a substance, such as a drug, must be repeated to demonstrate efficacy. Unfortunately, P2 changes may occur faster than the government can respond. Many permit changes can take long periods of time to attain in even the most efficient governmental agencies.

Some P2 projects may affect product quality, even when properly implemented, and thus may be regarded with skepticism.

Product quality issues. Organizations have great concern for the quality of the products and services they offer. Some P2 projects may affect product quality, even when properly implemented, and thus may be regarded with skepticism. For example, the use of mineral oils instead of mineral spirits (that have high volatile organic chemical [VOC] emissions) to carry dyes to fabrics may mean that some of the oils will remain on the fabric once it is dried, thereby changing the "feel" of the fabric and possibly the value of the finished product.

Some large organizations have encouraged their supply chains to adopt P2 behaviors to further the competitive advantage of the entire value chain.

Customers' acceptance. The customer ultimately defines product quality; anything that affects the quality, or even the perception of quality, may affect acceptance by the customer. Customers often have a greater influence on how an organization operates than other outside parties. Some large organizations have encouraged their supply chains to adopt P2 behaviors to further the competitive advantage of the entire value chain.

Implementation of P2 projects are often viewed by production as requiring time, money, and personnel, all of which are usually in short supply.

Immediate production concerns. Implementation of P2 projects are often viewed by production as requiring time, money, and personnel, all of which are usually in short supply. Production quotas must be met as a first priority. After all, meeting the customers' demands is what pays the bills. However, production often finds the means to improve productivity, and P2 needs to be seen in this same light.

Organization image concerns. Organizations may be hesitant to admit that the "old way" may not be the best way. Once easy-to-implement P2 practices such as improved operations are underway, for example, some organizations may resist publicly acknowledging the changes out of concern that such acknowledgment might expose previous, less environmentally sound practices. However, the implementation of P2 practices provides managers with an opportunity to lead the organization through changes that will benefit everyone.

Available time/technical expertise. Some organizations may lack sufficient time or technical expertise to develop and implement P2 practices. Even though many state and federal technical assistance programs (References 1-2, 1-3, 1-4) are available at little or no cost, some organizations simply fail to take advantage of them.

Even though many state and federal technical assistance programs are available at little or no cost, some organizations simply fail to take advantage of them.

Inertia. Whenever a production system is in place and working with some degree of success, there is a tendency to leave well enough alone. The old adage "if it ain't broke, don't fix it" still prevails in most organizations. Overcoming resistance to change is a major challenge for P2.

Overcoming resistance to change is a major challenge for P2.

P2 IN STEPS

Previous editions of this *Guide* have defined a path (adapted from Figure 3 in EPA/600/R-92/088) depicting how P2 should be implemented (see Figure 1-1).

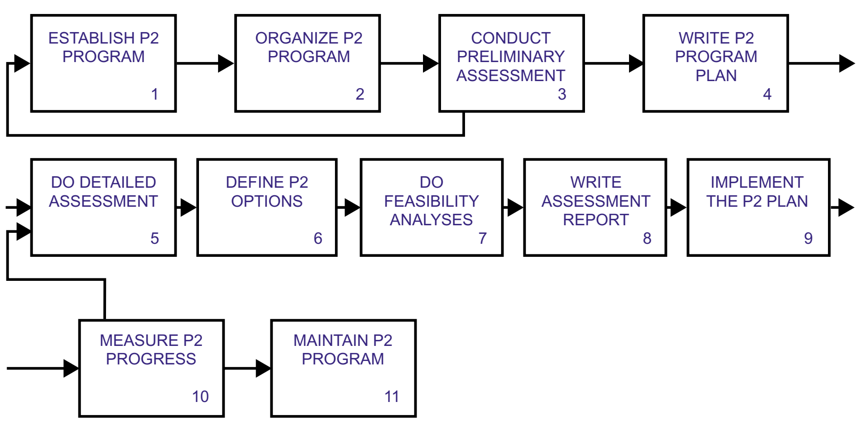


Figure 1-1. Process Map of a Traditional P2 Program.

Following is an alternative view of P2. The primary difference lies in the fact that the P2 Program is established after much of the information has been gathered rather than in the first step of the program. It also uses quality tools that have been adapted to P2 programs and published in the literature. This view of P2 consists of five simple steps (see Figure 1-2):

The primary difference lies in the fact that the P2 Program is established after much of the information has been gathered rather than in the first step of the program.

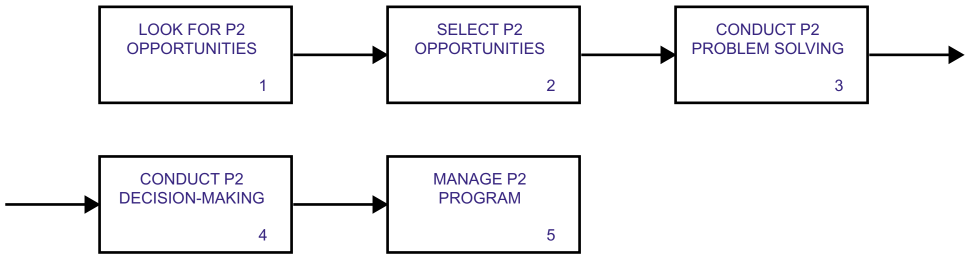


Figure 1-2. An Alternative Approach to a P2 Program.

While these steps will be discussed in more detail in Chapter 4 of this *Guide*, it is important to highlight some of the differences between the methods described here and the methods contained in the traditional approach to P2.

Step 1. Looking for P2 Opportunities

- Process mapping
- Main process/supporting processes
- Maps as information templates

The process maps become templates for maintaining information about the process.

All of the organization's processes are characterized in detail using a tool known as process mapping. This tool allows the information to be aggregated to a higher level when necessary. All supporting operations (ancillary and intermittent) are examined and linked to the main processes. Nothing is missed using this visual tool. All resources (e.g., energy, water, and materials) are accounted for at the work-step level (i.e., at the lowest level in the process maps as they define the actual work task that is being performed). The process maps become templates for maintaining information about the process. The costs of using and losing resources can also be collected by work-step using the process maps as templates. Traditional P2 methods have relied on a walk-through process assessment to gather information on P2 opportunities.

Step 2. Selecting P2 Opportunities

- Rank ordering
- 80/20 rule
- Pareto chart
- Monetary metrics

Every process in every organization will produce P2 opportunities.

Every use of a resource in a process represents an *opportunity* to conserve the use of that resource. Every loss of a resource in a process represents an *opportunity* not to lose that resource. Every process in every organization will produce P2 opportunities. It is possible to rank P2 opportunities using monetary units and also to construct a Pareto chart. This chart will show that 20% of the P2 opportunities represent 80% of the true costs of environmental management of the uses and losses. No matter how the P2 opportunities are selected, it is important to have the organization keep its collective eye on the most important ones. Many organizations select a manageable number of P2 opportunities to work on each year. Ideally, P2 opportunities should be selected from every department in the organization to ensure that everyone stays involved.

Step 3. P2 Problem Solving

Once the P2 opportunities are selected, the use and loss of resources are seen as "problems." Worker teams are assembled to address these problems using root cause analysis to first ask *why* each is a problem. A simple cause and effect (fishbone) diagram can help the team examine how materials, machines (technology), methods, and labor contribute to the problem. This visual tool can communicate the causes of the problem to all levels of the organization. In fact, the cause-and-effect diagram is the most widely used problem-solving tool in the world.

A simple cause-and-effect (fishbone) diagram can help the team examine how materials, machines (technology), methods, and labor contribute to the problem.

With this important information gathered and analyzed, the team can now search for alternatives to solve the problem using tools like brainstorming and brainwriting. It is important to remember the adage that "the only way to find a good P2 alternative is to find many alternatives." In the past, many P2 problem-solving efforts centered on finding the "right answers" instead of searching for alternatives. Previous P2 success stories should be used only to provide ideas to the team using this problem-solving method. Because workers often wish to be involved in solving problems associated with their work, home-grown solutions are often more readily implemented than expert-generated solutions from the outside.

- Root cause analysis
- Cause and effect diagrams
- Fishbone diagrams
- Brainstorming
- Brainwriting

Step 4. P2 Decision-Making

Now the team must select an alternative to implement. A good tool for doing this is known as *bubble-up/bubble-down*. It is a forced-pair comparison of all the alternatives. Some teams prefer to use a criteria matrix or selection grid for rating each alternative against a predetermined set of criteria. Alternatives that are inexpensive and easy to implement go to the top of the list using the bubble-up/bubble-down tool. These "low hanging fruit" or "quick win" alternatives can often be implemented without much further study. More effective alternatives may require additional study. In some cases, a detailed feasibility study must be prepared. It is always beneficial from a team development perspective to have the "quick wins" precede these more complex programs.

Now the team must select an alternative to implement.

- Bubble-up/bubble-down
- Criteria matrix
- Action plan

To implement the alternatives, a written action plan should be prepared and submitted to management for review and approval. The key component of the P2 plan at the facility will be the action plans that are being implemented during the current year.

To implement the alternatives, a written action plan should be prepared and submitted to management for review and approval.

Step 5. P2 Program Management

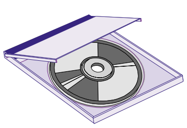
This *Guide* suggests ways an organization can establish, implement, and manage its P2 program. The activities described in Steps 1

P2 program management must be designed to fit the culture of the organization using P2.

through 4 will take place within that program. While Steps 1 through 4 apply to many organizations, P2 program management (Step 5) must be designed to fit the culture of the organization using P2. The organization must provide training for the people participating in the program. There must be understandable policies and a management commitment. Relationships to other organizational programs must be clearly defined. Oversight for the P2 program can be provided in the form of program audits, by both internal and third parties. Finally, there must be a way to measure progress and evaluate the effectiveness of the P2 program. Some information that enables organizations to adapt the program management to their own culture is provided in Chapters 5 through 7.

ORGANIZATION OF THIS *GUIDE*

This *Guide* will provide information to help organizations get their P2 programs started or to help re-evaluate existing P2 programs. Chapter 2 provides some advice on how to get started with the P2 program process. The planning of the P2 program is covered in Chapter 3 and is discussed along with some planning elements that should be addressed. Most P2 programs can use tools (discussed in Chapter 4) to facilitate communication within the organization and between organizations. Tools that support the five-step model described previously are presented in Chapter 4. These tools can also be used in all of the implementation models covered in this *Guide*. Several models are presented to help in implementing the P2 program. A traditional P2 implementation model is presented in Chapter 5. It can be used with or without the tools presented in this *Guide.* Also presented is a version of this model called “Nothing to Waste” that is particularly useful to small organizations. Chapter 6 shows how an environmental management system (EMS) may be used to implement a P2 program. Chapter 7 presents a quality model that can be used to implement a P2 program. Chapter 8, the final chapter, examines how individuals can design and implement their own P2 programs from the materials presented in this *Guide.*



A companion CD-ROM is included to provide supporting information on all of these topics and additional information that may be required to plan and implement a P2 program for your organization. All of the referenced material is accessible through the CD-ROM. The following information is provided on the CD-ROM:

- P2 Checklists
- Links to Information on the P2 Tools
- Information on EMS to Support P2 Implementation
- Information on Quality Model to Support P2 Implementation
- Other P2 Manuals
- Other Sources of Useful P2 Information

The CD-ROM should be useful as your organization develops the P2 Program.

REFERENCES

1-1. *Compliance Through Pollution Prevention (CTP2): Implementation Guide.* U.S. Air Force Material Command, Wright-Patterson AFB, December 2000.

1-2. National Pollution Prevention Roundtable (NPPR) Web Site http://www.p2.org/

1-3. National Institute for Science and Technology Manufacturing Extension Program (NIST MEP) Web Site http://www.mep.nist.gov/

1-4. Small Business Development Centers (SBDC) Web Site http://www.sbaonline.sba.gov/SBDC/

Other Sources of P2 Information

EPA Environmentally Preferable Purchasing (EPP) Program
http://www.epa.gov/opptintr/epp/

EPA Environmental Accounting Project
http://www.epa.gov/opptintr/acctg/

EPA Design for Environment
http://www.epa.gov/dfe/

EPA P2 Programs and Initiatives
http://www.epa.gov/opptintr/p2home/programs/index.htm

EPA P2 Resource Exchange (P2Rx)
http://www.p2rx.org/

EPA Sustainable Industry
http://www.epa.gov/sustainableindustry/

State P2 Programs
http://www.epa.gov/opptintr/p2home/resources/statep2.htm

CHAPTER 2

Getting Started

So you have decided to move from conducting specific P2 projects to having a formal P2 program. Maybe you are just trying to revive an older P2 program in your organization. In either case, this section of the *Guide* will provide you with information to consider before beginning your P2 program planning process.

HOW TO DEFINE P2

It is important to decide how you will define P2. In order to know what you can include in your P2 program, it helps to know what is possible. There are many definitions available to choose from and many programs that are closely related to P2. We will present a few P2 concepts to help you determine where you wish to focus your efforts. First, the definition of pollution prevention adopted by the U.S. Environmental Protection Agency (EPA) is provided in Box 2-1.

In order to know what you can include in your P2 program, it helps to know what is possible.

Box 2-1. Pollution Prevention Definition

Pollution prevention means "source reduction" (as defined under the Pollution Prevention Act) and other practices that reduce or eliminate the creation of pollutants through:

- increased efficiency in the use of raw materials, energy, water, or other resources, or
- protection of natural resources by conservation.

The Pollution Prevention Act defines *source reduction* to mean any practice that:

- reduces the amount of any hazardous substance, pollutant, or contaminant entering any waste stream or otherwise released into the environment (including fugitive emissions) prior to recycling, treatment, or disposal
- reduces the hazards to public health and the environment associated with the release of such substances, pollutants, or contaminants.

Under the Pollution Prevention Act, recycling, energy recovery, treatment, and disposal are not included within the definition of pollution prevention. Some practices commonly described as "in-process recycling" may qualify as pollution prevention.

From Hank Habicht's EPA memorandum of May 28, 1992 (Reference 2-1)

The EPA definition stresses the importance of placing source reduction at the top of a "waste management hierarchy." Recycling, proper treatment, and safe disposal of the residues are farther down the hierarchy. There are other similar P2-like concepts that some feel compete with the EPA definition.

The EPA definition stresses the importance of placing source reduction at the top of a "waste management hierarchy."

The international community has adopted the term *cleaner production.* As you can see from the definition of cleaner production in Box 2-2, it has a broader meaning than the one we give to the term P2. The final term *eco-efficiency* is used extensively in the sustainable development arena and is defined in Box 2-3.

Cleaner production *is the continuous application of an integrated preventative environmental strategy applied to processes, products, and services.*

Box 2-2. Cleaner Production Definition

Cleaner production is the continuous application of an integrated preventative environmental strategy applied to processes, products, and services. It embodies the more efficient use of natural resources and thereby minimizes waste and pollution as well as risks to human health and safety. It tackles these problems at their source rather than at the end of the production process; in other words, it avoids the 'end-of-pipe' approach.

For processes, cleaner production includes conserving raw materials and energy, eliminating the use of toxic raw materials, and reducing the quantity and toxicity of all emissions and wastes.

For products, it involves reducing the negative effects of the product throughout its life-cycle, from the extraction of the raw materials through to the product's ultimate disposal.

For services, the strategy focuses on incorporating environmental concerns into designing and delivering services.

United Nations Environment Program (Reference 2-2)

Box 2-3. Eco-efficiency Definition

Eco-efficiency is the efficiency with which ecological resources are used to meet human needs. It is expressed as the ratio of an output—the value of products and services produced by a firm, a sector, or the economy as a whole—to the "input"—the sum of environmental pressures generated by the firm, sector, or economy. Measuring eco-efficiency depends on identifying indicators of both input and output.

The World Business Council for Sustainable Development (WBCSD) (Reference 2–3) considers that eco-efficiency places seven demands on a firm:

1. Reducing material intensity of goods and services
2. Reducing energy intensity of goods and services
3. Reducing toxic emissions
4. Enhancing material recyclability
5. Maximizing sustainable use of renewable resources
6. Extending product durability
7. Increasing the service intensity of goods and services

All three of these terms—pollution prevention, cleaner production, and eco-efficiency—address:

1. Elimination of process losses at the source without resorting to end-of-pipe pollution control devices.
2. Conservation of resources (including energy, materials, and water) that are used in the process or operation.

There are also some differences between these terms. For example, **eco-efficiency** looks at maximizing the sustainable use of renewable resources while **cleaner production** focuses on the more efficient use of natural resources. **P2** looks at the protection of natural resources by conservation. All of the definitions address hazards to public health and the environment and seek to reduce toxic emissions and the use of toxic raw materials. However, only cleaner production addresses the need to consider whether there is a shift in risk from the environment to worker safety as a result of changes made in the process.

Consider whether there is a shift in risk from the environment to worker safety as a result of changes made in the process.

Eco-efficiency and cleaner production address processes, products, services, and life cycle issues. P2 considers "in-process recycling" while eco-efficiency considers "enhancing material recyclability."

The authors use the term P2 throughout this *Guide.* However, you can choose to add elements of cleaner production and/or eco-efficiency to your program if you wish to do so. The definitions of these terms are provided to help you see what is possible. There are organizations already incorporating many of these additional items into their P2 programs. P2 can be defined more broadly than EPA originally intended.

The authors use the term P2 throughout this Guide. *However, you can choose to add elements of cleaner production and/or eco-efficiency to your program if you wish to do so.*

P2 can be defined more broadly than EPA originally intended.

SUSTAINABLE DEVELOPMENT

P2 plays an important role where the goal is sustainable development. There are many definitions of sustainable development. The following definitions provide broad and operational perspectives to cover the range of components that are commonly included under the sustainability umbrella. According to the World Commission on Environment and Development, "sustainable development is a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations." An operational definition of sustainable development is "Good stewardship of natural resources such that long-term productivity may be maintained or improved with minimal, if any, adverse impacts on the environment and worker health and safety."

P2 plays an important role where the goal is sustainable development.

If your organization is interested in a sustainable development goal, it is important to consider setting a goal of zero waste or zero emis-

Consider setting a goal of zero waste or zero emissions.

sions (Reference 2–4). For some organizations, this goal may seem unrealistic. However, many organizations reach these goals by converting previously unused wastes into other products and driving their programs to near zero waste. This zero concept is very popular in the quality movement and more particularly with a program referred to as "six sigma" (i.e., attaining the goal of only 3.4 defects per million operations instead of the 35,000 to 60,000 defects per million operations that most very competitive organizations now tolerate). This number of defects is very close to zero. Some organizations have extended the six sigma approach to regulatory compliance issues where they consider a "notice of violation" a defect. However, more progressive organizations use six sigma to *prevent* regulatory compliance issues.

INTEGRATING THE NEW P2 PROGRAM INTO CORE BUSINESS PRACTICES

When getting started with a P2 program, look around to see what other types of "prevention" programs already exist in the organization.

Organizations considering a P2 program may already have compatible programs in place. When getting started with a P2 program, look around to see what other types of "prevention" programs already exist in the organization. Box 2-4 lists some prevention-oriented programs that currently exist in many organizations. Can the P2 program be tied to any of these or similar programs? The integration of the P2 program into existing core business practices can help small organizations find resources to start a new P2 program and large organizations consolidate existing programs, allowing each to remain competitive in the global marketplace as they implement P2.

Box 2-4. Typical Prevention Programs in Industry

- Environmental management systems
- Quality management initiatives
- Preventive maintenance
- Health and safety programs
- Insurance/risk management

Environmental Management Systems

This Guide *will provide some methods you can use to emphasize P2 within an EMS.*

One program that may be compatible with a new or revised P2 program is an environmental management system (EMS). One popular EMS format, known as ISO 14001, has been issued by the International Organization for Standardization (Geneva, Switzerland). ISO 14001 is a management system standard, not a performance standard, providing a general framework for organizing the tasks necessary for effective environmental management. This approach may prove effective in encouraging the organization to take an active, preventive, and systematic approach to managing its environmental impacts. This *Guide* will provide some methods you can use to emphasize P2 within an EMS (see Chapter 6). An EMS protocol requires the organization to consider the **prevention of pollution,** compliance with all legal requirements, and continual improvement. Like P2, an EMS seeks to integrate environmental concerns into core business practices.

Quality Initiatives

Quality initiatives focus on preventing defects in processes, products, and services.

Quality initiatives focus on preventing defects in processes, products, and services. These initiatives often declare a "war on waste." However, too few also consider air emissions, water discharges, solid and hazardous wastes, and spills and leaks to be a waste. Organizations develop ISO 9000 programs to deal with quality. ISO 9000 programs are prepared in the same format as the ISO 14001 program. Quality initiatives have evolved just as P2 has been defined and refined. Many people have less than fond memories of certain management fads like "Total Quality Management (TQM)." Despite the approaches and fads that cycle in and out, most organizations would agree that quality refers to everything an organization does to provide goods and services that meet customer requirements, the way that organization's employees interact together, and the organization's expectations of its suppliers and other interested parties. Developers of P2 programs should become familiar with the quality improvement initiatives in the organization.

The Baldrige criteria are currently used in approximately 50 countries and 44 of the 50 states to help improve competitiveness in both manufacturing and service businesses.

Some organizations use the Baldrige criteria to judge their overall operating performance. The Malcolm Baldrige National Quality Program is the Presidential Award program in the United States (Reference 2-5). These performance-based criteria are currently used in approximately 50 countries and 44 of the 50 states to help improve competitiveness in both manufacturing and service businesses. An environmental excellence program has been developed in New Mexico using the Baldrige model. This Green Zia Program is used to rate organizational environmental programs that "go beyond mere compliance." This program (Reference 2-6) helps an organization establish core values for its program and demonstrates how quality and P2 can be effectively integrated. A set of criteria and a rigorous scoring system allow any organization to track and search for trends in its continual improvement using a unit-less score. This eliminates the need to "normalize" for production. These concepts are covered in Chapter 7.

Preventive/Predictive Maintenance

Unscheduled equipment downtime often leads to the generation of wastes in organizations.

Preventive and/or predictive maintenance is designed to keep machinery from breaking down. Unscheduled equipment downtime often leads to the generation of wastes in organizations. There are a number of Internet sites dedicated to the topic of preventive/predictive maintenance (Reference 2–7). The principles from this field are applicable to P2 programs.

Safety

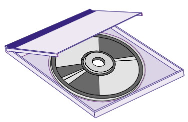
Safety has always had its focus on preventing *incidents and exposures.*

Many environmental managers are gaining some oversight of the safety function in their organizations. Organizations track safety closely because it impacts worker compensation rates and related insurance costs. P2 training and safety training are often combined in organizations to stress the prevention message. Safety has always had its focus on *preventing* incidents and exposures. There is information on safety available on the Internet (Reference 2-8).

Insurance/Risk Management

Insurance companies and organization risk management professionals frequently audit organization processes and facilities to prevent property loss and other forms of insurable risk. P2 programs should collaborate with risk management personnel, whether in the company or sent by the insurance company.

WHO SHOULD IMPLEMENT P2?



Many states have legislatively mandated programs that require P2 planning while others have programs that encourage voluntary P2 planning.

Many states have legislatively mandated programs that require P2 planning (Reference 2-9) while others have programs that encourage voluntary P2 planning (see the CD-ROM for further information on these statutes). The focus of most state P2 planning programs is the environmental manager. However, it is becoming clear that operational changes not commonly controlled by the environmental manager are needed to make P2 work. Recognizing this point, many organizations are establishing **multi-functional teams** to provide oversight of their waste-elimination efforts. These teams often include environment, operations, accounting, and a variety of other internal service providers and functions. Representatives from upper management are often essential members of such P2 oversight teams.

For maximum effectiveness, workers need to be directly involved in P2 program development.

Although a commitment to the P2 program should begin with management (i.e., top-down approach), line employees can often suggest valuable improvements in operations and procedures (i.e., bottom-up approach). For maximum effectiveness, workers need to be directly involved in P2 program development. The Quality model (Chapter 7) stresses this need by dedicating one of its seven performance criteria categories to worker involvement. Many organizations use P2 tools to give everyone a common frame of reference and to enhance problem-solving and decision-making skills. Management can authorize and give responsibility to worker teams to implement the P2 program. Management should also monitor all P2 efforts periodically. Whether an organization runs a service business or operates in a manufacturing setting, it can implement a successful P2 program.

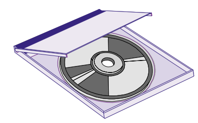
WHEN WILL YOU BEGIN?

As mentioned previously, you may have already started your P2 efforts. Perhaps you have had some P2 successes and are now seeking ways to formalize and sustain the program. Maybe this is the first time you have formally looked at eliminating waste from the organization. If so, you might wish to start by preparing a list of all the projects you have implemented in the past two or three years that would fit under the heading of P2. Make sure that representatives of all parts of the organization participate in the creation of this list. As you begin to focus on P2, many organizations are able to double or triple the number of P2 projects appearing on their listing of past accomplishments. As more people get involved in P2, they may begin to recognize that they have most likely been doing some of this all along. Resolve to keep this list current and share it with regulators, customers, suppliers, community organizations, and all other interested parties. Then prepare to start your new P2 program.

As more people get involved in P2, they may begin to recognize that they have most likely been doing some of this all along.

LESSONS LEARNED FROM PAST P2 PROGRAMS

There is a substantial body of literature on P2 efforts in the United States and internationally. References to much of this P2 literature is included on the companion CD-ROM. Some of the lessons learned during those efforts specific to the preplanning phase are described in the following paragraphs.



The implementation of P2 projects can yield some modest, immediate benefits. However, the big payoff from P2 often requires a program that is integrated into the operations of the organization and supported for a minimum of two to three years. Like quality, P2 is a mindset that needs to permeate into the culture of the organization. One of the greatest P2 myths is that a P2 program is a “quick fix” used to turn around organizations. Many P2 programs do not offer instant financial success. P2 is a long-term effort with *both* long- and potential short-term bottom-line benefits.

Like quality, P2 is a mindset that needs to permeate into the culture of the organization.

P2 is a long-term effort with both *long- and potential short-term bottom-line benefits.*

P2 success requires full financial support as well as management commitment. Resources that will be needed include funds, people, training, facilities, support structure, and, in some cases, the adoption of new technology. Often projects that are already funded can be turned into P2 projects by emphasizing different aspects. Other financial commitment concerns will be covered in Chapter 4.

P2 success requires full financial support as well as management commitment.

Some have said that P2 is a way of life, not a new program. P2 requires many changes in behavior that cannot be demanded. The goal of P2 is to institutionalize the philosophy and guiding principles as part of the organization. This can only be accomplished by continual actions that reinforce P2 behaviors. Since people resist change, a move to new prevention methods involves a campaign for their hearts as well as their minds.

P2 is a way of life, not a new program.

The goal of P2 is to institutionalize the philosophy and guiding principles as part of the organization.

Change occurs because people as a group accept it. Approach such change deliberately. Involve the organization's members and listen to them. Be responsive to their needs and ideas. When change represents a new work style for people, allow time to adjust to it and experiment with it. An idea approached as a pilot project may be accepted more readily than one imposed as a permanent change. You can combat resistance by surrounding the organization's members with a network of familiar activities, support, and guidance. Encourage them to feel anchored to the direction and mainstream activities of the organization.

Change management is a fundamental and critical element of P2 program implementation.

Change management is a fundamental and critical element of P2 program implementation. Failure to develop bureaucracy-elimination initiatives, communication improvement, and training programs sends mixed signals to the employees. Empowering teams to fully implement the new P2 behaviors is central to successful change management.

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Many P2 consultants and P2 technical assistance providers have tried to sell P2 as an environmental program. Your organization will probably find greater success by linking P2 to its strategic needs. Address the true scope and impact of P2 as part of managing your business needs. To increase your effectiveness, integrate the P2 program into the organization's core business practices. The business case needs to be made for all P2 projects. Success needs to be measured economically, as well as in volume and weight.

The business case needs to be made for all P2 projects.

DEALING WITH CHANGE

Instituting a P2 program can facilitate change in an organization.

Instituting a P2 program can facilitate change in an organization. Technical savvy and operational knowledge are not sufficient by themselves. Everyone in the organization must change to make P2 work. This will not be easy. There are seven things you should consider when you start a P2 program in your organization:

Everyone in the organization must change to make P2 work.

- **Present reason for change.** If you want people to change, persuade them of the need for change. This might be accomplished as part of a "war on waste" or related to issues surrounding competitive advantage. The very reasons that organizations are trying to become "lean" are the same reasons that P2 should be an integral part of that program. What is management pointing to when it seeks change? How is P2 related to that change? Moving more money to the bottom line is important in a private organization. Maintaining the same mission with fewer funds is a common cause for many not-for-profit and government organizations. Many times money has something to do with the need for change. This should make P2 very attractive.

The very reasons that organizations are trying to become "lean" are the same reasons that P2 should be an integral part of that program.

- **Offer a compelling vision.** The concept of having a P2 vision will be covered in the next chapter. Everyone will be asking, "How will things be better with the change?" All P2 projects must fit the vision and must be related to the reason for change previously stated. Finding the right vision will be challenging. However, once found, it will provide the rallying call that is often missing in a P2 program.
- **Show results quickly!** Many successful P2 programs gain momentum when economic benefits are demonstrated. P2 programs should pay for themselves. Do not measure progress by the number of activities (i.e., P2 opportunity assessments, P2 teams in action, opportunities identified, etc.) or pounds or volume of waste avoided. P2 goals are best measured in dollars—enough dollars to provide an incentive to keep the P2 program going from year to year. It could even be treated as a profit center in a private sector organization. All organizations can support value-added programs.
- **Communicate, then communicate some more.** You can never do enough to get the P2 message across to all interested parties—workers, suppliers, regulators, customers, the community, and all other interested parties. Keep the communication simple so everyone can understand what is going on. "Walk the talk" at all levels of the firm, even top management. Provide incentives for suppliers to join the program. Show the customers how the program can benefit them. Join in the regulators' voluntary programs that encourage waste reduction.
- **Build a strong, committed management P2 guiding team.** This high-level oversight team should sponsor all P2 efforts while articulating the P2 vision, fostering communication, eliminating obstacles, coaxing the short-term wins, serving as mentors to the worker P2 teams, and embedding new approaches into the organization's culture. Generally, whenever such a team is present, the P2 program has a much higher level of success. Implementation of P2 through the intervention of only vendors, consultants, and technical assistance providers reduces the chance of success. The P2 program must be internalized, continuously reinforced, and rewarded by management in order to yield long-term results.
- **Add some level of complexity to the P2 program.** This may sound counter-intuitive, but breakthrough complex change may be easier to accomplish than incremental change. Integrating P2 into core business practices instead of relegating it to environmental personnel is one way to accomplish this goal. To maximize integration, change every-

Finding the right vision will be challenging. However, once found, it will provide the rallying call that is often missing in a P2 program.

You can never do enough to get the P2 message across to all interested parties—workers, suppliers, regulators, customers, the community, and all other interested parties.

The P2 program must be internalized, continuously reinforced, and rewarded by management in order to yield long-term results.

To maximize integration, change everything at the same time.

thing at the same time. P2 should be a collaborative effort with operations department efforts to increase productivity.

- **As stated previously, people do not resist their own ideas.** Involve the organization's members in the change. Rely on outside expertise and technical assistance only to *facilitate* internal change. Provide the needed resources required to *initiate* the P2 program. People who participate in deciding what P2 changes are needed and how they will occur are more likely to support the changes and advance the program. Provide training and lessons learned to increase the success of the P2 program.

Chapter 3 will describe some of the elements that will help make the P2 program work and thrive.

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CHAPTER 3

P2 Program Elements

Includes:
- ☐ P2 Program Planning
- ☐ Core Values
- ☐ Selecting Program Elements
- ☐ Lessons Learned
- ☐ References

P2 PROGRAM PLANNING

Before planning begins, the team seeking to implement the P2 program should consider preparing a ***vision statement***, a ***mission statement***, and a ***statement of goals.*** If similar statements already exist for the organization, you should see how P2 fits into these existing statements. If the organization has no formal statements, the P2 program team may wish to draft these statements to help provide some focus to their efforts. It is important not to get side tracked on trying to differentiate between vision statements, objectives, values, purpose, guidelines, covenants, standard of performance, mission statements, core values and guiding principles. For the purposes of talking about P2 planning, we will adopt some simple definitions that can be modified as you see fit.

Before planning begins, the team seeking to implement the P2 program should consider preparing a ***vision statement****, a* ***mission statement****, and a* ***statement of goals****.*

A vision statement represents what the organization wants in terms of P2. A mission statement identifies what the organization needs to accomplish, in the future, in the key areas that affect P2 and its business. A mission statement specifies an organization's purpose or "reason for being." It is the primary objective toward which the organization's plans should be aimed. The mission is something to be accomplished, while a vision is something to be pursued. Goals establish the metrics that will be used to measure progress. Indicators are used to measure progress along the way. These statements and measures will help provide a good foundation for the P2 plan that your organization develops. Some of these statements may already have been formulated in an ISO 14001 effort or other EMS initiative. Planning provides an organization with a time frame in which to ask questions related to the enactment of P2 programs (see Box 3-1). Considering these questions will encourage the proper thought and analysis for your planning effort.

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Goals establish the metrics that will be used to measure progress. Indicators are used to measure progress along the way.

Box 3-1. Questions to Consider During the P2 Planning Process

Where are we right now?
Where do we want to go?
How do we get there?
When do we want to arrive?
Who will get us there?
What will it cost?
How do we measure results?
Who will help accomplish the plan?
When will each goal be completed?
What are the expected results?

Vision Statement

A key component of a P2 Plan is the ***vision statement****. It provides a way of seeing or conceiving what the organization wants to achieve in the P2 program. The vision of the organization usually provides a concise word picture of the organization at some future time.*

A key component of a P2 Plan is the ***vision statement***. It provides a way of seeing or conceiving what the organization wants to achieve in the P2 program. The vision of the organization usually provides a concise word picture of the organization at some future time. This helps set the overall direction of the organization. The vision statement defines what the organization strives to be. (If you are seeking environmental excellence, the criteria described in Chapter 7 may be helpful in defining what you want to achieve.)

Sustainable development programs, like "The Natural Step," have successfully posed a vision of the future framed by four system conditions. Reviewing a vision statement from a sustainable development program such as this can help you develop a general direction, image, and philosophy to guide your organization in its P2 program.

It is difficult to find a perfect example of a vision statement. Several samples are provided so you can see how others have addressed this issue. Does your organization already have a vision statement? How would the statement change if some element of P2 or sustainable development were added to it?

Sample Vision Statements

At Olin, we sum up our commitment to achieving excellence in the realms of workplace health and safety with one phrase: The Goal is Zero. As this phrase indicates, our health and safety programs begin with the premise that no amount of workplace injuries or illnesses is acceptable. These initiatives not only make good ethical and moral sense, but they respond to what our customers demand and our communities expect. This includes operating in a safe and environmentally sound manner, practicing good product stewardship in teaching others how to safely and properly handle our products, and providing our employees with the training and resources to do the right thing.

Reference: http://www.olin.com/environment/default.asp

We are dedicated to transforming DuPont into a sustainable growth company. We will hold onto the core values that define "who we are" but reshape our portfolio as needed to achieve growth in the new global economy. We will intensify our efforts to reduce our environmental footprint by beginning the transition to renewable feedstocks and energy. We will expand our market focus and begin to understand how we can deliver the miracles of science to a much greater percentage of the world's population than we do today. And, we will strive to increase shareholder value in a way that is less "materials and energy" intensive and more "knowledge and service" intensive.

Reference: http://www.dupont.com/corp/environment/comment.html

The National Park Service strives to facilitate a culture of environmental stewardship and sustainable development.

Reference: http://es.epa.gov/oeca/fedfac/complian/emsrcemp.pdf

The USPS is committed to conducting all of its activities in a way that protects human health and the environment.

In establishing environmental policies and practices the USPS will, as appropriate, promote the sustainable use of natural resources and protection of the environment through conservation, recycling, and reuse of material in its own operations.

The USPS encourages the use of non-polluting technologies and waste minimization in the development of equipment, products, and operations. Awareness of environmental responsibilities and adherence to sound environmental practices is encouraged.

Reference: http://www.usps.gov/environ/textmirr/webpages/envco.htm#INTRO

Mission Statement

The second component of a P2 plan is the ***mission statement***. This statement needs to "send forth" the people in an organization to take P2 actions that will accomplish the vision statement. A good mission statement should include all of the essential components of an organization's future thrust and communicate a positive feeling that will guide others to action. Think of the mission statement as providing the overriding purpose of P2 in the organization. An effective statement should explain how P2 could be integrated into other business initiatives.

The second component of a P2 plan is the **mission statement**. *This statement needs to "send forth" the people in an organization to take P2 actions that will accomplish the vision statement.*

Think of the mission statement as providing the overriding purpose of P2 in the organization. An effective statement should explain how P2 could be integrated into other business initiatives.

As with the vision statements above, there are many ways to express an organization's mission. Some examples are provided here to help your organization begin the task of preparing a mission statement. If your organization already has a mission statement, how would it change with some P2 or sustainable development clauses added to it? Does the P2 program 's mission reflect the mission of the organization as a whole?

Sample Mission Statements

The Environment, Health, and Safety Program will be implemented and maintained and will provide reasonable assurance that the corporation

- complies with all applicable governmental and internal health, safety, and environmental requirements.
- operates plants and facilities in a manner that protects the environment and the health and safety of its employees and the public.
- develops and produces products that can be manufactured, transported, used, and disposed of safely.
- recognizes and responds to community concerns about chemicals and our operations.
- makes health, safety, and environmental considerations a priority in planning for all existing and new products and processes.
- reports promptly to officials, employees, customers, and the public information on health or environmental hazards, and recommends protective measures.

- counsels customers on the safe use, transportation, and disposal of chemical products.
- extends knowledge by conducting or supporting research on the health, safety, and environmental effects of products, processes, and waste materials.
- works with others to resolve problems created by past handling and disposal of hazardous substances.
- participates with government and others to create responsible laws, regulations, and standards to safeguard the community, workplace, and environment.
- promotes the principles and practices of Responsible Care by sharing experiences and offering assistance to others who produce, handle, use, transport, or dispose of chemicals.

Reference: http://www.unioncarbide.com/respcare/1998/whoweare.html

We affirm to all our stakeholders, including our employees, customers, shareholders and the public, that we will conduct our business with respect and care for the environment. We will implement those strategies that build successful businesses and achieve the greatest benefit for all our stakeholders without compromising the ability of future generations to meet their needs.

We will continuously improve our practices in light of advances in technology and new understandings in safety, health and environmental science. We will make consistent, measurable progress in implementing this Commitment throughout our worldwide operations. DuPont supports the chemical industry's Responsible Care® and the oil industry's Strategies for Today's Environmental Partnership as key programs to achieve this Commitment.

Reference: http://www.dupont.com/corp/environment/commitment.html

Statement of Goals

The third basic component of a P2 plan is the ***statement of goals***. Goals are specific statements that express where the organization wishes to go within a specific time period (e.g., this financial quarter). The quantitative measures used are absolute. Goals can be defined in action plans prepared to help implement the P2 program. Action plans are discussed in Chapter 4. Setting goals and objectives in a P2 program are also addressed in Chapter 6.

Goals can be defined in action plans prepared to help implement the P2 program.

Many P2 programs state quantitative and specific goals of both a short-term and long-term nature. Sometimes the goals are set during the initial planning period of the P2 program. In other cases, the goals are to be set after much more information has been gathered and analyzed. Once the goals are set, it is important to measure their progress over time.

Some quality experts feel that goals actually tend to hold an organization back because no one ever tries to exceed the goals by a significant amount. These people have suggested that organizations constantly measure their continual improvement effort in specific areas.

Indicators

During the planning stage, many organizations start considering the use of **indicators**. An indicator is a metric that helps you understand where you are, which way you are going, and how far you are from where you want to be. Indicators can be based at the organizational level (e.g., environmental training hours per worker, conservation of resources, reduction in emissions, good housekeeping, operational and maintenance practices) or at the government level (e.g., area-wide greenhouse gas concentrations, biodiversity in major rivers, acres of trees impacted by acid rain). Indicators are used to express the outcomes of the performance improvements that are made in the P2 program and are further covered in the "results" section of the quality model presented in Chapter 7. These environmental results actually link the performance indicators with the cost to and benefits for the organization.

An indicator is a metric that helps you understand where you are, which way you are going, and how far you are from where you want to be.

Sustainable development programs use indicators that link economy, environment, and the community. The element of community represents both workers and the other *interested* parties associated with the organization. Examples of indicators are given in Box 3-2 (Reference 3-1).

Sustainable development programs use indicators that link economy, environment, and the community.

Box 3-2. Examples of Indicators

- Number of people going to clinics for respiratory problems
- Ratio of renewable to non-renewable energy consumption
- Public awareness of hazardous materials/waste issues as measured by annual survey
- Tons of waste landfilled annually
- Recycling rate as a percentage of material generated
- Percentage of residents, businesses, and institutions that participate in recycling programs
- Recycled water use
- Mass of pollutants in wastewater
- Number of enterprises adopting ISO 14001 standards
- Number of hazardous materials incidents
- Number of schools that integrate and progressively update environmental education in their curricula
- Number of organizations with formal pollution prevention plans

These components of the P2 plan help determine the strategy of the organization's P2 program. The strategy or actions decided upon reflect the way the organization plans to achieve its objectives and goals. Organizations should develop strategies for every goal that it plans to implement. A good way to develop these strategies is by preparing an action plan. This tool and other tools useful in implementing P2 programs are discussed in Chapters 6 and 7.

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CORE VALUES

Because the P2 program deals with change in the organization, it is essential that you express the core values that must be achieved as you integrate key business requirements within a results-orientated P2 framework. These core values are also referred to as ***guiding principles***. They will help bridge the gap between the various components discussed previously by identifying the fundamental, underlying beliefs that guide the actions within the organization. All organizations have a set of core values, although in some cases they do not exist in written form.

Each element of the organization's P2 program should link itself with the organization's core values.

Each element of the organization's P2 program should link itself with the organization's core values. Certainly, there are no prescriptive ways to do this. Each organization must approach these core values in a manner that fits the local organizational culture.

Following are examples of several core values that could be reflected in a P2 program. Paying particular attention to how these core values relate to the organization's core values is a very important component of a P2 program (References 3-2, 3-3).

Interested-Party–Driven P2

This core value recognizes what various interested parties would like to gain from a P2 program and ensures to it that they get what they want.

This core value recognizes what various interested parties would like to gain from a P2 program and ensures that they get what they want. If P2 saves money, managers and shareholders will support it. If P2 helps an organization stay in compliance, regulators will support it. If P2 helps improve working conditions, employees will support it.

A P2 program should work to build trust, confidence, and loyalty by not just meeting interested party requirements, but going the extra distance to reduce waste and conserve resources.

By comparing your program with other P2 programs, your organization's commitment to P2 and sustainability can be differentiated from that of the competition.

By comparing your program with other P2 programs, your organization's commitment to P2 and sustainability can be differentiated from that of the competition. This unique focus, which probably fits well within your organization's culture, should leave the interested parties delighted—not just satisfied—by the P2 program.

Interested Parties Include:

- Customers
- Employees
- Suppliers
- Regulators
- Public groups and non-government organizations (NGOs)
- Community Groups

Leadership

All senior leaders in the organization must create an interested-party orientation. They must set clear and visible P2 values and have high expectations. These values and expectations are reinforced by a substantial personal commitment to the P2 program. Leaders should serve as role models throughout the organization, thus reinforcing the P2 core values at all levels. In other words, they should “walk the talk.” Management must have active, visible leadership roles in the ongoing strategic planning process to incorporate P2 into all business functions. Leadership’s commitment to environmental performance is demonstrated through consistent decisions on resource allocations such as money and employees for P2 program implementation and evaluation. If the P2 program is perceived as just another environmental initiative, this leadership core value cannot be realized.

All senior leaders must set clear and visible P2 values and have high expectations. These values and expectations are reinforced by a substantial personal commitment to the P2 program.

Continual Improvement

Every organization must strive for continual improvement. The organization should also have a commitment to the continual elimination and reduction of waste. These goals can be accomplished by encouraging creativity, maintaining a continual improvement environment, and recognizing and rewarding employees for doing a good job. Employees at all levels and in all areas of the organization should be actively involved and contribute ideas for P2 and P2 program improvement.

The organization should also have a commitment to the continual elimination and reduction of waste.

The P2 program cannot be oriented to simply completing individual P2 projects. It must take the knowledge gained and use it to address other P2 opportunities. This use of “lessons learned” fosters continual improvement. The P2 program must always strive for zero waste, zero emissions, and conservation of all resources. Zero is where continual improvement should strive to be.

Valuing Employees

An organization’s P2 success depends increasingly on the knowledge, skills, innovative creativity, and motivation of its workforce. Employee success depends increasingly on being given opportunities to learn and practice new skills. Organizations need to invest in the development of their workforces through education, training, and opportunities for continuing growth. Such opportunities include enhanced P2 awareness and rewards for demonstrated P2 knowledge and skills. On-the-job training offers a cost-effective way to train and better link P2 training to work processes. Education and training programs may need to utilize advanced technologies, such as computer-based learning and satellite broadcasts. Increasingly, training, development, and work units need to be tailored to a diverse workforce and to more flexible, high performance P2 work practices. These items will prepare employees and the organization for success.

An organization’s P2 success depends increasingly on the knowledge, skills, innovative creativity, and motivation of its workforce.

Employee success depends increasingly on being given opportunities to learn and practice new skills.

Designing Quality and Prevention Together

A P2 program provides an effective process for evaluating, planning, and controlling changes to existing products and the design of new products that would generate less waste in the production process and at the end of their useful life.

Successful organizations charge their P2 multifunction teams with the responsibility for creating high-quality products that are inexpensive to manufacture while using fewer toxic materials and generating less waste.

By building quality into products and services in the production process, an organization reduces the need to correct problems downstream. This mind-set leads to prevention rather than detection. A P2 program provides an effective process for evaluating, planning, and controlling changes to existing products and the design of new products that would generate less waste in the production process and at the end of their useful life.

For years, P2 technical assistance providers have recognized the importance of design as a means of P2 progress through a concept called "Design for Environment." However, instead of handling this as a separate initiative, the need for design changes must infuse all P2 activities as a core value. Successful organizations charge their P2 multifunction teams with the responsibility for creating high-quality products that are inexpensive to manufacture while using fewer toxic materials and generating less waste. Whenever possible, these organizations involve key suppliers at an early stage of the new product development in order to determine the types and constituents of wastes, and to address potential health and safety issues. Many quality philosophies work very well in P2 programs.

Long-Range Outlook

To achieve P2 goals, organizations must make long-term commitments to all interested parties—customers, employees, suppliers, regulators, shareholders, the public, and the community. To develop a long-range outlook, an organization must anticipate many types of change, including:

- Strategic moves by competitors
- Evolving regulatory requirements
- Technological developments
- Stakeholder expectations
- Community expectations

Management by Fact

The P2 feedback system must be built on objective data and analysis, all of which are quantitative and can be charted over time.

The information needs to be comprehensive and timely enough for all levels of workers to understand the current performance of the P2 program.

Many organizations rely on anecdotal information to indicate their progress. In the P2 field, mountains of case histories feed this tendency.

By contrast, management relies on specific, measurable data. The P2 feedback system must be built on objective data and analysis, all of which are quantitative and can be charted over time. Most of this information can be gathered quite easily, with no need for sophisticated statistical techniques. The information needs to be comprehensive and timely enough for all levels of workers to understand the current performance of the P2 program.

When an organization has this information, it has positioned itself to monitor its progress efficiently. It can then compare its performance to that of competitive or benchmarked organizations and evaluate its P2 action.

Partnership Development

Successful organizations build internal and external partnerships to help them accomplish their overall P2 goals. Examples of internal partnerships include better labor-management cooperation, employee development, cross-training, and the creation of worker P2 teams. Some organizations have concerted training programs and active employee involvement. This engenders good communication between management and workers. Employee involvement needs should be assessed often to ensure that sufficient resources are provided to assist these programs in their P2 efforts.

Successful organizations build internal and external partnerships to help them accomplish their overall P2 goals.

External partnerships include cooperation with customers, suppliers, regulators, and other outside organizations and interested parties. For example, hotels and hospitals can create partnerships to improve their similar work processes and benchmark their gains with each other. Many trade associations have created partnerships for P2 best practices. Strong partnerships with key suppliers that are mutually beneficial can improve cost competitiveness, quality, and overall responsiveness, as well as minimize toxics use and waste. Key suppliers can participate in the development and design of shipping and packaging materials that incorporate good ergonomics and reduce or eliminate other wastes. It is helpful for the external partners to have a financial or other stake in the achievement of the organization's goals for the P2 program.

External partnerships include cooperation with customers, suppliers, regulators, and other outside organizations and interested parties.

Corporate Responsibility and Citizenship

Successful organizations always address their corporate and citizenship responsibilities. Corporate responsibility refers to the basic expectations of the organization and includes business ethics and the protection of public health, safety, and the environment. Corporate citizenship refers to the leadership and support of publicly important purposes, such as education, environmental excellence, improved industry and business practices, and the sharing of nonproprietary P2-related information. Leadership as a corporate citizen also entails influencing other organizations, private and public, to partner for these purposes.

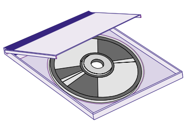
Corporate citizenship refers to the leadership and support of publicly important purposes, such as education, environmental excellence, improved industry and business practices, and the sharing of nonproprietary P2-related information.

Fast Response

Permits and regulatory compliance often add significant time to organizational decision-making. Success in globally competitive markets demands ever-shorter cycles for introductions of new or improved products and services. Also, a faster and more flexible response to interested parties is now a more critical requirement. Major improvements in response time often require simplification of work units and processes together with timely incorporation of P2 into the design phase (e.g., design for environment). To accomplish this, the P2 performance of work processes should be among the key process measures. Other important benefits can be derived from this focus on time. Time improvements often drive simultaneous improvements in organization, quality, P2, cost, and productivity. Hence, it is beneficial to integrate response time, quality, P2, and productivity objectives.

SELECTING PROGRAM ELEMENTS

P2 programs are composed of a number of program elements. Different organizations often mix and match these elements to construct a program that meets the intent of their P2 vision.



P2 programs are composed of a number of program elements. Different organizations often mix and match these elements to construct a program that meets the intent of their P2 vision. A number of states have enacted P2 planning legislation. These acts contain a wide variety of different planning components. More information can be found on the CD-ROM that accompanies this *Guide*. In 1989, the EPA specified six program action elements that should be considered for organizations seeking to prepare waste minimization programs as required by the Resource Conservation and Recovery Act (RCRA). (See 54 *Federal Register* 25056–25057) This guidance was finalized on May 28, 1993 (58 *Federal Register* 31114-31120). All organizations generating hazardous waste in the United States must certify on their manifest forms that they have a program in place that meets these requirements. These six program elements are:

1. Provide top management support
2. Characterize the process
3. Perform periodic assessments
4. Maintain a cost allocation system
5. Encourage technology transfer
6. Conduct program evaluations

Let's take a brief look at each of these elements. Keep in mind that individual organizations may include additional elements in their P2 programs for their own purposes or to comply with state P2 planning requirements. The number of elements used and the degree to which each element is stressed should be a function of the group implementing the P2 program in each organization.

1. Provide Top Management Support

Top management support is essential for ensuring that P2 becomes an organizational goal.

Top management support is essential for ensuring that P2 becomes an organizational goal. You will remember that leadership is considered to be an important core value. Most articles written on quality programs list upper-level management support as the single most important program element. Management should encourage employees at all levels of the organization to identify opportunities to reduce waste generation and promote energy and water conservation. Management should also encourage employees to adopt the P2 philosophy in day-to-day operations and identify new opportunities at meetings and other organizational functions. P2 should be a process of continual improvement when incorporated into an organization's policy. Ideally, a P2 program should become an integral part of management's strategic plan to increase productivity and quality.

Some techniques top management can use to demonstrate their support are:

- Serve on the P2 oversight committee and be active in approving strategic P2 goals.
- Include P2 goals in business planning efforts that are independent of the environmental program. Integration into core business practice is key to the long-term viability of P2 efforts.
- Revise the compensation/merit system to recognize P2 contributions.
- Ensure that P2 action plans with measurable goals be put in writing.
- Commit the organization to implementing P2 action plans.
- Provide training for all employees on how resource use and production losses result from wasteful work processes.
- Publicize P2 results.

2. Characterize the Process and Assess P2 Opportunities

Some P2 assessments focus on wastes being generated by a facility's main processes. In contrast, process characterization leads to the identification of all P2 opportunities (including those in related ancillary and intermittent operations), not just the ones uncovered in a limited P2 assessment or walk-through. Both resource use and loss are considered.

Process characterization leads to the identification of all P2 opportunities (including those in related ancillary and intermittent operations), not just the ones uncovered in a limited P2 assessment or walk-through.

An effective way to conduct process characterization is through the use of hierarchical process maps. These maps (see Chapter 4) can be used to analyze all processes, including ancillary and intermittent operations. An organization using this assessment method can also examine energy and water use, landscaping, commuting, noise, odor, and other aspects of their operations. These process maps can also be used as templates for collecting information on resource use and the loss of resources, with the information organized by work step. Some organizations use process maps as a means for maintaining a resource use and loss accounting system to track the types and amounts of resources involved, including the rates and dates they are used or lost.

Process maps can also be used to assess the costs of resource use by work step. These costs can then be used to rank order opportunities for P2 and charge back the costs to the processes and products that are responsible for creating the waste—a sort of internal "polluter pays" principle.

Process maps can also be used to assess the costs of resource use by work step. These costs can then be used to rank order opportunities for P2 and charge back the costs to the processes and products that are responsible for creating the waste—a sort of internal "polluter pays" principle. It is very important to focus not on the wastes, but rather on the processes and products that are responsible for them. Every resource used in a process represents an opportunity to conserve the use of that resource, and every loss or waste from a process represents an opportunity not to generate that loss or waste.

3. Perform Periodic P2 Assessments

P2 assessments are used to verify and update process maps. As each P2 opportunity is examined, a P2 assessment can be used to gather new information (including cost data) necessary to support the use of other Systems Approach problem-solving and decision-making tools.

In the Systems Approach, P2 assessments are used to verify and update process maps. As each P2 opportunity is examined, a P2 assessment can be used to gather new information (including cost data) necessary to support the use of other Systems Approach problem-solving and decision-making tools.

The organization should decide the best method to use for performing P2 assessments and related data gathering. Once this is decided, individual processes and procedures should be reviewed periodically. In some cases, performing complete resources balances for some work steps in the process maps can be helpful. P2 assessment teams can revisit existing process maps or prepare new ones. Process maps from the main process can be linked to process maps of related ancillary and intermittent operations that support these processes. Process maps can be prepared for different products or families of products. The end goal may be to have a complete "book of process maps" after a number of years of periodic P2 assessments.

True costs associated with resource use and loss will change over time. Periodic P2 assessments can be used to update the cost information in the process map templates.

True costs associated with resource use and loss will change over time. Periodic P2 assessments can be used to update the cost information in the process map templates. Many organizations track resources used and lost by a variety of means and then normalize the results to account for variations in production rates. Each organization should find the best method to account for the true costs of resource use and loss in its operations.

Analyzing the cost and benefits of each P2 opportunity is an important process, especially when the true costs of managing environmental wastes, discharges, and emissions are considered. Organizations should establish a good method for selecting P2 opportunities to include in the P2 program each year. Assessments should support and invigorate a P2 program. They should not be the basis upon which the P2 program is built.

4. Maintain a Cost Allocation System

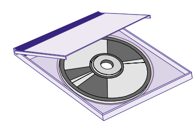
The EPA suggests that organizations track all the costs associated with resource use and loss and charge them back to the processes and products responsible for these costs instead of assigning them to facility overhead. These costs include those that flow from the general ledger, the cost of resources lost in the waste itself, and the activity-based costs of managing the losses. When all these categories are included, it is not uncommon for a company's waste costs to be increased by three to five times.

The EPA suggests that organizations track all the costs associated with resource use and loss and charge them back to the processes and products responsible for these costs instead of assigning them to facility overhead.

Not all processes and products use and lose resources equally. Ideally, each product should bear the burden of all the environmental, health, and safety services that it uses. Managers are encouraged to utilize accounting systems that generate valid product costs, reflecting the true costs involved in producing and delivering the organization's products and ensuring proper environmental management of resources, wastes, emissions, and discharges. This is good business because it will avoid putting an unfair overhead burden on cleaner products; such products can then be sold for less money or as "premium" products.

Not all processes and products use and lose resources equally. Ideally, each product should bear the burden of all the environmental, health, and safety services that it uses.

The limitations of traditional performance measurements, particularly those methods related to overhead allocation, can produce misleading or incorrect information. Whenever possible, accounting procedures and paperwork should be simplified, eliminating non-value adding activities while providing accurate information for decision-making and audit requirements. They should also be consistent. Financial personnel, for example, should be using the same source data as other personnel. Managerial accounting methods can be used like project management methods in most organizations. Such information can be reconciled on a periodic basis as it is allocated to products and families of products. Further information on environmental accounting can be found on the CD-ROM.



5. Encourage Technology Transfer

It is important for an organization to seek or exchange technical information on P2 from other parts of the organization, other companies, trade associations, professional associations, consultants, vendors, and university or government technical assistance programs. A considerable amount of time, effort, and taxpayer money has already been invested by public technical assistance programs and universities to research P2 alternatives for specific industries and processes. Although it is risky to use this information as a "silver bullet" for the P2 problems faced by any particular organization, the information does offer some potential technology options that facilities can consider when they generate and prioritize P2 alternatives.

It is important for an organization to seek or exchange technical information on P2 from other parts of the organization, other companies, trade associations, professional associations, consultants, vendors, and university or government technical assistance programs.

Organizations are encouraged to share the nonproprietary knowledge they have gained in their P2 programs through trade associations and other information clearinghouses. Many P2 award programs require the participants to share the information that was submitted in the application for the award.

Organizations are encouraged to share the nonproprietary knowledge they have gained in their P2 programs.

6. Conduct Program Evaluations

Organizations should implement any cost-effective recommendations identified by their P2 program planning efforts. They are encouraged to conduct periodic evaluations of P2 program effectiveness to provide feedback and to identify potential areas for improvement.

Organizations should implement any cost-effective recommendations identified by their P2 program planning efforts. They are encouraged to conduct periodic evaluations of P2 program effectiveness to provide feedback and to identify potential areas for improvement. During the evaluation, it is important to determine what was learned from each P2 activity and how that information will be utilized in constructing P2 action plans for the coming year. P2 programs can also be benchmarked against others. Reviews can be conducted internally or performed with an independent third party. Many companies now accept the practice of using third-party individuals because they already are employing them in their ISO 9000 and ISO 14001 programs. The quality model (see Chapter 7) also offers a way to measure progress made by a P2 program and have it scored by an independent team of trained examiners.

Other Program Elements

There may also be other elements that can be included in the program. For example, the American Chemistry Council's (ACC) Responsible Care® Program has a "Pollution Prevention Code of Management Practices" (Reference 3-4). One of the items required in this program is: "Inclusion of waste and release prevention objectives in research and in design of new or modified facilities, processes, and products." The National Pollution Prevention Roundtable has published a white paper on facility pollution prevention planning (Reference 3-5) that could also be helpful in finding other P2 program elements.

The ACC's P2 Code states that each member company shall have a P2 program that shall include the following:

1. "A clear commitment by senior management through policy, communications, and resources to ongoing reductions at each of the company's facilities in releases to the air, water, and land, and in the generation of wastes.
2. A quantitative inventory at each facility of wastes generated and releases to the air, water, and land, measured or estimated at the point of generation or release.
3. Evaluation, sufficient to assist in establishing reduction priorities, of the potential impact of releases on the environment and the health and safety of employees and the public.
4. Education of, and dialogue with, employees and members of the public about the inventory, impact evaluation, and risks to the community.
5. Establishment of priorities, goals, and plans for waste and release reduction, taking into account both community concerns and the potential health, safety, and environmental impacts as determined under Practices 3 and 4.

6. Ongoing reduction of wastes and releases, giving preference first to source reduction, second to recycle/reuse, and third to treatment. These techniques may be used separately or in combination with one another.
7. Measurement of progress at each facility in reducing the generation of wastes and in reducing releases to the air, water, and land by updating the quantitative inventory at least annually.
8. Ongoing dialogue with employees and members of the public regarding waste and release information, progress in achieving reductions, and future plans. This dialogue should be at a personal, face-to-face level where possible, and should emphasize listening to others and discussing their concerns and ideas.
9. Inclusion of waste and release prevention objectives in research and in design of new or modified facilities, processes, and products.
10. An ongoing program for promotion and support of waste and release reduction by others, which may, for example, include:
    a) sharing of technical information and experience with customers and suppliers.
    b) support of efforts to develop improved waste and release reduction techniques.
    c) assisting in establishment of regional air monitoring networks.
    d) participation in efforts to develop consensus approaches to the evaluation of environmental, health, and safety impacts of releases.
    e) providing educational workshops and training materials.
    f) assisting local governments and others in establishment of waste reduction programs benefiting the general public.
11. Periodic evaluation of waste management practices associated with operations and equipment at each member company facility, taking into account community concerns and health, safety, and environmental impacts and implementation of ongoing improvements.
12. Implementation of a process for selecting, retaining, and reviewing contractors and toll manufacturers taking into account sound waste management practices that protect the environment and the health and safety of employees and the public.
13. Implementation of engineering and operating controls at each member company facility to improve prevention and early detection of releases that may contaminate groundwater.

14. Implementation of an ongoing program for addressing past operating and waste management practices and for working with others to resolve identified problems at each active or inactive facility owned by a member company taking into account community concerns and health, safety, and environmental impacts."

LESSONS LEARNED

To be truly successful, P2 requires a systematic, integrated, consistent, organization-wide approach. This approach can be achieved through comprehensive P2 planning.

The creation and maintenance of a P2 Program necessitates an overall plan. P2 does not just happen. To be truly successful, P2 requires a systematic, integrated, consistent, organization-wide approach. This approach can be achieved through comprehensive P2 planning. A clear and understandable vision that can be made real by the organization is of primary importance for success in the program. Without a mission, the organization can have difficulty moving toward success. Everyone in the organization must see how he or she can contribute to P2 success. Top leadership must begin to understand the P2 philosophy and the application of the core values. Many times P2 starts with the individual efforts of a "champion." It may catch on with a particular process area or product group. To have it take hold organizationally, a P2 planning effort is required.

P2 often requires the development of awareness to accomplish the improvement effort.

P2 often requires the development of awareness to accomplish the improvement effort. The building of awareness can come from training. Such training can be accomplished in a formal setting or on the job. Some larger organizations have trained facilitators on staff who work with the members of a team, managers as well as workers, as they address each specific improvement effort. Smaller companies rely on the use of P2 technical assistance providers to facilitate these efforts with on the job training assistance and other guidance. No matter how it is accomplished, the training, either formal or informal, must be effective and timely, and pursued continuously.

Within an organization, informal groups have their own leaders and "rules" that determine, for example, the pace of work or the relationship with the top management. If the informal organization and its leaders accept a proposed change, events will proceed more smoothly; if they oppose it, change may be nearly impossible. Identify these informal group leaders. Get to know them and spend time listening to their opinions and perspective. When you understand their needs and concerns, you will better understand how the P2 changes you seek can be implemented more effectively.

Although you can learn from others' P2 success stories, real P2 success comes from the persistent application of the P2 philosophy and core values in each organization's specific environment.

Although you can learn from others' P2 success stories, real P2 success comes from the persistent application of the P2 philosophy and core values in each organization's specific environment. Success is measured differently in each organization. It cannot be achieved by simply copying others.

When you tailor the P2 program to your organization's vision, mission, and goals, you speed its acceptance by the members of the organization. The P2 program's overall success will be ensured.

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CHAPTER 4

P2 Tools

Includes:
- ☐ Using P2 Tools
- ☐ Systems Approach Tools
- ☐ Checklists
- ☐ Lessons Learned
- ☐ References

USING P2 TOOLS

P2 teams can use a variety of specialized tools to get their work accomplished. These tools provide visual aids that are essential in communicating P2 information to management, workers, and other interested parties. Tools also help P2 teams gather information and provide problem-solving and decision-making guidance to the P2 team. Finally, by using specialized tools, the P2 team can construct an action plan for each project covered by the program. This plan allows for consistent tracking by the P2 oversight committee.

Specialized tools provide visual aids that are essential in communicating P2 information to management, workers, and other interested parties. Tools also help P2 teams gather information and provide problem-solving and decision-making guidance to the P2 team.

There is an endless variety of different problem-solving and decision-making tools available. Most of these tools have been used throughout the world in a variety of quality programs for more than 50 years. Only in the past 10 years or so have they been applied to P2 projects. Many small organizations have learned these tools by using the Environmental Justice manual entitled, *Nothing to Waste* (Reference 4-1). Larger organizations have often learned the tools through the various types of quality programs that have come and gone over the years. The problem is that environmental managers are often unfamiliar with such tools. This is beginning to change as more organizations seek to integrate environmental programs into their core business practices. This integration effort helps align the ways problems are addressed and solved within the organization. Keeping the P2 program independent of mainstream operations activities may limit the program's efficiency and effectiveness.

SYSTEMS APPROACH TOOLS

An organization acts as a *system* that functions as a whole through the interaction of its parts. The Systems Approach looks at the whole organization, and the parts, and the connections between the parts. The functionality of the parts depend on how they are connected, rather than what they are. The parts of a system are all connected directly or indirectly. Therefore, a change in one part affects all the other parts. Given this interdependence, tools that address the complexity of organizations are important. There are several reasons why the Systems Approach tools meet this need and work so well in the planning and implementation of your P2 program.

The Systems Approach looks at the whole organization, and the parts, and the connections between the parts.

First, processes that use resources and generate wastes do not always provide synoptic information clearly suited for checklist-style presentation. Instead, these processes are more than likely intertwined with other situations such as emotional distress or political issues that arise within the organization—which in turn may stem from some difficulty with the way things work (or don't work). Because of these entanglements, too much time and energy may be spent trying to understand the situation before ever getting on to the problem-solving stage. Systems Approach tools can help.

The Systems Approach tools point out how things can be changed to conserve the use of that resource or prevent the waste from occurring.

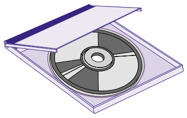
The Systems Approach tools cut through such situations. They facilitate problem solving by allowing the workers to understand why a regulated or expensive resource is being used or a waste is being generated. These tools point out how things can be changed to conserve the use of that resource or prevent the waste from occurring. This is fundamentally different from having the environmental coordinator or external assistance provider suggest a way to change the process without involving the workers in decision-making.

The Systems Approach relies on intra-organizational teams, not individual experts, to make decisions. It requires team members to analyze a resource or waste problem thoroughly, determine the underlying root cause, and generate possible alternatives. Based on this, the problem solvers can make an objective, rational, comparative evaluation. This is not to say that the team should not use the proper expertise as a resource to their work. It should. However, responsibility for decision-making should rest in the hands of team members who will implement and evaluate the proposed measures.

Because the Systems Approach is interactive and based on workers' own decision-making efforts, team members feel they "own" a portion of the analysis. Of course, employees have preferences and different points of view, and because the Systems Approach tools are "team-friendly," they allow for this. This involvement is important because an answer imposed from outside is less likely to work than one arrived at within the organization.

The Systems Approach provides management with a reasonably accurate profile of process problems.

Another consideration is the overall management process in the organization. It is important to identify the process-related reasons for resource use and loss before you can convince a manager to change the process to avoid them. In this context, the Systems Approach provides management with a reasonably accurate profile of process problems. It makes clear that, unless the problems are corrected, these and similar problems are likely to recur. Effective planning, including the revision of current strategies and policies, benefits from the use of the Systems Approach.



Checklists do have a place in P2 programs. Throughout the Systems Approach, it is useful to make lists of questions and answers for anything related to each of the tools. Such lists form an outline of the entire problem situation and are important entries in any record of the process. Some sample checklists can be found on the CD-ROM that accompanies this *Guide.*

Using the Systems Approach Tools

Many organizations are finding they have to adapt to survive in the global economy. Managers are learning new ways to run their organizations, and workers are learning how to contribute their knowledge to improving processes. By learning how to monitor, control, and constantly improve production and various supporting systems, organizations are better able to provide their customers and other interested parties with what they want, when and how they want it. These business practices lead to better decisions for the interested parties and for the organization—workers and managers alike.

The principles of quality improvement can be useful tools for achieving environmental excellence. Just as defect prevention is better than the "find and fix" approach to quality control, P2 is preferable to "end-of-pipe" control. The application of the quality improvement tools used by the Systems Approach is a powerful force in eliminating environmental inefficiencies and preventing pollution.

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Process Mapping

Getting to know more about the uses and losses of resources in a process and clarifying all that you already know are the two basic tasks of process characterization. These tasks involve information gathering, listing, sorting, and comparing.

Process characterization is the step where the bulk of your learning about the process takes place. This is where your existing systems knowledge regarding the process is revealed and organized and where new knowledge comes easily because the process-mapping tool makes all process relationships "visible." You will find that you no longer need to restrict yourself to the main process. It is now possible to look at all supporting operations—both ancillary and intermittent—to see how they impact the main process.

Process characterization is where your existing systems knowledge regarding the process is revealed and organized and where new knowledge comes easily because the process-mapping tool makes all process relationships "visible."

Consider that every time a laboratory sample is taken to monitor a process, the laboratory creates a waste. This waste could be prevented if the sample were not taken in the first place. Of course, some monitoring is necessary and perhaps even required. This circumstance presents an opportunity to improve the efficiency of the monitoring process. Maybe you could make an argument to the regulatory agency for less monitoring based on your organization's compliance record. For example, the use of sensors for continuous monitoring would offer an alternative to traditional "grab" samples. An argument could be made and supported by the P2 program to change the sampling, thereby reducing the wastes produced in the laboratory.

Process characterization makes P2 opportunities visible. Worksheets probably do not do this effectively. Diagrams are often a better tool. Connections between all work steps help clarify the causes

Connections between all work steps help clarify the causes for resource use and waste generation.

for resource use and waste generation. Every use of a resource in a process represents an opportunity to conserve the use of that resource. Every loss of a resource in a process represents an opportunity to avoid that loss. Taking advantage of these opportunities benefits everyone in the organization. The discovery, correction, and prevention of waste generation should be the responsibility of everyone in the organization.

An effective means to characterize processes is with a hierarchical process map.

It has been widely recognized that most people can only "see" up to six objects at a time and comprehend visually what they mean. Hierarchical process maps allow only three to six objects on a page.

An effective means to characterize processes is with a hierarchical process map (Figure 4-1). In most organizations, process documentation is typically organized into categories such as company, facility, product line, and department. Much process documentation is then carefully filed away in reports or databases that most people do not review on a regular basis. This information may take the form of process flow diagrams, flow charts, value stream maps, process and instrumentation diagrams, machine configurations, arrow diagrams, box diagrams, floor plans, or other schematic depictions. All of these process characterizations suffer from complexity—too many objects on a single page.

The assemblage process steps constitutes a node tree which establishes the relationship and connections between the work steps at each level. In a Systems Approach, every work step is connected to every other work step in this diagram, which depicts the entire system.

It has been widely recognized that most people can only "see" up to six objects at a time and comprehend visually what they mean. Hierarchical process maps (Reference 4-2) allow only three to six objects on a page. The entire process must be depicted in three to six boxes. Sub-processes can be used to provide detail at the next level but are also restricted to the three-to-six-box rule. The assemblage process steps constitutes a node tree which establishes the relationship and connections between the work steps at each level. In a Systems Approach, every work step is connected to every other work step in this diagram, which depicts the entire *system.* There are two very important rules associated with process mapping:

1. The process maps must help the P2 team understand the process better than they could through other means.
2. These same process maps must help the P2 team communicate what they plan to accomplish to management and other interested parties.

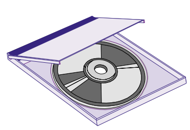


Figure 4-2 shows examples of process maps. You can find other examples of process maps on the CD-ROM accompanying this *Guide*.

Using Maps as a Template

Some organizations think of a process as a single box with its inputs and outputs. Using this model, it is difficult to change an entire process to make P2 happen. By using the process map as a template, process documentation can be organized by, and linked to, individual work steps in the process at the lowest level. All standard operating procedures (SOPs), best management practices (BMPs), regulations,

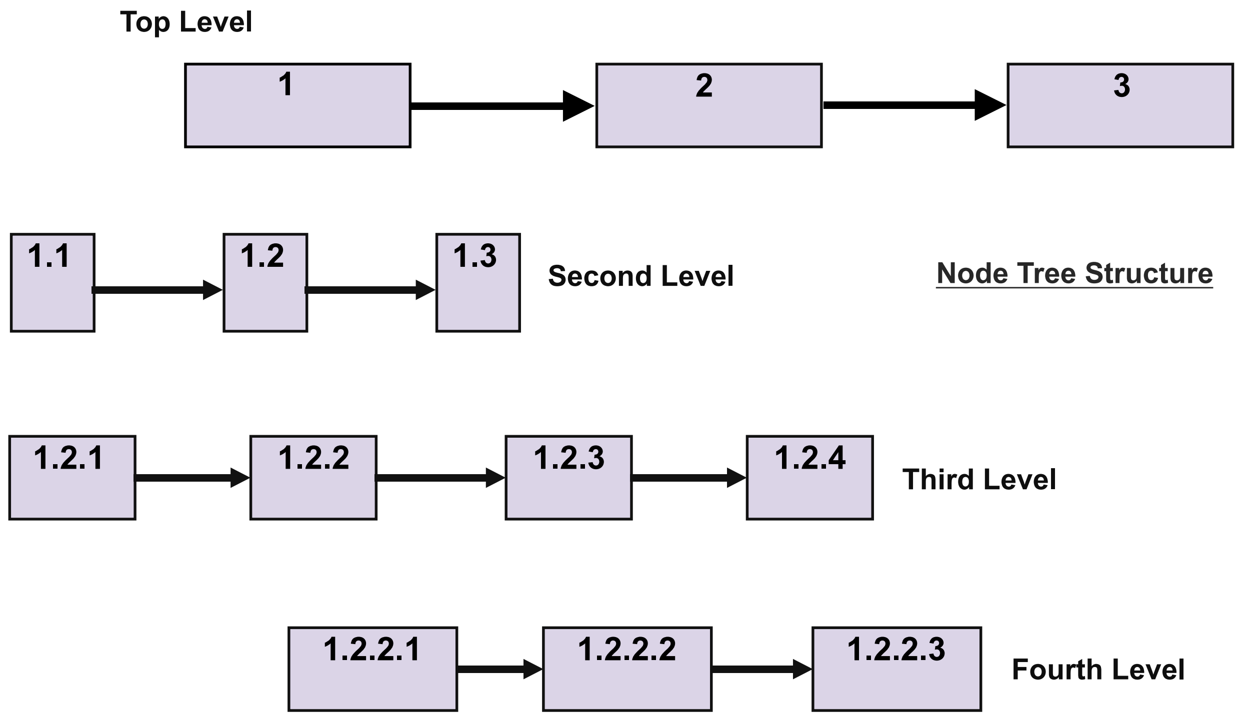


Figure 4-1. Hierarchical Process Map Structure.

maintenance requirements, glossaries of terms, and material safety data sheets (MSDSs) can be filed by work step using the process maps. What you may find when using the process maps is that many problems are associated with a single work step. It may then be easier to focus the P2 activity on that work step. This focus is necessary to help P2 activities succeed in the day-to-day operation of the organization.

While many process map designers simply use pencil and paper, hierarchical process maps can also be computerized using inexpensive, off-the-shelf software commonly used to prepare organizational charts (e.g., VISIO®). If the organization decides to computerize the process information, everyone involved in a particular work step can have access to all the information on that work step using an Intranet or other electronic or hard copy means. Using process maps as a template helps an organization keep track of resource use and loss by each work step in a main process, or in supporting ancillary and intermittent processes.

Using process maps as a template helps an organization keep track of resource use and loss by each work step in a main process, or in supporting ancillary and intermittent processes.

All resources (e.g., energy, water, and materials) can also be tracked (Reference 4-3) on the same process map (Figure 4-3). The term *non-product use* means that the resource does not become part of the interim or final product. The term *non-product loss* means that the resource is lost in that work step as a waste, discharge, or emission. Process losses can be classified by medium (air, water, solid waste, spills/leaks, and accidental losses). Costs can also be tracked by pro-

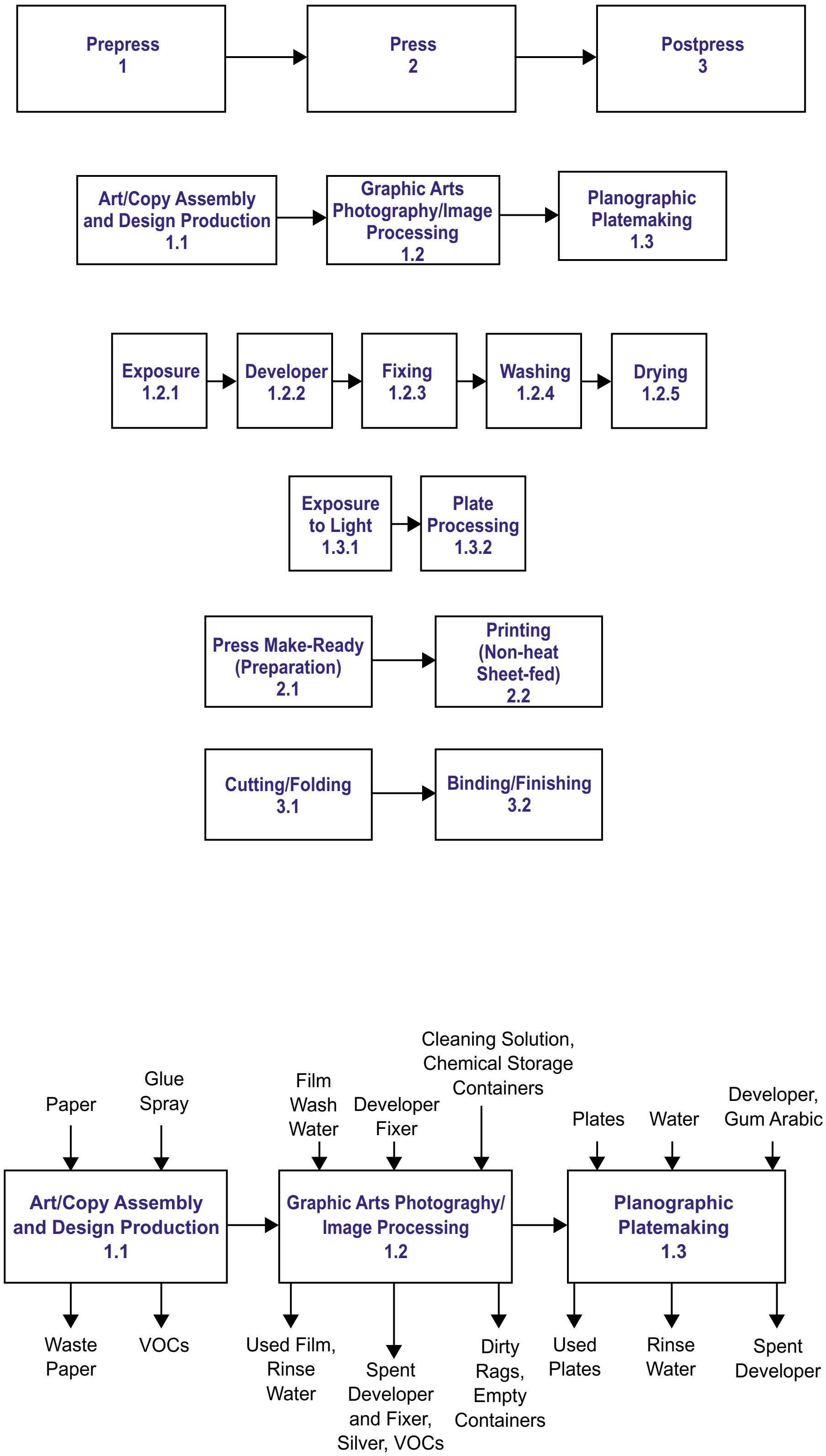


Figure 4-2. Hierarchical Process Maps.

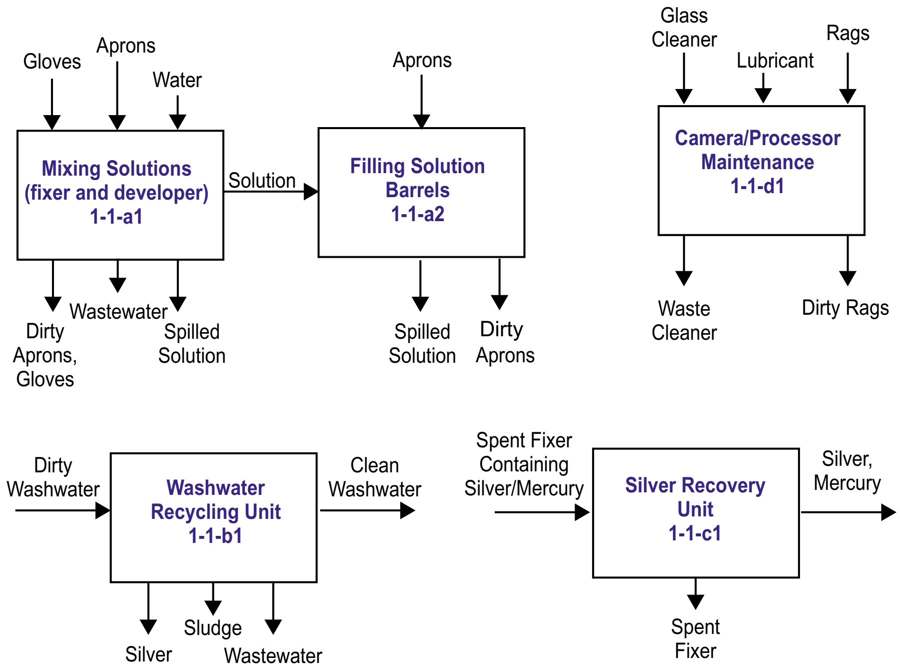


Figure 4-2. Hierarchical Process Maps (continued).

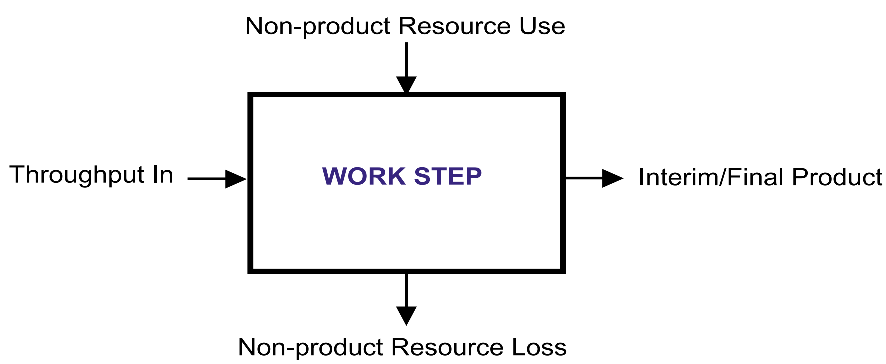


Figure 4-3. Using the Process Map as a Resource Accounting Template.

cess work step. Spreadsheets can be linked to the objects in a computerized process map, as well as to word processing files. Keeping track of this information is useful for helping rank-order P2 opportunities by cost. This can all be accomplished using your organization's charting software.

Determining the Cost of the Loss

Gathering accurate cost information is important for justifying investment in P2 alternatives.

Gathering accurate cost information is important for justifying investment in P2 alternatives. This cost typically needs to be collected by work step because this is where the P2 will be applied. There are three types of costs that should be tracked:

1. General ledger costs
2. Cost of the lost resources
3. Activity-based costs associated with the management of the non-product loss

For each loss identified in the process map, the P2 team should examine the "chart of accounts" to see if the cost is tracked by the accounting department in the general ledger. For example, if an organization generates solid waste, there may be a cost for the disposal contractor in the general ledger. The chart of accounts provides a vendor number and/or other code for this payment category. It is important to remember that the general ledger typically tracks *only* money that goes in and out of an organization (i.e., payment for invoices and payroll and revenues or financial allocations). It *does not* track internal transactions (e.g., environmental coordinator preparing a permit). These internal transactions are activity-based costs that will be discussed in more detail below. All cost data obtained from the general ledger is quite accurate and does not involve estimates of any kind.

A second cost category is associated with the cost of the resources that become non-product outputs or process losses. For example, when a part is spray painted, some of the paint does not end up on the part. This overspray is probably captured on a paint filter in the ventilation system. If 60% of the paint is incorporated on the part (i.e., interim product in throughput), 40% of the paint is lost from the work step (i.e., non-product loss). The cost of this lost paint should be added to the general ledger cost associated with this loss along with the cost of the paint filters (i.e., the intent of purchasing the filters was only to dispose of them after they captured droplets of paint, preventing these drops from getting into the air handling/treatment system). The plastic bags in the wastebaskets in your office represent a similar case. Your building management firm purchased those plastic bags intending to throw them away, thereby making the custodian's job easier. The cost of all the bags that are purchased must be added to the cost of your solid waste disposal bill along with the estimated cost of everything else that you purchased and threw away in that wastebasket.

To obtain the cost of the losses, it is often necessary to confer with the purchasing department. Some of these costs are estimated since they may be split between product and loss, such as in the paint example. Sometimes you throw away a container included in the cost of the product inside the container. Of course, because estimates are less accurate than the general ledger costs, you may want to estimate conservatively to maintain the credibility of your analysis.

A third cost category is associated with the activity-based cost of managing the loss. If the loss is regulated (e.g., hazardous air pollutant, hazardous waste, or wastewater priority pollutant), there are a number of activities that may be required by the regulations. You first must determine all the activities that must be performed for the non-product losses from each work step at the lowest level in the process map. Then you must estimate the cost associated with each of these activities. The total activity-based cost associated with each loss is added to the total cost of the loss associated with the general ledger cost and the cost of the lost resources.

Often the cost of a non-product loss will triple when adding the cost of the lost resource (i.e., the second cost category above). If the loss is regulated, the activity-based cost of managing the loss may increase this composite cost to five times the original general ledger cost.

Often the cost of a non-product loss will triple when adding the cost of the lost resource (i.e., the second cost category above). If the loss is regulated, the activity-based cost of managing the loss may increase this composite cost to five times the original general ledger cost. Obviously, there are large variations in the true cost of the non-product losses. However, capturing *all* the cost components is necessary because if the loss can be prevented, all of this money is saved, not just the general ledger cost of the loss.

Capturing all *the cost components is necessary because if the loss can be prevented, all of this money is saved, not just the general ledger cost of the loss.*

Selecting P2 Opportunities

Information gathered in the process-mapping phase of the P2 program can be used to select P2 opportunities on which to focus for problem solving and decision-making. This is generally more useful than relying solely on a walk-through or other P2 assessment. However, walk-throughs using process maps are essential to the proper verification of the information in the maps. Some P2 programs target opportunities by trying to eliminate costly compliance issues associated with the use or loss of regulated materials. Other P2 programs seek to address targets that have been pre-selected by management or environmental personnel. Each organization has its own means for selecting P2 opportunities. However, there is a tool that can be used to help the P2 team through this process.

If all the P2 opportunities identified in the process maps were arranged in order of their true cost to the organization, you would find that 20% of the P2 opportunities provide approximately 80% of the cost benefits. Conversely, the remaining 80% of the P2 opportunities provide 20% of the true cost benefits. In most cases, you will find the 80/20 rule (also called the *Pareto Principle*) to be a great guide for selecting P2 opportunities (Figure 4-4). Most organizations use Pareto analysis in

If all the P2 opportunities identified in the process maps were arranged in order of their true cost to the organization, you would find that 20% of the P2 opportunities provide approximately 80% of the cost benefits.

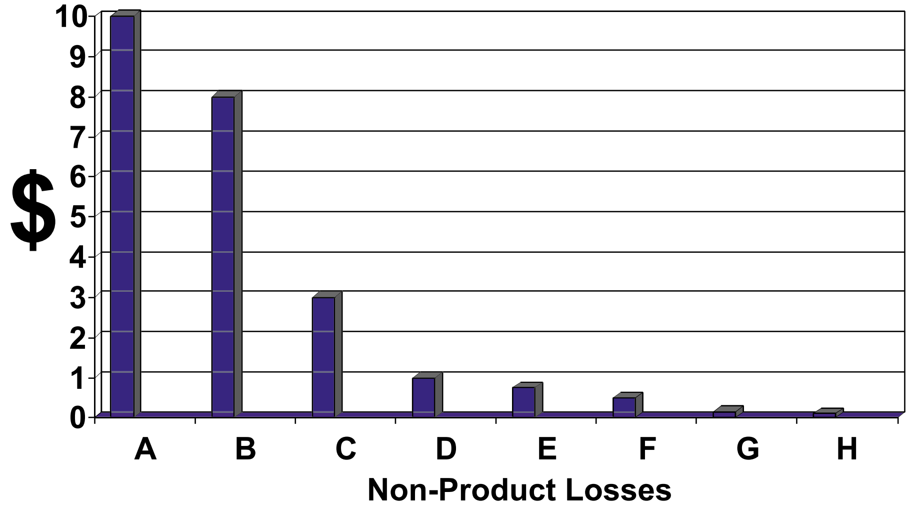


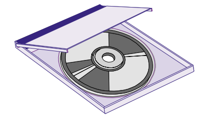
Figure 4-4. Pareto Diagram Showing True Cost Versus Waste Type.

some aspect of their work (Reference 4-4) to help focus their efforts. This tool dates back to 1897 and has the greatest staying power of any of the tools presented in this *Guide.*

Pareto analysis helps identify the most obvious opportunities for improvement in present operations.

Quality improvement experts advise concentration on the “vital few” sources of problems and avoiding distraction by those of lesser importance. The term for this process is called *rank ordering.* Pareto analysis is a rank-ordering tool. However, the fact that you have rank ordered your P2 opportunities does not mean you shouldn’t address the easier opportunities early on. Early in a P2 program, projects must be carefully selected to ensure the greatest chance of success. P2 teams may be tempted to immediately tackle projects that are too large or too diffuse for them to handle. Too often, these projects may seem necessary to gain and maintain management approval for the P2 program. The resulting frustration only dampens enthusiasm for the prevention effort. Avoid bogging down in P2 opportunities that offer minimal cost benefits. Instead, focus your long-term efforts on the 20% where the true cost savings may be found. This approach maximizes the value of the P2 program to the organization. Pareto analysis helps identify the most obvious opportunities for improvement in present operations.

It is interesting to note that focusing on wastes by volume or weight may cause the P2 team to overlook some important wastes. In some cases, small volume wastes may be responsible for the highest costs. An example of this involves laptop computers that become contaminated when used in radiologically controlled areas. Contaminated laptops represented only a very small volume of the mixed radioactive waste from a National Laboratory in the United States. However, the cost of disposal was the highest of all the items considered in the analysis. Other examples of the use of Pareto analysis are presented on the CD-ROM that accompanies this *Guide.*



Analyzing Root Causes

"Root cause" is the basic reason that a resource is being used or a process loss is occurring. If this cause can be eliminated, the resource use or loss would be prevented. This approach is the very basis of P2.

Root cause analysis refers to the process of identifying causal factors. Most people involved in P2 are ardent problem solvers, but in their haste to get to a solution, some may skip over this very important problem-solving activity. P2 teams which skip this important step may simply take the most obvious action, rather than the one that would best solve the problem.

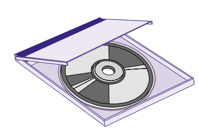
Root cause analysis teaches organizations to look at all potential causes: materials, technology, work practices, and people.

For example, when faced with environmental problems caused by a toxic chemical, P2 "problem solvers" might initially assume that the best way to address the issue is to find a "safe" substitute. In fact, the problem may be caused by *how* the company is using the chemical, rather than by the chemical itself. Changing work procedures or equipment or training employees more effectively might offer a better and/or less costly solution. Root cause analysis teaches organizations to look at all potential causes: materials, technology, work practices, and people.

Root cause analysis can be an effective management tool for determining the true or actual cause of resource use or loss in a process, facilitating effective corrective action, and preventing recurrence of the problem. It also provides obvious opportunities for improvement since it identifies both the underlying reasons for problems and the obstacles to correcting them.

The cause and effect diagram (also known as a fishbone diagram) provides an effective tool for conducting root cause analysis (Reference 4-5). Studies have found that this tool is the most widely used problem-solving tool in the world. However, it takes a little training and experience to use this important tool effectively. This tool is to be used by the P2 team, not by individuals. It provides a useful graphic to explain to management and other interested parties exactly what may be causing a problem. Once the diagram has been completed, the P2 team can count the number of causes found. The 80/20 rule can be used to help focus on the most probable causes by drawing circles around the 20% of the causes that may account for 80% of the problem. The P2 team will be more effective if it has this understanding and focus before attempting to generate P2 alternatives. An example of a cause and effect diagram can be found in Figure 4-5. Other cause and effect diagrams are included on the CD-ROM that accompanies this *Guide*.

The cause and effect diagram (also known as a fishbone diagram) provides an effective tool for conducting root cause analysis.



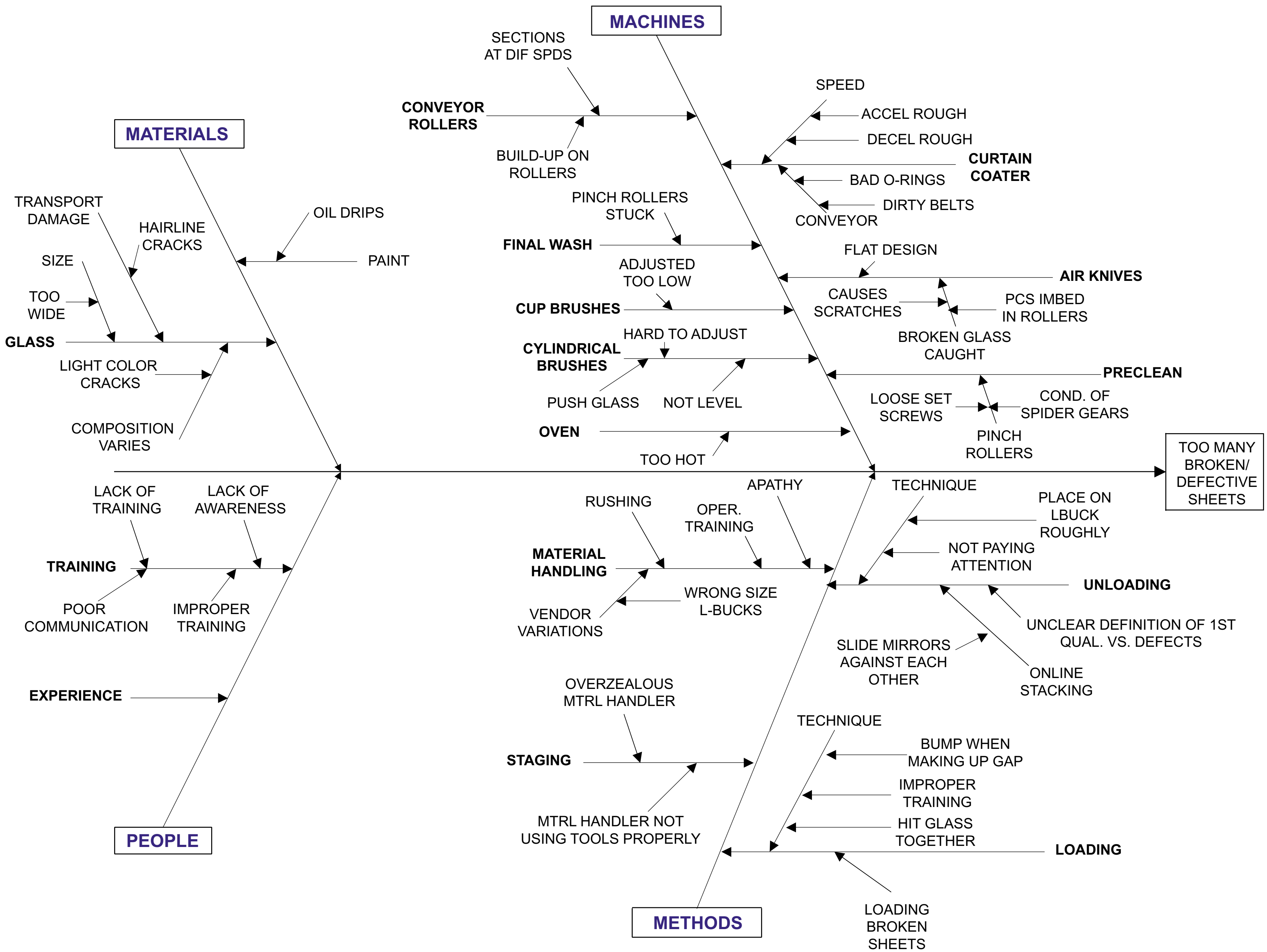


Figure 4-5. An Example of a Cause and Effect Diagram.

Generating Alternative Solutions

Every P2 approach has some method of deriving alternatives for solving the P2 problem. Some P2 practitioners restrict themselves to only a small number of P2 alternatives for a given problem because they have not performed root cause analysis (and thus may lack key information) or because the P2 team members are not adequately involved in the process of deriving alternatives. P2 literature (i.e., case studies and success stories) provides only some ways to address each problem. An expert may offer limited tried-and-true solutions. Your organization's P2 team should feel confident that it may develop equally effective alternative ways to address the situation.

The Systems Approach operates on the theory that "the only way to find a good P2 alternative is to have many P2 alternatives." A good method for generating alternatives is "brainwriting," a technique similar to brainstorming, but tends to be less restrictive (Reference 4-6). Brainwriting is a written form of brainstorming that uses forms like that shown in Figure 4-6. It takes advantage of the fact that many people are much more likely to write down their ideas than say them. This brainwriting technique allows resource people (i.e., those not on the P2 team, vendors, or technical assistance personnel) to lend their expertise in generating alternatives. Brainstorming is a very widely used tool for generating alternatives. Some organizations use a tool known as an affinity diagram. No matter what your preference, the quantity of alternatives is what counts. Experience has shown that brainwriting is often

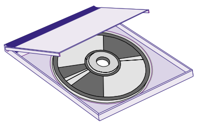
The Systems Approach operates on the theory that "the only way to find a good P2 alternative is to have many P2 alternatives."

1	2
3	4
5	6
7	8
9	10

Figure 4-6. Form Used for Brainwriting Exercise.

able to help the P2 team generate as many as 18–40+ alternatives in a short period of time.

Employing worker knowledge and a little creativity has led to many successful P2 projects.



To help encourage P2 team members to "think outside the box," it is important to get each team member to express the "most outrageous alternative that just might work." This gets everyone involved in using a bit of creativity to address the P2 problem at hand. Even "wild" concepts may trigger a search for alternatives that are a bit unusual but could work in the case under consideration. This technique is called "provocation." Employing worker knowledge and a little creativity has led to many successful P2 projects.

See Figure 4-7 for a listing of brainwriting alternatives for a common problem. Other examples of brainwriting alternatives can be found on the CD-ROM that accompanies this *Guide.*

Install a closed-loop (fully recycling) system.
Fully automate the system to control drive speed.
Use water-saving nozzles.
Wash less frequently.
Put dehumidifier in room to collect water vapor.
Use high-pressure jet spray (rinse/clean in one step).
Redesign water application.
Hand wash.
Reduce evaporation by lowering room temperature.
Try to collect evaporated water.
Use multistage washing process.
Only use undercarriage spray in winter.
Only wash vehicle once a week.
Dip vehicles in a tub-like device.
Lower temperature of water to decrease evaporation.
Use drying apparatus so vehicles do not drip dry.
Use a switch to activate/deactivate each step.
Close garage door before starting washing process.
Spit shine.
Use a squeegee to scrape off excess water.
Change soap application method.
Use alternative to city water source.
Use fewer absorbent sponges (less water trapped).
Use rental cars (rental agency will wash).
Redesign collection of water.
Drive through faster.

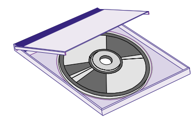
Figure 4-7. Brainwriting Alternatives for an Automated Vehicle Cleaner.

Selecting an Alternative for Implementation

The bubble-up/bubble-down tool is an excellent means for prioritizing and selecting an alternative to implement from a long list of possibilities.

Selecting a P2 alternative for implementation is facilitated with decision-making tools such as a *criteria matrix* (also known as a *selection grid*) or *bubble-up/ bubble-down* (also known as *forced pair analysis*). These are prioritization tools. The bubble-up/bubble-down tool in particular is an excellent means for prioritizing and selecting an alternative to implement from a long list of possibilities (Reference 4-7). When using this tool, the P2 team is allowed to examine only two alternatives at a time. They must ask which is best and use general criteria such as the effectiveness of the alternative, the ability to implement the technique, and the cost associated with that implementation. This method of discussing the various alternatives is very interactive. Other tools do not allow for a lot of verbal communication among P2 team members. This communication leads to more information that will ultimately help facilitate implementation of the selected alternative.

Alternatives that “bubble up” to the top are typically easy to implement and have a relatively low cost. These alternatives may be characterized as the *low hanging fruit* or *quick wins.* Little or no capital is required to implement these alternatives and work can begin right away in most cases. If good cost data is collected, these “quick wins” can generate savings that can be reinvested by the organization to create more prevention and value. Alternatives that currently fall below the grouping of quick wins are generally more effective at preventing resource use and process losses. However, they may require more study and capital investments. Since it will take time to test and study these alternatives in an engineering feasibility study (See *Waste Minimization Opportunity Assessment Manual*, EPA/625/7-88/003 and *Facility Pollution Prevention Guide*, EPA/600/R-92/088 on the CD-ROM for more information on conducting a feasibility study), the P2 team can be working on the problem with the higher ranked, albeit less effective, alternatives. The results of the feasibility study will be useful for preparing a capital justification request to use the more effective alternative at a later time. Continual improvement can be maintained in a P2 program in this way.

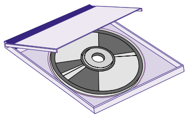


The alternatives, in order of priority, are as follows:

1. Simply reduce the soap input in the car wash
2. Use high-pressure water instead of soap
3. Alter the soap application step
4. Use degradable soap
5. Install a closed-loop system
6. Use alternative cleaning materials
7. Use a local, off-base car wash
8. Use rental cars instead of owning/maintaining
9. Locally treat the water before discharge to sewer
10. Drive less, walk more, use bicycles
11. Reuse dirty/soapy water
12. Install a new/improved car wash
13. Use a softening agent to take the soap out of the water
14. Handwash the cars
15. Use ultrafiltration to filter the water
16. Dry-clean the cars
17. Ultrasonic cleaning
18. Ablative paint for cars
19. Use dirt-colored cars
20. Paint the cars with slippery paint
21. Do not clean the cars at all
22. Buy new cars constantly

Figure 4-8. Bubble-up/Bubble-down Example.

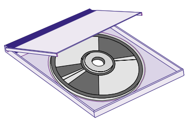
Many P2 practitioners currently use prioritization tools. One limitation, however, is that they begin with a finite set of potential solutions to choose from because they have not used a method such as brainwriting to generate sufficient alternatives. An example of the prioritization of the alternatives generated in the previous step may be found in Figure 4-8. You may note that alternatives can be grouped in different combinations during the bubble-up/bubble-down procedure. Other examples of the use of bubble-up/bubble-down can be found on the CD-ROM.



Action Planning

A formal action plan should be prepared for every P2 activity that is planned for each year of a P2 program.

Finally, a formal action plan should be prepared for every P2 activity that is planned for each year of a P2 program (Reference 4-8). In the rush to implement, P2 practitioners should not overlook the need to formalize their action plans. Each action plan should list the P2 alternative that will be implemented and show the sequence of steps necessary to implement the alternative. The person responsible for ensuring that each step is completed should be indicated in the action plan. Performance of that step must have some recognizable goal that must be reached. A metric should be devised to measure the progress toward meeting that goal and to provide a time frame for reaching the goal or completing that step. Finally, an indication of the resources required to reach the goal should be included in the formal action plan.



A sample form for use as an action plan is shown in Figure 4-7. Some action plan examples can be found on the CD-ROM that accompanies this *Guide.*

When P2 programs are audited on an annual basis, the auditor can select action plans and confirm that the work indicated actually has taken place. Periodic assessments of P2 program status depend on information like this to serve as the basis for measuring progress.

ALTERNATIVE SELECTED:				Date:	
Action	Responsible Person	Performance	Monitoring Technique	Completion Deadline	Resources Needed
1					
2					
3					
4					

Figure 4-9. Example of an Action Plan.

CHECKLISTS

Checklists are often necessary tools for P2 programs. A checklist helps guide an organization's activities and progress. Checklists provide important steps and method information for measuring operational performance and effectiveness and help the organization collect and organize data for assessing its current status and how well it is operating. It is useful to make lists of questions and answers for anything related to each of the problem-solving and decision-making tools presented in this *Guide.* Such lists form an outline of the entire problem situation and are important entries in any record of the process.

Checklists also help the P2 facilitator and P2 teams by providing guidance for further action and indicate things to do, process components to visit, people to see, and questions to ask. By devising a series of checklists, the P2 team provides itself with a means to review the entire resource use or loss problem.

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Checklists are a handy way to jot down ideas as they arise for possible use at a later date. As the checklists increase in size and number, they can be reorganized and combined to simplify dealing with the problem as a whole and to clarify its parts. Checklists help the team organize the tasks and provide an overall view of the situation, its requirements, attributes, alternatives, and consequences.

Here are some simple steps for deriving checklists for a P2 program.

- ❑ Determine the purpose and intended use of the checklist.
- ❑ Perform research to ensure that the checklist covers all requirements and asks for specific data to be recorded.
- ❑ Provide space for checking off completed steps, ideas, or data items.
- ❑ Ask the subject matter expert to review the final draft of a checklist to ensure that nothing of importance has been overlooked or omitted.
- ❑ Perform revision and pilot-test the checklist before placing it into use.

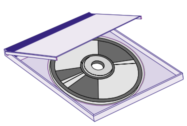
P2 teams should compose checklists that complement the process they use in their P2 program. The various components of a typical P2 effort using the Systems Approach tool are listed so that a P2 team may use checklists to achieve better results in these areas:

- ❑ Keep track of the process characterization effort, including all ancillary and intermittent operations.
- ❑ Assure proper resource accounting for uses and losses at the work-step level.

- ❑ Gather the true costs for each work step in the process characterization effort.
- ❑ Gather information for rank ordering of P2 opportunities.
- ❑ Select a P2 opportunity to analyze.
- ❑ Make sure that all causes in each cause category are considered in the root cause analysis for the selected opportunity.
- ❑ Document the search for potential solutions and alternatives.
- ❑ Gather information on each alternative to be used in the prioritization effort.
- ❑ Document the selection of the best alternative for implementation.
- ❑ Test the completion of the action plan.
- ❑ Track the implementation of the solution and evaluate progress.
- ❑ Test the use of each of the P2 program elements in this process.
- ❑ Test the overall P2 program effectiveness.

The periodic use of checklists generates a consistent means of assessing progress.

The periodic use of checklists generates a consistent means of assessing progress. Checklists should be designed to provide managers and P2 team members with a tool for assessing the significant characteristics of each step in the Systems Approach, checking the vital "how to" of each step, and analyzing in greater detail how well the tools are being used.



A number of checklists can be found in the CD-ROM that accompanies this *Guide*. You should be able to use and customize these electronic documents to fit the needs of your organization.

LESSONS LEARNED

Tools take time to master, but they help foster skills that the P2 team needs to characterize the process, solve problems, and make decisions.

Tools take time to master, but they help foster skills that the P2 team needs to characterize the process, solve problems, and make decisions. The repeated use of the tools makes P2 team meetings more productive. Many people avoid the use of tools because they believe that it takes too long and the benefits are not worth the effort. The tools lead to increased focus and questioning. P2 teams that use the root cause analysis tool usually derive a minimum of 20 P2 alternatives for future consideration. In contrast, teams that do not use the tool typically limit themselves to three or four alternatives.

The more methods and tools that you have time to use, the better the P2 program will be in the long run. Limiting tool selection can impair the development of the P2 program.

Continual improvement is important to focus the organization on P2 success. Organizations strive to improve, but few understand the difficulty in trying for continual improvement. Frequently, organizations initially set percentage improvement goals beyond their reach with too little information. P2 is based on achieving many successes over time. Many of the problems of organizations have evolved over many years and cannot all be solved at one time. The organization can use Systems Approach tools to generate the information effectively and use it to set goals during the development of the action plans. Although it is important to focus improvement efforts on critical issues (Pareto diagrams), improvements can be made little by little until these major issues are resolved.

Organizations strive to improve, but few understand the difficulty in trying for continual improvement.

Incremental improvements can lead to breakthrough improvements. This is accomplished by learning from the improvements and seeking to make larger improvements. Incremental improvements also allow for "quick wins." These little victories, when accompanied by cost data, help maintain management approval for the P2 effort. Continued funding of P2 projects also provides the time for breakthrough improvements to materialize.

Checklists are useful tools for gathering information and data and tracking progress of the problem-solving and decision-making method. However, they are relatively ineffective at communicating that information to management and other interested parties. Each of the Systems Approach tools has a visual output that is much more effective in this regard.

Making P2 a way of life in order to achieve success takes more than words; it requires action. Action plans provide documentation for these actions and a means of tracking P2 progress over time.

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CHAPTER 5

Traditional Approach to P2 Implementation

INTRODUCTION

A number of models are available for implementing your P2 program. This chapter will focus on a "traditional" model based on the previous editions of this EPA Guide (*Waste Minimization Opportunity Assessment Manual*, EPA/625/7-88/003 and *Facility Pollution Prevention Guide*, EPA/600/R-92/088). Chapter 6 will examine an implementation model that utilizes a formal environmental management system (EMS). Chapter 7 will evaluate the use of a quality model for P2 implementation. This *Guide* will not prescribe or recommend any one of these P2 implementation models. Instead, you can mix and match components to derive a P2 program implementation model that works best in your organization. If you do this, your organization's P2 program is far more likely to be implemented and maintained. This concept will be presented in Chapter 8.

You can mix and match components to derive a P2 program implementation model that works best in your organization. If you do this, your organization's P2 program is far more likely to be implemented and maintained.

At the top level (Figure 5-1), the traditional P2 model offers a logical path for implementing P2. First you establish the P2 program using the information provided. Then, you prepare a written P2 plan to describe how the program will be implemented. Next, you execute the program implementation. Finally, you must maintain the P2 program over time.

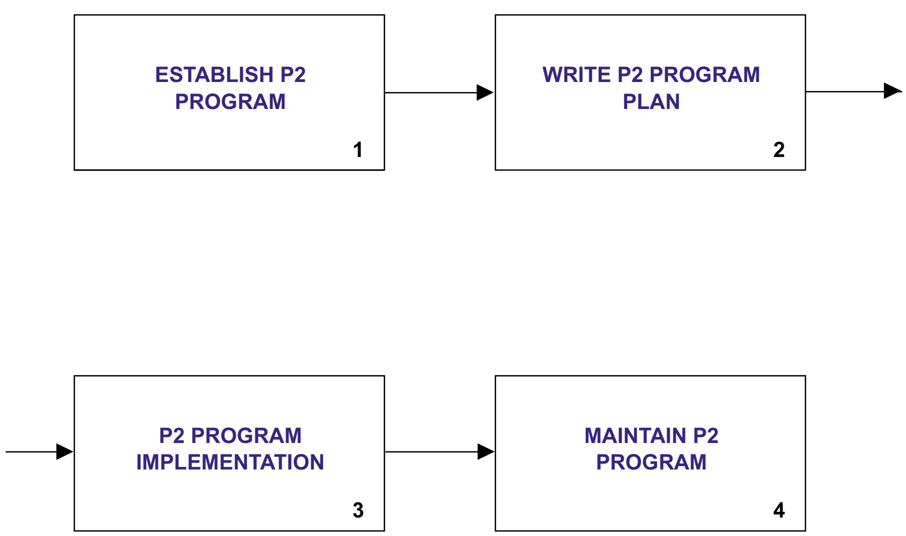


Figure 5-1. Top-level Depiction of the Traditional Approach to Pollution Prevention Implementation.

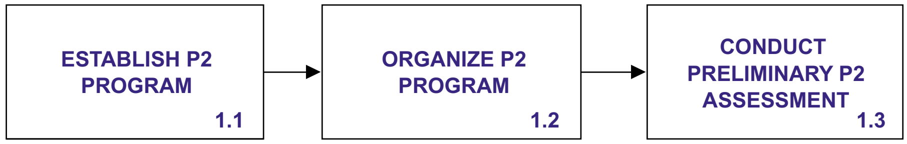


Figure 5-2. Establishing a P2 Program.

Let's look at the details in each of these steps to see how the information in this *Guide* can ease the implementation using the traditional approach to P2.

ESTABLISHING A P2 PROGRAM

The traditional approach has a "top-down" focus.

The traditional approach has a "top-down" focus. This approach, as presented in the earlier EPA publications (Figure 5-2), begins with getting management approval and setting program goals *before* P2 information is collected. The first step is to obtain an executive-level decision to establish the P2 program. This decision is communicated to the workforce using a policy statement. Consensus-building efforts will promote acceptance of this policy statement.

To organize the P2 program, management names a P2 task force and states goals before any formal information is gathered. Goals that are established upfront for a P2 program challenge the effort.

The traditional approach views the preliminary assessment as a "walk-through" activity to be performed by a team of employees or by an outside service provider or process expert.

Under the traditional approach, the task force next conducts a preliminary P2 assessment to collect some P2 data, reviews sites for future P2 studies, and establishes the priorities for the P2 program. A preliminary assessment is necessary to gather information for the written P2 plan (Figure 5-2, work step 1.3). Some organizations may consider conducting this preliminary assessment prior to work steps 1.1 and 1.2 (see Figure 5-2). The traditional approach views the preliminary assessment as a "walk-through" activity to be performed by a team of employees or by an outside service provider or process expert.

The Systems Approach described in Chapter 4 of this Guide *allows for some "bottom-up" efforts before the endorsement of senior management.*

The Systems Approach described in Chapter 4 of this *Guide* allows for some "bottom-up" efforts before the endorsement of senior management. Using the process-mapping tool described in Chapter 4 of this *Guide* gives the team a more complete understanding of the processes (including the ancillary and intermittent processes). This leads to a more complete listing of opportunities for P2. Pareto analysis can be used to rank order the opportunities for P2. The organizational management can then propose goals based on a more complete assessment of the P2 opportunities and establish clear priorities for the program. Goals could be stated in the action plans for each year instead of as program goals. These ideas show how you can organize this part of the P2 program using the tools presented in this *Guide*.

These ideas show how you can organize this part of the P2 program using the tools presented in this Guide.

WRITING THE P2 PROGRAM PLAN

The traditional approach next addresses writing the P2 program plan (Figure 5-3). A good planning effort makes careful note of what the stakeholders want in the program. These are the interested parties or external groups described in the quality-based implementation model (see Chapter 7). Stakeholders may include the following: customers, suppliers, employees, regulators, environmental interest groups, community organizations, stockholders, and anyone else with a stake in the outcome of the P2 program.

Stakeholders may include the following: customers, suppliers, employees, regulators, environmental interest groups, community organizations, stockholders, and anyone else with a stake in the outcome of the P2 program.

The P2 plan should state clear objectives for the P2 program. It should anticipate obstacles to program implementation and plan means to overcome them. A good planning effort addresses these obstacles during the preparation of the plan. Finally, the P2 plan requires a firm schedule. It can be a challenge to set a schedule based solely on the information gathered to this point, but a schedule is essential for management to track the plan's progress during the course of the year.

The P2 plan should state clear objectives for the P2 program.

A schedule is essential for management to track the plan's progress during the course of the year.

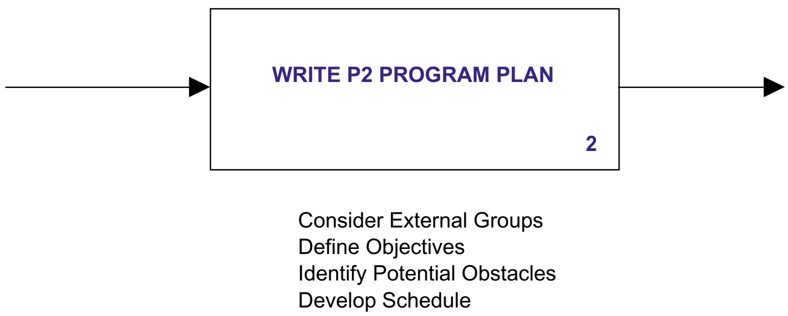


Figure 5-3. Writing the P2 Program Plan.

Earlier in this *Guide* (Chapter 4), action plans were described. The action plan is a tool that can be used to address all the concerns that can arise when writing a P2 program plan. Each organization should have an action plan for each P2 project conducted in the P2 program. The collection of these action plans (many organizations implement 8 to 11 P2 action plans in a typical year) constitutes the major portion of the P2 plan. The other part of the P2 plan outlines the management structure within which these plans will be used and reviewed during the course of the year. The objectives of the program should reflect the vision and mission statements for the P2 efforts.

Each organization should have an action plan for each P2 project conducted in the P2 program.

P2 PROGRAM IMPLEMENTATION

In the traditional approach the detailed P2 assessment is the starting point of the program implementation phase (Figure 5-4). An assessment team is assembled for this task. It is not defined as a worker team but rather as a higher-level, multidisciplinary team which may

In the traditional approach the detailed P2 assessment is the starting point of the program implementation phase.

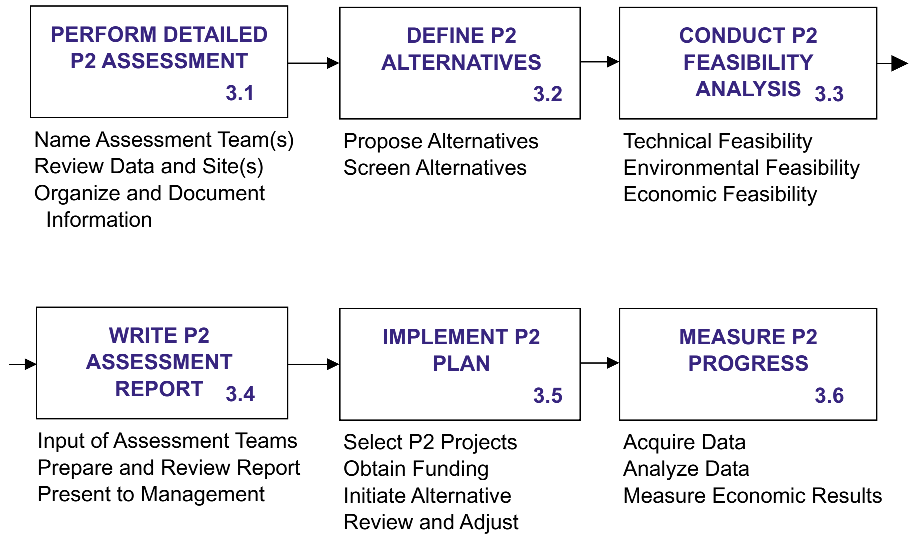


Figure 5-4. P2 Program Implementation.

include some employees. Checklists and worksheets are provided to help the team collect data and information. This assessment team will review the data and visit the sites where the P2 activity is planned to occur.

The purpose of the detailed assessment is to help the team derive alternatives.

The purpose of the detailed assessment is to help the team derive alternatives (called “options” in the previous publications) for P2. The team uses brainstorming as a tool to find potential alternatives. The traditional approach does not formally include root cause analysis before deriving alternatives.

Based on the detailed assessment, the assessment team proposes a number of P2 alternatives and screens them to help focus on the implementation that will follow.

Based on the detailed assessment, the assessment team proposes a number of P2 alternatives and screens them to help focus on the implementation that will follow. Most of the P2 industry-specific manuals provided a limited number of alternatives, so the screening was fairly straightforward. The traditional approach model uses criteria matrices for screening. Once screening is complete, it is time for a feasibility analysis of the priority alternatives. Of course, not all P2 alternatives require such formal analysis. Quick wins or “low-hanging fruit” P2 alternatives can proceed more expediently. They do not compete for capital funding. When an alternative requires some capital funding to implement, it is frequently subjected to a technical feasibility study, a determination of its environmental feasibility, and finally a determination of the economic feasibility. At this point, the traditional approach requires the preparation of a formal, written P2 assessment report. This report details the analysis of the P2 assessment team and allows that information to be presented to management in a formal manner after a review by the P2 task force. Once the P2 projects have been

Once the P2 projects have been selected, the traditional approach has the P2 team obtain funding and initiate work on the alternative.

selected, the traditional approach has the P2 team obtain funding and initiate work on the alternative. The work is reviewed and adjusted during execution to make sure it meets the objectives. There is no requirement in the traditional approach to prepare a formal action plan. The P2 implementation team reviews its progress on an informal basis and makes necessary adjustments to enhance the P2 effort.

The final step in the traditional P2 program implementation is to measure P2 progress. Data is acquired from the implementation phase and analyzed. The traditional approach recommends the measurement of economic results.

MAINTAINING THE P2 PROGRAM

At this stage, the traditional approach shifts to the maintenance of the P2 program.

At this stage, the traditional approach shifts to the maintenance of the P2 program (see Figure 5-5). Five activities are detailed in this program component.

Program maintenance begins with the integration of the P2 program into other formal corporate P2 initiatives.

This program maintenance begins with the integration of the P2 program into other formal corporate P2 initiatives. These programs could include safety, quality, preventive maintenance, lean manufacturing, and so on. Accountability for wastes are assigned to the generating process. All wastes are carefully tracked and formally reported in the organization. The program results are evaluated annually.

Educational training for those who participate in the P2 program needs to be specified.

Educational training for those who participate in the P2 program needs to be specified. No tools are taught in the traditional approach; however, the participants do become familiar with the process. Training is provided to new employees to orient them to P2. Advanced training is provided to those most involved with the P2 program. Each year, every employee needs to be updated on knowledge of P2.

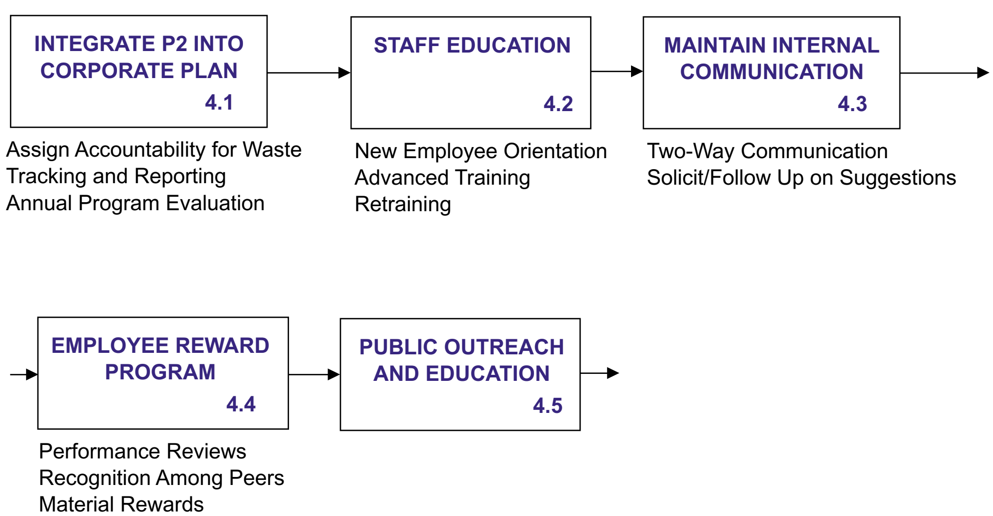
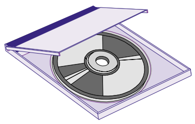


Figure 5-5. Maintaining the P2 Program.

The traditional approach looks at all routine communications and finds ways to encourage them.

Communication is important to any program. The traditional approach looks at all routine communications and finds ways to encourage them. It also promotes the solicitation and follow-up of employee suggestions.

As an incentive for participation in the P2 program, the traditional approach includes an employee reward program. It features performance reviews, recognition among peers, and material rewards. Finally the traditional approach recommends a public outreach and educational program.



More information on the traditional approach, including copies of the previous EPA publications, can be found on the CD-ROM that accompanies this *Guide*. All the checklists and worksheets from the traditional approach are provided on that CD-ROM.

COMBINING THE TRADITIONAL APPROACH WITH THE SYSTEMS APPROACH

The traditional approach recommends a public outreach and educational program.

Many of the readers of this *Guide* have been using the traditional approach for years. The process maps provided here and in Chapter 1 should help you use this approach more effectively. You may have begun to consider changes you might make to the approach that will work well for you. It is instructive to prepare a process map of your approach to P2 so everyone in your program can understand it clearly.

The Systems Approach tools presented in this Guide *can be used to enhance the effectiveness of the traditional approach.*

The Systems Approach tools presented in this *Guide* can be used to enhance the effectiveness of the traditional approach. One area where improvement can be made is in the process characterization. It is easier for management and team members to "*see*" the process maps. Having piles of information and checklists to review can be far more daunting. The process maps also enable the team to focus on certain areas that offer the best opportunities for P2.

Process mapping can be conducted by those interested in promoting P2 before going to management for commitment to the program. It may be a wise decision to let them understand what opportunities await them if they approve this program. Process maps will typically find more opportunities for P2 than a walk-through or preliminary assessment.

Another potential improvement is in the use of root cause analysis to examine why a selected P2 opportunity has a problem associated with the use of a regulated material or a regulated loss.

Another potential improvement is in the use of root cause analysis to examine why a selected P2 opportunity has a problem associated with the use of a regulated material or a regulated loss. Experiments have been conducted with P2 teams to test the theory that root cause analysis will lead to better alternative generation. A team that does not use root cause analysis and goes directly from the selection of the P2 opportunity to the generation of alternatives typically is capable of specifying two to four alternatives. In contrast, a team that uses root cause analysis first and then tries to generate alternatives will come up with

18 to 40+ alternatives. Many of the alternatives derived in the former case may not finish in the top-10 listing after the longer list of alternatives is prioritized. The cause-and-effect diagram is the most widely used problem-solving tool in the world. It deserves consideration in the implementation of your P2 program.

The cause-and-effect diagram is the most widely used problem-solving tool in the world.

The issue of goal setting is very important in P2. The traditional approach sets goals up front. Many state-mandated P2 programs also set statewide goals at the start of the program. In the Systems Approach, the organization sets performance goals in the action plans after the information on P2 has been gathered and evaluated. They are set year-by-year and project-by-project. The sum of all the action plan performance goals is the overall performance goal of the year. Some quality experts believe that goal setting is rarely done properly. They argue that one should measure continual improvement and always increase the amount of P2 accomplished, no matter how small they may be. There should also be no backsliding in areas in which improvements have already been made. This sort of seemingly incremental improvement can yield large breakthroughs as P2 program participants learn how to master change.

The issue of goal setting is very important in P2.

This sort of seemingly incremental improvement can yield large breakthroughs as P2 program participants learn how to master change.

The basics of the traditional approach can be integrated with the lessons of the Systems Approach. They work well together and allow the organization to make continual improvement in the conduct of the traditional P2 program.

The basics of the traditional approach can be integrated with the lessons of the Systems Approach.

APPROACHES FOR VERY SMALL ORGANIZATIONS

One argument for retaining the traditional approach exclusively was that it worked well for very small organizations. The tools of the Systems Approach were sometimes thought to take too long to use and to be too difficult for very small organizations to master. Some observers thought that these organizations would have to rely on outside P2 technical assistance providers to help them with P2 alternatives.

The following case study illustrates how the Systems Approach could be used by small organizations to complement the use of the traditional approach. Use of this Systems Approach does not rule out the traditional approach, but illustrates how the tools that are presented in this *Guide* might increase the effectiveness of the traditional approach.

EPA funded the development of a publication called *Nothing to Waste* (Reference 5-1) for its Environmental Justice program. This publication uses the Systems Approach for dealing with very small businesses. A model for helping very small organizations succeed was developed by a team lead by a not-for-profit group, Working Capital. They formed groups of leaders of very small organizations who met on a regular basis outside of working hours. A facilitator helped them work through some modules that taught them how to write a business plan and how to apply for a loan. Banks provided the groups with money to

EPA funded the development of a publication called Nothing to Waste *for its Environmental Justice program. This publication uses the Systems Approach for dealing with very small businesses.*

loan. When the group determined that a member was qualified for a loan, the group had the power to grant that loan. The bank stipulated that if the person missed any payments, everyone in the group was dunned and could not get a loan for a specified period of time. This stipulation made the members of the group work together better so that everyone paid back loans. Banks were very happy with the results. Previously, typical loan defaults for this segment were as high as 60%. Using this model, loan defaults dropped to less than 10%.

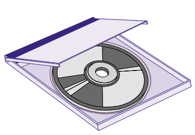
It became obvious that these small organizations could not afford any waste.

It became obvious that these small organizations could not afford any waste. Their initial loan could only be $500. If an individual borrower wasted any of this money, the entire group would be less successful. For example, a small furniture maker needed to know that finish overspray led to the loss of some of the valuable finish that was purchased. The furniture maker had to find out how more of that finish could be placed on the furniture to reduce the waste.

In the *Nothing to Waste* program, leaders from very small organizations still meet regularly in off-work hours in teams of five to seven companies. They use the Systems Approach tools under the guidance of a group facilitator trained in the use of the tools. They map each other's processes, apply the tools to identify opportunities for P2, and derive and select alternatives for dealing with the losses. The group facilitator also helps provide the group members with P2 information and resources that may be needed to implement the selected P2 alternative. States that have adopted this model (e.g., New Mexico, Maine, and Massachusetts) have been able to make better use of their technical assistance providers by having them "visit" with many small organizations at once instead of making many trips to separate operations.

States that have adopted this model have been able to make better use of their technical assistance providers by having them "visit" with many small organizations at once instead of making many trips to separate operations.

Very small organizations may not have the technical capability to follow the formal traditional approach on their own. However, they can master the problem-solving and decision-making tools quickly and use them to communicate effectively with one another, even though they do not actually work together. They can learn how to communicate better with their customers, suppliers, and lending institutions as a result of learning how to use these tools. Action plans allow the group to track each other's progress. These plans are reviewed at each meeting.



Nothing to Waste has been formally adopted for use in the Green Zia Program in New Mexico (Reference 5-1). This publication is available on the Internet and can be found on the CD-ROM. It can be used by P2 teams in larger companies to help worker teams get an understanding of the use of the tools in the Systems Approach without an expensive training program.

OTHER IMPLEMENTATION APPROACHES

Chapter 6 will examine how an organization can use the environmental management system (EMS) to help implement a P2 program. This is an important implementation model since many organizations are now considering this type of EMS (i.e., ISO 14001, EMAS, etc.). Chapter 7 will examine how an organization can use a quality-based program like the Baldrige approach to implement a P2 program. A prevention-based approach is built into the criteria that allow an organization to compare itself to organizations which have achieved environmental excellence. An organization that scores well in the rating system should have a significant amount of P2 in its operations.

Process maps have been prepared in each of these chapters so you can compare them to the process maps in this chapter. By using this tool, you will be able to select the approach that is most effective for you and compare it to the implementation approaches provided in this *Guide*. Chapter 8 will provide some tips on how to mix and match these implementation approaches.

REFERENCE

5-1. Nothing to Waste Manual
http://www.pojasek-associates.com/Reprints/Nothing-to-Waste.pdf

CHAPTER 6

EMS Approach to P2 Implementation

Includes:
- ☐ Introduction
- ☐ Getting Started
- ☐ Environmental Policy, Management Commitment, and Scope
- ☐ EMS Planning
- ☐ EMS Implementation
- ☐ Monitoring and Measurement
- ☐ Lessons Learned
- ☐ References
- ☐ Supplemental Reading

INTRODUCTION

The new international voluntary standard for environmental management systems (EMSs) known as ISO 14001 is proving to be an effective tool for improving organizational environmental performance and implementing P2 opportunities. The intent of the standard is to establish and maintain a systematic management plan designed to continually identify and reduce the environmental impacts resulting from an organization's activities, products, and services. Currently, no government mandate requires organizations to have a comprehensive EMS, but several states are exploring the effectiveness of having organizations use an EMS in implementing and complying with P2 planning requirements.

The intent of the standard is to establish and maintain a systematic management plan designed to continually identify and reduce the environmental impacts resulting from an organization's activities, products, and services.

Government policymakers are interested in EMSs as a possible way to supplement the so-called "command-and-control" environmental regulations. The EPA recognizes that an EMS can help organizations integrate environmental considerations into day-to-day decisions and practices (References 6-1 and 6-2). EMSs will not replace existing regulatory systems in the United States but will work best when they complement the existing regulatory programs including formal enforcement actions. Other EMSs are emerging, but the focus of this chapter will be on the ISO 14001 standard's elements.

The EPA recognizes that an EMS can help organizations integrate environmental considerations into day-to-day decisions and practices.

For several years, the EPA has been engaged in a number of important activities designed both to promote and evaluate the effectiveness of EMSs in a variety of settings. These activities vary widely and include (1) a major EMS research program conducted in partnership with states through the Multi-State Working Group (MSWG), (2) programs to promote and demonstrate the value of EMSs in various sectors such as local government and metal finishing, and (3) the use of EMSs as components of voluntary leadership programs. The EPA has also used EMSs as important components in enforcement settlement agreements. The MSWG has adopted a consensus policy document to help guide states and others in designing EMSs, evaluating EMS credibility, and participating in EMS processes (Reference 6-3). The principles are as follow:

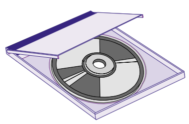
The MSWG has adopted a consensus policy document to help guide states and others in designing EMSs, evaluating EMS credibility, and participating in EMS processes.

- EMSs should improve compliance with environmental laws, enable organizations to achieve performance "beyond compliance" with legal requirements, and reduce environmental impacts from both regulated and unregulated activities.

- An EMS can serve as a supplementary tool that enables regulatory agencies and others to jointly achieve greater environmental protection.
- The quality of an EMS is linked to environmental performance achieved.
- EMS metrics can document improved environmental performance, which may enable regulatory agencies to achieve policy objectives more efficiently and improve communications with the public.

An EMS promotes important planning and improvement elements needed in the design of multimedia source reduction and recycling programs for all forms of pollution.

A growing number of organizations have pioneered new strategies for integrating environmental management into their overall business strategy. Although regulatory compliance remains an important driver of environmental performance and of the adoption of advanced practices, business factors such as cost savings and improved business performance are just as important. EMSs are motivating organizations all over the world to reconsider their environmental performance and effectiveness and determine how P2 strategies can help them reduce wastes, risks, and costs. These organizations should establish and maintain a systematic management plan that promotes P2 and is designed to continually identify and reduce the environmental harm (impacts) created by the organization's activities, products, and services. The EMS fosters innovative strategies and a framework for improving environmental performance by encouraging all the employees of the organization to look for ways to reduce environmental impacts by first using P2 techniques. Supporting information on EMSs can be found on the CD-ROM that accompanies this *Guide*.



GETTING STARTED

Like other management systems, an EMS is a formal approach for articulating goals, making choices, gathering information, measuring progress, and improving performance. An EMS promotes important planning and improvement elements needed in the design of multimedia source reduction and recycling programs for all forms of pollution. Several elements of an EMS provide positive reinforcement for P2 assessment and planning efforts and add an element for continual review by management that is needed for implementation and improvement. Figure 6-1 is a top-level process map for implementing P2 using an EMS program.

The goal of the standard is to establish a common approach to EMSs that is internationally recognized, leads to improved environmental performance, and provides an opportunity for gaining international recognition and market share.

The goal of the standard is to establish a common approach to EMSs that is internationally recognized, leads to improved environmental performance, and provides an opportunity for gaining international recognition and market share. ISO 14001 is a management system standard, not a performance standard. Given that ISO 14001 is a system built for industry by industry, it uses a language that management un-

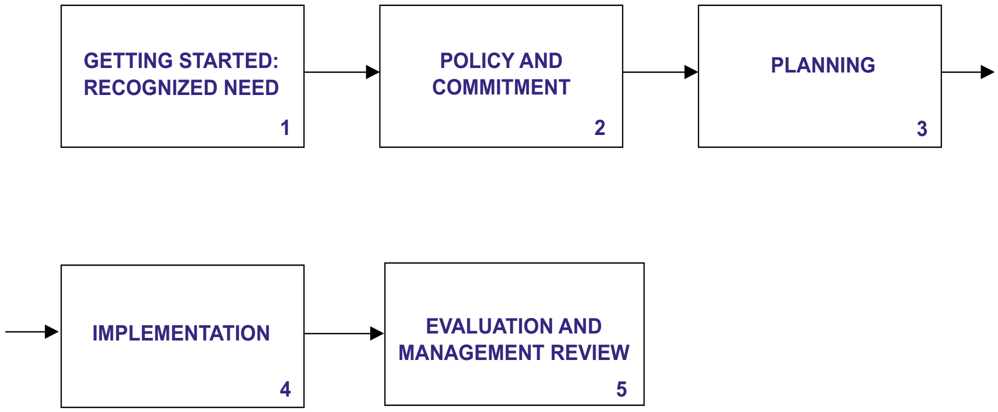


Figure 6-1. Implementing P2 Using an EMS Program (Top-level Process Map).

derstands, and it will keep top management's attention through involvement. The EMS provides a systematic approach for integrating environmental protection into all business functions and management strategies.

The EMS provides a systematic approach for integrating environmental protection into all business functions and management strategies.

One important way the EMS standard promotes integration of environmental and organizational management is by requiring top management to define the environmental policy. However, the EMS approach to P2 encourages several initial activities prior to setting up the policy:

- Identifying current environmental compliance procedures and management techniques
- Reviewing the policies in place and environmental concerns for the future
- Ensuring that all relevant information is up to date
- Generating an environmental plan for continual involvement and improvement for the future

Figure 6-2 is a process map that shows these initial steps in the EMS approach to P2.

As an initial step in developing a comprehensive EMS, most organizations find it helpful to complete an objective gap analysis of their existing environmental system. This enables the organization to discover its current status regarding environmental performance and compliance and highlight areas that require attention under an EMS. The results of a "gap" analysis will provide a benchmark for the organization's alignment and conformance to the ISO 14001 standard. Many organizations are developing useful gap audit tools, including facilities, consultants, and technical assistance providers. The scope of the gap analysis audit should include all areas of the organization related to environmental systems as well as the interfaces between a specific facility and its corporate environmental department.

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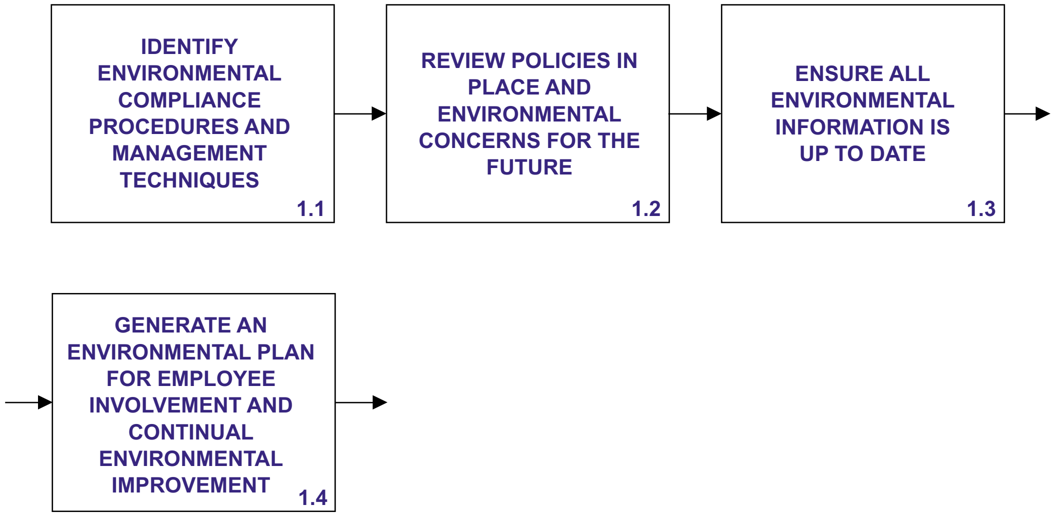


Figure 6-2. Getting Started—Recognized Need.

EMSs require that organizations have a "commitment to comply with relevant environmental legislation and regulations, and with other requirements to which the organization subscribes." An organization's current practices for tracking compliance are a good place to start, and they should be compared to what an EMS entails. An EMS aligned to ISO 14001 requirements offers the potential for delivering substantial gains in production and environmental efficiency and reduced costs in environmental compliance. It is likely that top-level management will view an EMS as a competitiveness issue rather than as a cost center for environmental compliance. Involvement of top management in defining policy, reviewing the current plan, and maintaining EMS awareness is seen as a positive outcome by many since management has sometimes been a tough audience to reach on environmental issues.

It is likely that top-level management will view an EMS as a competitiveness issue rather than as a cost center for environmental compliance.

An organization has to prove that its EMS has been implemented effectively and leads to compliance over time. The organization must have a procedure to identify and have access to legal and other requirements to which it subscribes. Periodic compliance and EMS system audits are required to assess procedural improvements and identify needed system improvements through corrective actions. Such a mechanism for improvement is completely absent in command-and-control regulations such as BAT (best available technology) standards and emission standards. Standards such as these give organizations no incentive to exceed what is necessary for compliance. In some cases, they may encourage the use of control technologies over other approaches that would result in better environmental performance. Command and control standards give organizations no incentive to exceed what is necessary for compliance.

Command and control standards give organizations no incentive to exceed what is necessary for compliance.

Another regulatory advantage of an EMS is the requirement to consider legal and other requirements when establishing objectives and targets for the significant aspects. The potential for exchange between an EMS and state P2 facility planning requirements is generating interest among environmental regulators in several states. As part of the MSWG initiative, the state of Washington studied organizations using ISO 14001 and concluded, "EMSs are proving to be a superior approach for implementing P2 assessments and planning activities." They allow the EMS to meet the organization's planning requirements if the waste management hierarchy is followed in setting objectives and targets. The EPA's Environmental Performance Track program has developed a matrix of several other state programs that have modified their requirements, and it can be found on their Web site (Reference 6-4).

The state of Washington studied organizations using ISO 14001 and concluded, "EMSs are proving to be a superior approach for implementing P2 assessments and planning activities."

ENVIRONMENTAL POLICY, MANAGEMENT COMMITMENT, AND SCOPE OF THE EMS

Based on the current environmental assessment and performance, it is management's responsibility to develop a shared vision and direction for the organization's EMS policy and to commit to its implementation (Figure 6-3, work steps 2.1, 2.2, 2.3). In the policy, management defines its scope and ensures consistency with the organization's vision, core values, beliefs, and other goals. Management may use the new policy to expand the organization's environmental perspective. The environmental policy for an EMS contains the following commitments:

- Commitment to "prevention of pollution"
- Commitment to compliance with all applicable requirements and other requirements to which the organization subscribes
- Commitment to continual improvement of the system itself and not specifically continued improvement of the required environmental performance criteria.

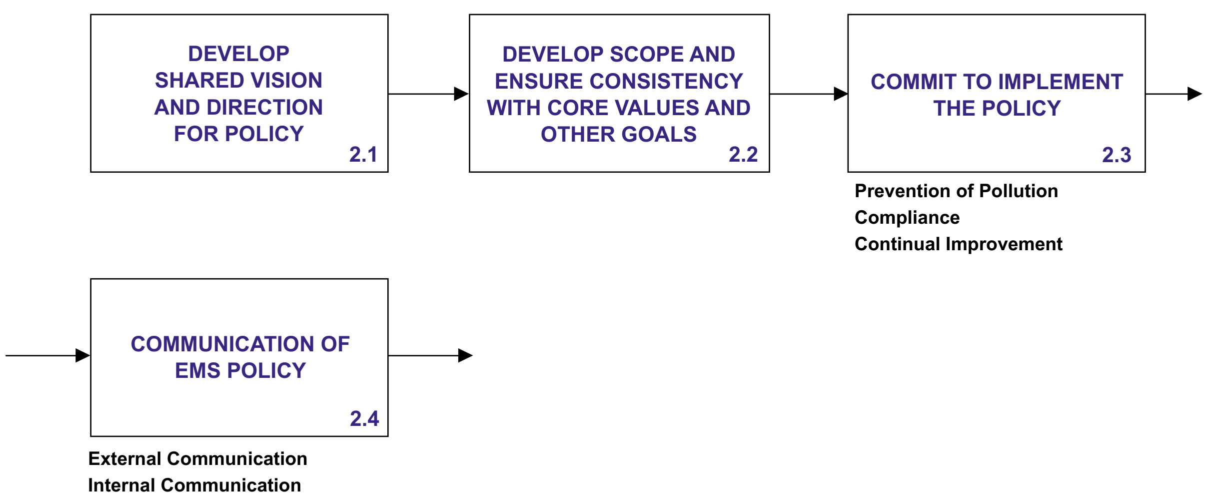


Figure 6-3. Policy and Commitment: Define Environmental Policy, Scope, and Commitment.

*Prevention of pollution is defined by the standard as **"use of processes, practices, materials or products that avoid, reduce** or control **pollution, which may include recycling**, treatment, **process changes**, control mechanisms, **efficient use of resources and material substitution**."*

P2 is different from prevention of pollution as defined in the EMS standard. Prevention of pollution is defined by the standard as **"use of processes, practices, materials or products that avoid, reduce** or control **pollution, which may include recycling**, treatment, **process changes**, control mechanisms, **efficient use of resources and material substitution**." This definition does include control and treatment scenarios but the phrases indicated in bold in the definition provide a clear mandate in the policy to pursue source reduction as a goal and objective of the EMS.

The EMS policy is used as the guidance for setting and reviewing the organization's environmental objectives and targets. The EMS standard does not require specific environmental goals. Instead, it provides a general framework for organizing the tasks necessary for effective environmental management and improved performance.

Communication of the EMS Policy

The EMS standard requires the environmental policy of the organization be made available to the public.

Once management reaches agreement on the policy, it should be documented, kept up-to-date, and used by all employees. Most organizations already have procedures in place on how they communicate their policies internally and externally (Figure 6-3, work step 2.4). The EMS standard requires that the environmental policy of the organization be made available to the public. Many organizations already provide far more environmental information through P2 plans, annual reports, regulatory records, and participation in emergency response planning.

An EMS addresses the process for responding to external communications or requests for environmental information. The organization documents its procedure on "how to" respond to these external requests for information on the EMS, environmental aspects, and P2, if and when they occur. The basic documentation an organization should keep for external requests includes who made the contact, the date, the nature of the request, the nature of the response, and what, if any, materials were sent.

The EMS requires the organization to develop and implement procedures to ensure internal communication of the EMS policy, responsibilities, and results.

The EMS requires the organization to develop and implement procedures to ensure internal communication of the EMS policy, responsibilities, and results. The EMS and environmental "aspects" need to be communicated to all internal levels of the organization and job functions that could impact the environment. The internal communication procedure specifies whose responsibility it will be to communicate changes relating to the EMS and environmental aspects. Changes may include environmental information, such as revised objectives and targets, changes in procedures, and environmental incidents or regulatory changes. Another internal communication "how to" is a process for responding to employee requests and concerns related to the EMS and P2. Internal communication should include discussions of general and useful P2 opportunities that apply to all wastes and losses identified in the organization.

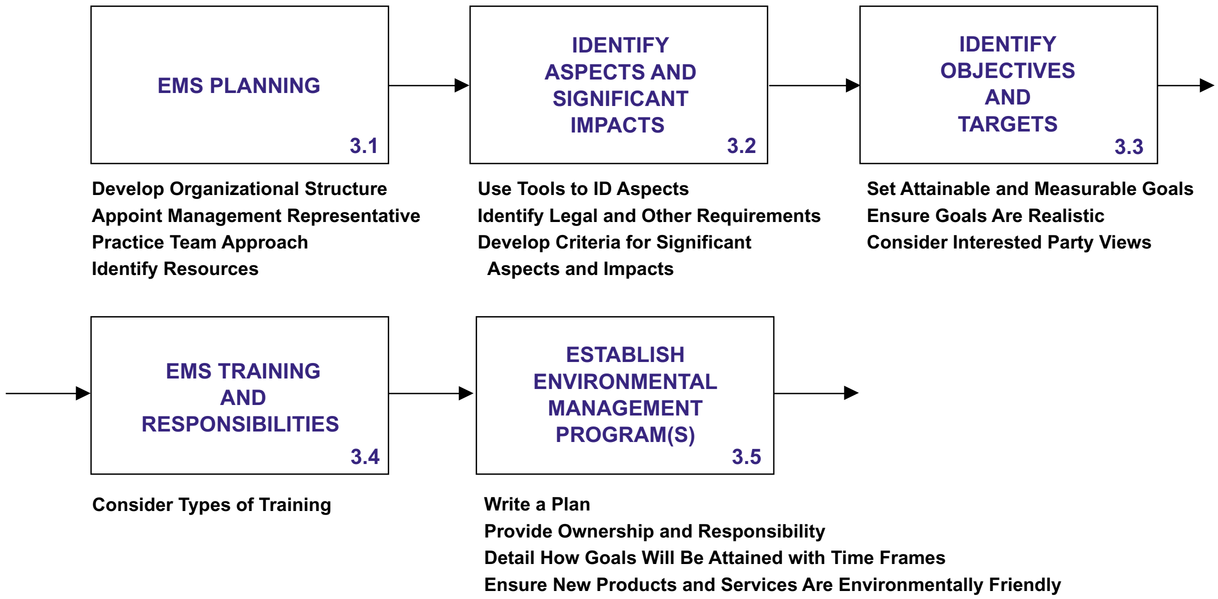


Figure 6-4. Planning in the EMS.

EMS PLANNING

As an organization grows and as product lines change, planning is necessary. Planning for P2 should go hand in hand with any business planning effort (Figure 6-4, work step 3.1). Unfocused, ill-timed, or poorly managed P2 efforts will lead to low performance and high cost. Conversely, a well-conceived and effectively implemented P2 program leads to high performance and reduced costs. Improved environmental performance is an important benefit for most organizations undertaking EMS development and implementation. Although some organizations have comprehensive EMSs that systematically track environmentally relevant activities, many do not. An EMS includes organizational structure, responsibilities, practices, procedures, processes, and resources for implementing effective environmental management.

As an organization grows and as product lines change, planning is necessary. Planning for P2 should go hand in hand with any business planning effort.

Top management appoints a management representative or representatives to ensure the organization accomplishes its goals when establishing an EMS. The management representative monitors and evaluates the system and reports to top management on the EMS's effectiveness. The coordinator(s) works with organizational teams to generate new ideas and modify the EMS when necessary for improvement. The organization could create an environment and select a forum in which creative ideas can be heard and tried.

The management representative monitors and evaluates the system and reports to top management on the EMS's effectiveness.

Most organizations choose to meet in teams to discuss production and wastes and develop questions for needed checklists. Teams are used to multiply the strength of the organization. The team approach

Teams are used to multiply the strength of the organization. The team approach allows for discussion and comparison of differences.

allows for discussion and comparison of differences. It may be useful to set up self-managing P2 teams chosen from all levels of the organization. The involvement of several levels of management in these discussions, normally in several groups, improves their usefulness. Clearly identifiable teams are the primary means of organizing the EMS work, as opposed to individual job functions or independent work areas. These teams can be used to identify, evaluate, and implement P2 opportunities.

These teams can be used to identify, evaluate, and implement P2 opportunities.

Teams are authorized to take direct action, make decisions, and initiate changes that result in continual improvement of the EMS to comply with the policy and achieve the organization's objectives and targets. When the employees' roles have been formally structured to support the work team approach, members can rely on one another for cross training, problem solving, administrative duties, and mutual support. Opportunities for waste elimination, reduction, reuse, recycling, and energy and water conservation are addressed by a P2 team of the most appropriate people regardless of their reporting level in the organization.

Teams are authorized to take direct action, make decisions, and initiate changes that result in continual improvement.

Identification of Aspects and Significant Environmental Impacts

The EMS is driven by environmental impacts. An EMS encourages organizations to systematically address the environmental impacts of their activities, products, and services (Figure 6-4, work step 3.2). This systematic approach may prove effective in encouraging organizations to take a proactive and P2 approach to managing their environmental impacts and programs. An organization's aspects may include waste generation and pollution, resource utilization and depletion, energy generation and utilization, and other ecological impacts on the environment.

The EMS is driven by environmental impacts.

An organization's aspects may include waste generation and pollution, resource utilization and depletion, energy generation and utilization, and other ecological impacts on the environment.

Aspect—element of an organization's activities, products, or services that can interact with the environment.

The standard outlines a core set of planning activities that are used in many organizations to assess and implement P2. This planning ensures a facility will:

- Identify facility activities, operations, processes, services, and products that have environmental impacts
- Identify all legal requirements that apply to the organization's activities, products, and services
- Evaluate which environmental impacts are significant
- Set objectives and targets for reducing negative environmental impacts
- Select and implement activities through environmental management program(s) to achieve the identified targets

Through the procedure of aspect identification and ranking, P2 should emerge as a core part of the environmental management plan(s). The P2 assessment is a systematic, periodic survey of the organization's operations designed to identify areas of potential waste reduction and conservation. A well-designed EMS can go far beyond the traditional process-driven view for characterization of wastes and losses. In evaluating all of its environmental aspects, an organization can take activities such as solid waste, energy and water use, landscaping, commuting, sound, and other impacts into consideration although they are not regulated. The organization can question suppliers about contents of materials, use and types of packaging, and methods of delivery. Aspect identification procedures include the following:

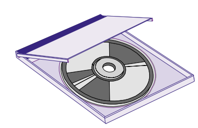
Through the procedure of aspect identification and ranking, P2 should emerge as a core part of the environmental management plan(s).

In evaluating all of its environmental aspects, an organization can take activities such as solid waste, energy and water use, landscaping, commuting, sound, and other impacts into consideration although they are not regulated.

- Process mapping
- Interviews
- Questionnaires
- Checklists
- Benchmarking
- Cost/benefit, energy, and life cycle analysis
- Inspections and audits
- Review of records and emergency responses
- Material balances of inputs and outputs

Consideration of operating conditions and controls and their effect on environmental impacts is an important part of identifying the organization's significant aspects. The organization should select criteria to determine the significance of its aspects. The criteria might include regulated activities, costs to manage, and risks associated with use of raw materials. What is most important is that the criteria reflect the organization's values as stated in the policy. Several good examples of ranking potential significant aspects/impacts can be found in US EPA's *Integrated Environmental Management Systems Implementation Guide* and NSF International's *Environmental Management Systems: An Implementation Guide for Small and Medium-Sized Organizations* (References 6-4 and 6-5). See the CD-ROM for more information on EMSs.

The organization should select criteria to determine the significance of its aspects. The criteria might include regulated activities, costs to manage, and risks associated with use of raw materials.



Identifying operations and monitoring and measuring activities associated with significant environmental aspects leads to the development of procedures that minimize the risk of those environmental impacts. This systematic approach can help foster P2 solutions by encouraging an organization to identify opportunities for doing things in new ways, for finding new products from "waste," and for going beyond the traditional view that environmental issues are the responsibility of the environmental, health, and safety managers.

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Typically, organizations separate their environmental strategies by media—land, air, and water—to address their environmental impacts and compliance with various environmental regulations. This leads to a single media dependence on reactive and end-of-pipe strategies that are potentially inefficient and costly. Many organizations that have instituted a thorough EMS have benefited by becoming aware of inefficiencies that were not apparent previously. Correcting these inefficiencies generates cost savings and reduced environmental liabilities. A multimedia EMS approach will ensure all significant aspects are identified that impact the environment and are costly for the organization.

A multimedia EMS approach will ensure all significant aspects are identified that impact the environment and are costly for the organization.

The organization benefits by involving suppliers and contractors in the EMS procedures and requirements for certain significant environmental aspects they could impact. Identification of health and environmental concerns associated with the raw materials used by an organization is important in assessing the significance of environmental aspects associated with that materials' use. It may be necessary to provide training and guidance to outside organizations whose actions onsite may create an aspect or impact the organization's environment. This provides a forum for the two organizations to investigate goods and services for P2 opportunities. From improving efficiencies to changing basic processes, design has played an important role in reducing waste. Good supplier partnerships can result in designing for P2 and meeting the objectives and targets established for the EMS.

The organization benefits by involving suppliers and contractors in the EMS procedures and requirements for certain significant environmental aspects they could impact.

An organization may choose to modify an existing assessment tool or develop a procedure for identifying all the organization's environmental aspects and their significance. Use a team approach during this planning phase and keep the aspects' list updated. Prioritize the significant aspects to begin addressing opportunities to improve the organization's impact on the environment. Finally, remember to look beyond regulatory requirements and your organization's boundary when considering your organization's aspects and invite input from all interested parties.

EMS Objectives and Targets

The EMS's objectives and targets are the most important place for articulating P2 planning goals.

The EMS sets explicit goals by establishing and maintaining objectives and targets for improvement (Figure 6-4, work step 3.3). The EMS's objectives and targets are the most important place for articulating P2 planning goals. Although an organization has discretion with regard to its objectives and targets, they must be consistent with the organization's environmental policy containing a commitment to prevention of pollution that helps reinforce source reduction goals and compliance with state P2 planning laws.

Objectives—overall environmental goals that an organization sets out to achieve.

Targets—detailed performance requirements that are set and met to achieve the environmental objectives.

Again, P2 (source reduction) practices and techniques succeed best when promoted as the number one strategy for improving environmental performance and meeting attainable and measurable goals. In setting the EMS's objectives and targets, the organization must consider (1) significant environmental aspects, (2) legal and other requirements, (3) the views of external parties and societal concerns, (4) technical options and operational feasibility, (5) financial requirements for paybacks, and (6) business requirements for marketability and profitability. All of these are usually taken into consideration when P2 opportunities are being examined for inclusion in an organization's P2 plan.

In setting the EMS's objectives and targets, the organization must consider (1) significant environmental aspects, (2) legal and other requirements, (3) the views of external parties and societal concerns, (4) technical options and operational feasibility, (5) financial requirements for paybacks, and (6) business requirements for marketability and profitability.

An EMS encourages innovative P2 solutions to waste and loss problems at all levels of the organization. Documented objectives and targets of the EMS must be provided for all relevant levels and functions of the organization that impact the environment. The objectives and targets may be different for various levels of the organization such as management, plant engineer, and line supervisors and operators. The keys are consistency with the environmental policy and the inclusion of P2. The EMS standard requires organizations to set objectives and targets for reducing their environmental impacts, select activities to achieve the identified targets, and then use a continual improvement cycle to evaluate and correct the system.

EMS Training and Responsibility

The EMS requires that all employees be made aware of their environmental responsibilities and trained to exercise care when performing duties with environmental consequences (Figure 6-4, work step 3.4). Consider what type of EMS training is needed to achieve the organization's objectives and targets and integrate this training into existing environmental, health and safety, and emergency preparedness training programs. This training requirement provides the opportunity to involve all employees in P2. If the absence of correct procedures could lead to deviations from your EMS policy, objectives, or targets, the procedure or work instruction should be documented and used in training. This is an extremely important part of a successful EMS.

The EMS requires that all employees be made aware of their environmental responsibilities and trained to exercise care when performing duties with environmental consequences.

Employees will need to be trained in the procedures relevant to their roles and responsibilities for meeting the objectives and targets and in the potential results of departure from specified operating procedures. It is important to ensure that EMS internal auditors are trained and familiar with the waste management hierarchy and P2 strategies. Training will ensure that EMS objectives and targets are assessed and are being met using source reduction methods.

It is important to ensure that EMS internal auditors are trained and familiar with the waste management hierarchy and P2 strategies.

One company created a bulletin board displaying the company's policy, significant aspects and impacts, and objectives and targets of the EMS. During morning line meetings, the line supervisors went with the line team to the bulletin board and reviewed this information all the way up to the week of the ISO 14001 registration audit. This approach was excellent for several reasons: (1) it built on a system already in place, (2) the regular meeting established and reinforced the importance of knowing this information, and (3) the employees knew where to go when the auditors asked them questions about these areas of the EMS.

Often, it is the employees most familiar with the organization's production processes who are in the best position to identify P2 projects for improving environmental program performance.

By providing environmental awareness training for all employees, an organization can count on the technical know-how of employees on the production floor to help find creative P2 strategies to reduce their environmental impacts. With respect to training competency, the EMS standard asks that the organization determine what qualifications (education, training, and/or experience) are necessary and to ensure that each employee completes these requirements for his/her job. Often, it is the employees most familiar with the organization's production processes who are in the best position to identify P2 projects for improving environmental program performance. Just as an organization uses incentives to boost employee productivity, management should provide incentives for developing useful ideas to reduce waste.

Environmental Management Programs (EMPs)

The EMS is designed to continually improve system and environmental performance through creation of an environmental management program (EMP).

The EMS is designed to continually improve system and environmental performance through creation of an environmental management program (EMP). The EMP is the last element of the EMS planning phase (Figure 6-4, work step 3.5). It sets up action items, assigns responsibilities at all levels of the organization for plan execution, sets specific time lines, and determines the resources needed for implementation to achieve the objectives and targets. With the goals established, the subset of activities defined, and the accountabilities in place, each person with specific responsibilities must now develop EMPs for implementation. One person or several people are assigned the accountability for meeting the goals and objectives in the planned time frame for each task in the action plan and for maintaining the current level of performance on each of these items.

Although setting objectives and targets is treated as a separate function from EMPs in the planning phase, they are related. You have to have an idea of how you will accomplish an objective and target before you set it up as a program in your system. This is the process many organizations now use in their P2 planning effort to accomplish specific projects. After P2 assessment and planning, projects are initiated to implement technically and economically feasible P2 opportunities. Without the continual improvement component of the EMS, however, P2 planning and implementation may be an end point instead of the ongoing process of setting new objectives and targets for other aspects that impact the environment.

The number of EMPs that an organization sets up can vary. One company uses one EMP to address all of its objectives and targets.

Another company set up four EMPs for dealing with (1) all regulated aspects, (2) solid waste, (3) energy usage, and (4) PCB elimination. Finally, one company's EMPs were developed largely at the departmental level. The EMP(s) and objectives are reviewed by the team when changes occur in the organization's operations. When objectives and targets are not met, corrective actions are identified and taken.

The number of EMPs that an organization sets up can vary. One company uses one EMP to address all of its objectives and targets. Another company set up four EMPs for dealing with (1) all regulated aspects, (2) solid waste, (3) energy usage, and (4) PCB elimination. Finally, one company's EMPs were developed largely at the departmental level.

As progress is made, it should be recorded against the EMPs created. Some questions and progress can be measured quantitatively. Other questions are more subjective, but progress can still be measured. The purpose is to monitor progress on currently active EMPs and watch for slippage on implemented activities. As with any implementation review, the questions to ask are the following:

- Have the milestones been achieved?
- If not, what can be done to bring this stage of implementation back on schedule?
- What issues need to be resolved to continue our progress?

EMS IMPLEMENTATION

At present, there is a clear need for careful evaluation of how an EMS will influence an organization's environmental effectiveness. This evaluation will facilitate more informed decision-making about how best to incorporate an EMS approach into existing environmental regulatory programs and P2 planning. At this point, many organizations already have sophisticated EMSs in place and perceive little customer demand or regulatory advantage to seek full registration. Many are aligning with the standard, however, and are aware that third-party auditing may become necessary in the future.

Most organizations already have regulatory and P2 procedures including work instructions, batch sheets, training records, testing and monitoring results, controls to meet permit operating limits, and calibration instructions (Figure 6-5, work step 4.1). Build on your existing documentation whenever you can if it is appropriate. The working documents provide the detailed "how to" and step-by-step instructions needed to perform tasks. Document the system requirements to meet your business needs and keep it simple.

Build on your existing documentation whenever you can if it is appropriate.

If instructions and documentation do not add value to operational control, question whether they are needed. Not every department in the organization will need the same amount or detail in documentation. Factors that can affect the need to document procedures include the risk and complexity of the activity and the frequency and degree of supervision needed to perform the activity. Organizational teams should identify gaps in the existing documentation and initiate new procedures to ensure continual improvement.

If instructions and documentation do not add value to operational control, question whether they are needed.

Factors that can affect the need to document procedures include the risk and complexity of the activity and the frequency and degree of supervision needed to perform the activity.

Records document that the organization is doing what it said it would, and they include forms, labels, tags, logbooks, and correspondences. Important record system questions are the following:

- How will records be collected?
- Where will records be filed?
- How will records be filed?
- How will records be disposed (recycled)?

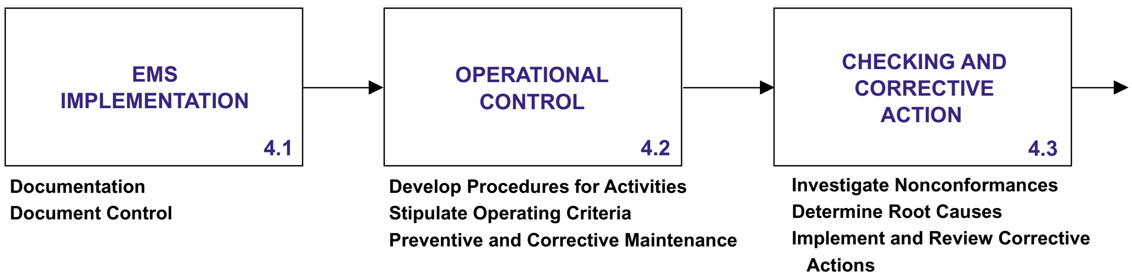


Figure 6-5. Implementation of the EMS.

Operational Control

Implementation of operational controls is the "do" part of the EMS cycle of "plan, do, check, review."

Implementation of operational controls is the "do" part of the EMS cycle of "plan, do, check, review" (Figure 6-5, work step 4.2). Procedures are instructions used by the organization for environmental system activities such as P2. They define the details of who, what, when, where, and why in the EMS activities and include some generic "how to's." This is where most organizations expend the most effort while implementing an EMS. Because procedures are extremely important, the organization will benefit from determining which procedures to document and how to best write them for guidance and training. Written procedures are an essential element of operational control if the absence of these procedures could lead to deviations from the environmental policy, objectives, and targets.

The important step for operational control is identifying activities and employee job functions that can have a potential or actual impact on the environment.

Good operational control for P2 is defined as a procedure or process within an organization that reduces multimedia wastes and conserves natural resources.

The important step for operational control is identifying activities and employee job functions that can have a potential or actual impact on the environment. Operational controls established for significant environmental impacts help the organization determine the roles, responsibilities, and authorities needed to ensure performance. You stipulate operating criteria for employees in these improved standard procedures. Large amounts of waste may be generated through improper storage practices, inefficient production start-up or shutdown, scheduling problems, lack of preventive maintenance, or poorly calibrated devices for pollution control. Good operational control for P2 is defined as a procedure or process within an organization that reduces multimedia wastes and conserves natural resources.

Process changes can result in new operational controls that reduce waste at the source, primarily during production. Good operating procedures and improved housekeeping are the simplest P2 practices. Improved housekeeping relies on using good common sense and is often the most effective first step toward waste reduction. By properly labeling materials and wastes, an organization can reduce the risk of misuse or disposal of the wrong substance. By properly separating wastes, an organization can assess the potential for reuse, recycling, or exchange of the materials. Inventory control and handling materials properly, including storage, will reduce loss of input materials and reduce expired shelf life of time-sensitive materials.

Good operating procedures and improved housekeeping are the simplest P2 practices.

Substituting less toxic raw materials may be difficult in certain situations, but it can be an efficient part of P2 operational control to reduce multimedia wastes. Changes may include equipment, layout, piping changes, use of automation, waste concentration or volume reduction, and energy conservation. Operational control ensures that equipment is working properly and avoids faulty valves or pipes leaking materials that become contaminated and a waste. Preventive maintenance procedures are designed to reduce incidents of equipment breakdowns, inefficiency, or process fluid leakage. Another important operational control is corrective maintenance, such as resetting control valves or adjusting process temperatures to increase efficiency and prevent raw material loss and waste generation.

Substituting less toxic raw materials may be difficult in certain situations, but it can be an efficient part of P2 operational control to reduce multimedia wastes.

The basic steps to success in P2 through operational control include building on existing systems, establishing procedures, assigning responsibility, determining access, communicating and training, and auditing procedures and records. These procedures are the core of a P2 program's operational phase and are often the "low-hanging fruit" that are within easy reach. Without a Systems Approach, much of the P2 "low-hanging fruit" will be lying on the ground.

Checking and Corrective Action

The checking and corrective action element in the EMS is the main focus for continual improvement (Figure 6-5, work step 4.3). Management involvement and commitment to reducing waste needs to deal successfully with checking and corrective action. P2 may benefit from closer supervision to improve production efficiency and reduce inadvertent waste generation through early detection of mistakes. EMSs ensure that nonconformances to procedures are investigated, that root causes of the nonconformity are identified, and that corrective and preventive actions are implemented, documented, and reviewed. This type of analysis leads to increased efficiency of the EMS and P2 through improved performance.

The checking and corrective action element in the EMS is the main focus for continual improvement.

As systems are put in place, it makes sense to establish measuring processes on how well the system is working, identify actual or potential problems, and act to eliminate them. This element of the EMS establishes measures of environmental performance and identifies where corrective actions are needed, if any. Organizations that have implemented an EMS have realized internal efficiency gains. Internal efficiency gains may be realized by the identification of root causes of waste and by easier access to environmental reporting information, records, and permits.

EMS MONITORING AND MEASUREMENT

The EMS standard requires procedures to monitor and measure your environmental performance, to record information that allows performance tracking of operational controls and conformance with the objectives and targets, and to evaluate compliance with environmental regulations.

Determining what to monitor and measure and what information to record is critical.

The EMS standard requires procedures to monitor and measure your environmental performance, to record information that allows performance tracking of operational controls and conformance with the objectives and targets, and to evaluate compliance with environmental regulations (Figure 6-6, work step 5.1). This element leads to success in determining real measurements that can be communicated internally or externally.

Determining what to monitor and measure and what information to record is critical. The objectives and especially the targets of the EMS are quantifiable and measurable so that progress toward achieving them can be tracked. EMS measures are used as environmental performance indicators. Legal and other requirements were considered in setting objectives and targets so monitoring of effluents and air emissions are measured and tracked. Key operational characteristics and parameters associated with significant environmental aspects are tracked and can serve as measures. Choose the number of indicators carefully—too many create information overload and an ineffective system, but too few mean you won't have enough information to make good business decisions. To ensure good measurement, the key questions to answer are the following:

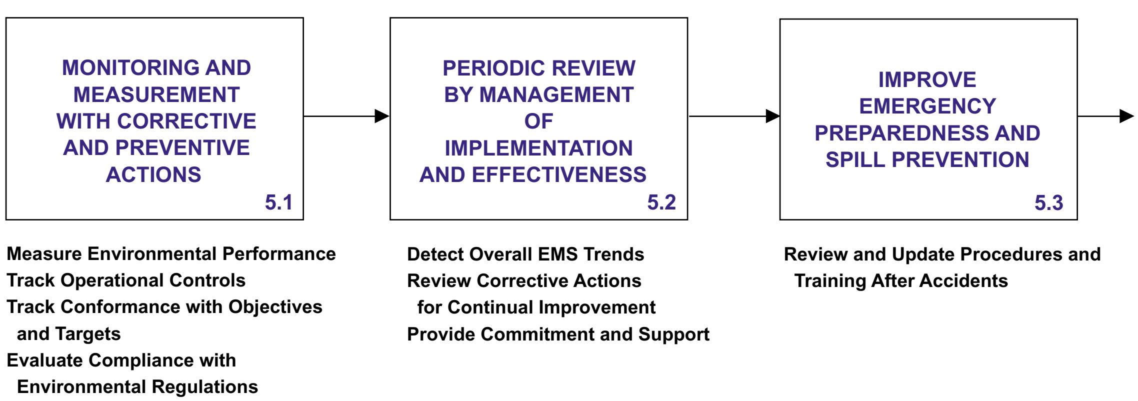


Figure 6-6. Evaluation and Management Review.

- Who is responsible for tracking, analyzing, compiling, and reporting data?
- What is the frequency of measurement for data?
- How will data be analyzed/compiled?
- How will data be reported?

Although the organization may be monitoring data on a hourly or daily basis for compliance purposes, the data will be used more strategically for the EMS. Monitoring will be used to detect overall trends and the possible need for corrective and preventive action. In this way, the organization may identify gradually declining performance and will be able to reverse it before a nonconformance, noncompliance, or other incident occurs.

Many companies are already evaluating their compliance in at least one of two ways: through compliance audits or through monitoring of regulatory permits. An environmental compliance audit compares an organization's performance with a set of environmental requirements relying largely on following a paper trail of permits, sampling data, and reports. Auditing the EMS's actual performance is different because it focuses on employees from various levels and job functions within the organization and their actions. A compliance audit compares an organization's performance to environmental requirements while an EMS audit focuses on employees and their actions.

A compliance audit compares an organization's performance to environmental requirements while an EMS audit focuses on employees and their actions.

There are two types of environmental solutions: short term to fix the immediate problem and long term to prevent the problem from recurring. The focus of the EMS and P2 is on the long-term solutions that eliminate or reduce the organization's environmental aspects and impacts. The first step to implementing a long-term solution is to develop plans that assign responsibility, determine progress dates, and designate needed resources to complete the corrective actions. If at some point the initial solution does not work, it may mean the true root cause was not correctly identified. At this point, generate new solutions and record the reason for the change.

The focus of the EMS and P2 is on the long-term solutions that eliminate or reduce the organization's environmental aspects and impacts.

Management Review and Continual Improvement

An EMS encourages a systematic approach to improving environmental procedures and performance through continual improvement. Top management periodically reviews EMS implementation and effectiveness (Figure 6-6, work step 5.2). Experience has shown that the effectiveness of management directly affects the chances of a successful EMS. EMSs are business systems that allow organizations to manage their environmental issues in a systematic, organized fashion based on continual improvement—just like any other area of business such as quality, purchasing and inventory control, accounting and payroll, and cash flow. Like these other areas, EMSs focus on top management support and commitment, accountability, employee involvement, responsibility and training, documentation, operational controls,

An EMS encourages a systematic approach to improving environmental procedures and performance through continual improvement.

EMSs focus on top management support and commitment, accountability, employee involvement, responsibility and training, documentation, operational controls, preventive actions, and periodic checking and review with corrective action.

preventive actions, and periodic checking and review with corrective action.

If a nonconformance has occurred, the responsible employees determine how to correct it and prevent it from recurring. Management review provides a broader, strategic look at the EMS and may be a source of direction on preventing nonconformance. There are many tools for developing solutions that have been discussed previously. The next step is to prioritize the solutions for possible implementation. Use of traditional business tools for prioritizing solutions can be used, such as cost-benefit analysis.

Emergency Preparedness and Spill Prevention

The EMS must include preventive actions and how to mitigate environmental impacts. Improving emergency preparedness procedures reduces accidental and material losses while maintaining or increasing productivity.

Accidents and emergency situations can create environmental impacts. Large amounts of waste may be generated through spills and lack of emergency response procedures. The EMS must include preventive actions and how to mitigate environmental impacts. Improving emergency preparedness procedures reduces accidental and material losses while maintaining or increasing productivity (Figure 6-6, work step 5.3).

Studies to implement preventive and corrective maintenance, emergency response, spill prevention, and P2 programs should be undertaken and their findings incorporated into the operational control procedures. Improved procedures can range from a change in management approach to a change in waste handling practices and must be a part of the overall emergency plan for the organization.

When it comes to developing solutions, the EMS stipulates that the corrective and preventive actions be appropriate to the magnitude of the problem and commensurate with the environmental impact encountered.

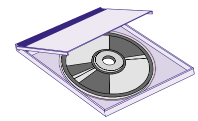
Preventive procedures should be reviewed and updated when necessary after accidents and emergency situations. When it comes to developing solutions, the EMS stipulates that the corrective and preventive actions be appropriate to the magnitude of the problem and commensurate with the environmental impact encountered. P2 can be implemented by changing existing procedures to reduce waste resulting from the cleanup of spills or leaks. Emergency plans already developed can be referenced in the overall emergency preparedness and response procedure of the EMS.

LESSONS LEARNED

The EMS is based on a documented and clearly communicated policy that includes three distinct guiding principles: compliance with applicable environmental requirements, prevention of pollution, and a commitment to continual improvement in environmental performance. In some cases, organizations' environmental policies, especially corporate policies, may have become too long and broad to be understood easily by employees and the public. An organization's EMS policy needs only to focus on the three guiding principles and to drive the accomplishment of the EMS's objectives and targets through training and involvement.

An EMS identifies, translates, and communicates applicable environmental and voluntary requirements to affected employees, suppliers, and contractors. Voluntary requirements may include those addressing P2, company or corporate initiatives, health, process safety management (PSM), and sustainable development. Health and PSM tend to be mandatory requirements of the Occupational Safety and Health Administration (OSHA). EPA's Green Lights, Climate Wise, Project XL, Design for the Environment (DfE), Environmentally Preferable Purchasing Program (Reference 6-9), and the American Chemistry Council's (ACC) Responsible Care® are examples of voluntary initiatives. Refer to the CD-ROM for more information on these programs. Standard operating procedures ensure that the employees, suppliers, and contractors can meet the EMS's requirements.

An organization's EMS policy needs only to focus on the three guiding principles and to drive the accomplishment of the EMS's objectives and targets through training and involvement.



Standard operating procedures ensure that the employees, suppliers, and contractors can meet the EMS's requirements.

Compliance with Environmental Regulation

The EMS specifies procedures for how compliance will be achieved and maintained organizationally. For example, it defines the compliance roles and responsibilities of environmental managers, establishes how they and management will be held accountable for achieving and maintaining compliance, and describes how environmental performance and compliance information will be communicated to relevant employees, suppliers, and contractors. The EMS establishes a mechanism for receiving and addressing environmental and compliance concerns raised by individuals, organizations, or other interested parties.

The EMS establishes a mechanism for receiving and addressing environmental and compliance concerns raised by individuals, organizations, or other interested parties.

The EMS includes procedures for identifying changes to applicable environmental requirements—including new ones that may apply as a result of process or material changes—and addressing these changes through the EMS process. For those organizations that are already performing environmentally, the EMS should establish objectives and targets that promote leadership and ensure continued achievement of compliance.

The EMS should establish objectives and targets that promote a leadership and ensure continued achievement of compliance.

Prevention of Pollution

Identifying all aspects and determining their significance is usually the largest gap in most organizations' current environmental systems. The EMS establishes and maintains a procedure to identify all of the environmental aspects of the organization's activities, products, and services that it controls and influences. Current procedures to identify existing process waste streams and review new customer work requests can be used as starting points for identifying all aspects. Also, a procedure to identify which of these aspects have significant impact on the environment is needed, and significant impacts must be considered in setting objectives.

Many organizations focus almost exclusively on negative environmental impacts. Positive environmental impacts are also important. These might include company-sponsored community recycling programs and household hazardous waste collection days. An EMS can develop approaches to procurement, processing, and delivery that reduce or minimize significant environmental impacts for organizations, customers, and interested parties.

An EMS establishes specific objectives, targets, and time frames for implementing P2 initiatives, improving environmental performance, and maintaining compliance.

An EMS establishes specific objectives, targets, and time frames for implementing P2 initiatives, improving environmental performance, and maintaining compliance. These should be documented and updated. An EMS ensures that the organization has skilled employees and financial and technical resources to achieve its objectives and targets and maintain compliance. In setting objectives and targets for each relevant job within the organization, it is important to consider pollution prevention goals; any additional significant impacts; legal and other requirements; technological options; financial, operational, and business requirements; and views of interested parties. These considerations are important in EMS planning and are used for capital improvement decisions, product and process design, training programs, and maintenance activities.

EMP requirements specifically include designation of responsibility for actions and the means and time frame by which the objectives are to be achieved.

The organization establishes environmental management programs (EMPs) to achieve its EMS objectives and targets. EMP requirements specifically include designation of responsibility for actions and the means and time frame by which the objectives are to be achieved. The EMP must review new activities, products, equipment, or services and address environmental changes through the EMS. For measuring performance-based improvement, targets must be quantifiable and use metrics that are related to the organization's overall goals. Most organizations have set some quantitative goals for various process waste streams, for example, reducing sludge production 10% by 2002 based on amount of wastewater treated. The EMP establishes the frequency at which the objectives and targets will be reviewed.

Continual Improvement

The EMS identifies and provides for the planning and management of all the organization's operations and activities, including facility maintenance, in order to achieve operational control and maintain compliance.

In many organizations, operational controls have been implemented for achieving waste reduction goals, although responsibility for achieving these goals has not always been designated. The EMS identifies and provides for the planning and management of all the organization's operations and activities, including facility maintenance, in order to achieve operational control and maintain compliance.

The EMS also establishes documented procedures for mitigating any adverse impacts on the environment that may be associated with accidents or emergencies.

The EMS establishes documented procedures for preventing, detecting, investigating, promptly correcting, and reporting (both internally and externally) actual and potential accidents, emergency situations, and environmental violations. The EMS includes procedures for tracking any preventive and corrective actions that are taken. If an environmental violation or accident resulted from a weakness in the system, the EMS is updated and refined, ensuring that similar situations are avoided. The EMS also establishes documented procedures for mitigating any adverse impacts on the environment that may be associated with accidents or emergencies. An EMS provides for the testing of emergency procedures when it is practicable.

EMS training programs ensure that all employees, suppliers, and contractors whose job roles may impact objectives, targets, and compliance are trained and capable of carrying out their responsibilities. The organization should evaluate competency for employees whose work may create significant environmental impacts. The organization must date and retain training records, training materials, and documents demonstrating evaluation of employee awareness and competency.

EMS documentation describes how all of the system elements will be integrated into the organization's overall decision-making and business planning process and provide direction to all relevant environmental procedures. An EMS document control system includes procedures for maintaining and protecting documents and other records as objective evidence of compliance and effectiveness. The EMS specifies retention times for environmental records in accordance with relevant laws.

An EMS document control system includes procedures for maintaining and protecting documents and other records as objective evidence of compliance and effectiveness.

Management must appoint a representative to ensure implementation and review of the EMS. The EMS requires periodic and objective auditing and review of the organization's environmental system effectiveness and compliance. Without top management review, visible involvement, and support, the EMS will not generate significant environmental improvement or better results over the current management system. This is the most important element of the EMS because management becomes a source of direction and oversees development of action items for sustainable improvement and long-term value creation. Management review promotes organizational leadership by demonstrating a commitment to environmental responsibility. The scope and frequency of the review will depend on the size and complexity of the organization's environmental impacts.

Management review promotes organizational leadership by demonstrating a commitment to environmental responsibility.

Organizations are discovering that their investments in EMSs are leading to improved environmental performance and compliance with benefits for the environment and community. An EMS provides a good method for establishing and implementing a P2 program. To achieve maximum environmental benefits, the EMS should embody the "plan, do, check, and act" model for continual improvement. This model ensures that environmental impacts are systematically identified, controlled, and monitored. The EMS helps ensure more consistency by organizations in achieving and maintaining compliance, promoting results-oriented efforts, and attaining more reliable data on environmental performance. Effective use of an EMS can be viewed as a demonstration of environmental responsibility and leadership by organizations. An EMS provides the basis for collaborating with regulatory agencies to enhance suitability and effectiveness and promote a leadership, performance-based system.

An EMS provides a good method for establishing and implementing a P2 program. To achieve maximum environmental benefits, the EMS should embody the "plan, do, check, and act" model for continual improvement.

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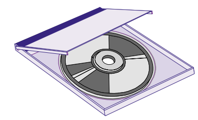


See the CD-ROM for more reading.

CHAPTER 7

Using a Quality Model to Implement P2

Includes:
- ☐ Introduction
- ☐ Seven Quality Model Criteria
- ☐ Eleven Quality Model Guiding Principles
- ☐ Five-Step Process to Improve Your P2 Plan
- ☐ Using the Quality Model to Implement P2
- ☐ Supplemental Reading
- ☐ Web Sites

INTRODUCTION

This chapter presents an approach to preparing a P2 plan that is business-oriented, while still meeting any state or local P2 requirements. P2 has sometimes suffered from its reputation as something that the environmental personnel do or direct others to do. A more effective approach is integrating P2 into your organization's core business practices. This approach allows you to communicate the value of P2 to both senior management and workers. Your P2 plan also can be maintained and improved on an annual basis. This chapter presents a proven quality model that is based on the highly successful Baldrige Quality Program.

The Malcolm Baldrige National Quality Award is bestowed each year by the President of the United States on organizations that have demonstrated proficiency in the use of this quality model. The award was established by the U.S. Congress in 1987 to raise awareness about the importance of quality and performance excellence. When this award was established, the organizers believed that quality was no longer optional for American companies but was instead a necessity for doing business in an ever-expanding and more competitive world market. Nearly 50 countries now offer awards based on the Baldrige quality model, and 43 of the 50 states in the United States offer awards based on this model.

The Malcolm Baldrige National Quality Award was established by the U.S. Congress in 1987 to raise awareness about the importance of quality and performance excellence.

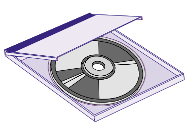
In 1998, the State of New Mexico began the Green Zia program, which adopted this quality model to measure environmental excellence. *Environmental excellence* is a term that describes the ultimate goal sought by using a quality program for environment, health, and safety (EHS) management. An environmental excellence program sets a "stretch goal" of attaining "best-in-class" status in those areas that best support a prevention-oriented approach to EHS management. No longer are short-term goals with percent reduction targets accepted by upper management and other interested parties. Results from these goal-driven activities are only "outcomes" of EHS performance and not a measure of the performance itself. Also, results by themselves offer little diagnostic value (i.e., were "good" results well below those of your competitors?). Green Zia shows an organization how to use a 15-item list of performance characteristics that can be modified to enable fast-paced EHS program improvement and thus contribute to the results. By focusing on performance, the organization can both help encourage P2 program development and provide a metric to show how effectively that P2 program is working.

In 1998, the State of New Mexico began the Green Zia program, which adopted this quality model to measure environmental excellence. Environmental excellence *is a term that describes the ultimate goal sought by using a quality program for environment, health, and safety (EHS) management.*

Using this quality model, the stretch goal can be set at **zero**—zero defects, zero inventory, zero equipment breakdowns, and zero waste. Many organizations are now extending the zero concept to EHS programs—zero incidents, zero accidents, zero wastes, zero emissions, and zero drain on world resources (sustainability). P2 is a major driving force in the quest for zero waste and zero emissions.

The Green Zia model has all the essential ingredients that make a zero waste vision possible.

The Green Zia model has all the essential ingredients that make a zero waste vision possible. First, it has criteria that define "best in class" so each organization can measure progress towards excellence. Second, it has a set of guiding principles (or core values) that must be present in order to integrate the criteria throughout the program. Third, it has a rigorous scoring system that is used by trained examiners to provide a score that represents the current state of the environmental excellence program on a 1000-point scale. Fourth, the examiners issue a feedback report detailing the strengths and weaknesses of an organization's excellence program against the criteria and guiding principles. The scoring system and the feedback reports are important tools for organizations to use in their environmental excellence programs. Organizations seek excellence, in their own way, using this model by selecting the performance elements for improvement and determining how to leverage these efforts in the organization. The P2 plan is often used to drive the program.



This chapter will first look at the criteria contained in this quality model. Next, the quality model's guiding principles will be discussed. Finally, a five-step process will be presented to show how this quality information can be integrated with the Systems Approach presented in the first four chapters of this *Guide*. You can find more readings on this topic in the reference section at the end of the chapter and on the CD-ROM that accompanies this *Guide*.

SEVEN QUALITY MODEL CRITERIA

When implementing a P2 program, it is important to keep your eye on what is important. Based on years of quality management experience, this boils down to seven criteria:

1. Leadership
2. Strategic planning
3. Interested-party involvement
4. Employee involvement
5. Process management
6. Information analysis
7. Results

These criteria form the basis for the Green Zia program and will be used in the quality model presented in this chapter. Within each of these criteria, you will need to address **how** you are working to integrate P2 into your organization. In the past, you have probably focused on **what** you were doing. This may still be important. The "how" approach will lead you to the level of P2 integration that you seek. The first six criteria show you how to drive performance that will then lead to results, something that is covered in the seventh criterion. Let's take a look at the types of "how" questions that should be asked in each of these criteria.

The first six criteria show you how to drive performance that will then lead to results, something that is covered in the seventh criterion.

Leadership. A strong top-down direction for P2 or an EMS will enhance the chances of success in the program and help integrate it into the organization as a whole. P2 will be seen as important if the top leaders support it. Two sets of issues must be dealt with in the leadership criterion:

A strong top-down direction for P2 or an EMS will enhance the chances of success in the program and help integrate it into the organization as a whole.

- How do senior leaders **communicate** their commitment to continual P2 program improvement to the employees and other interested parties?
- How do senior leaders **demonstrate** that commitment?

The time you take to keep the leaders informed and involved (i.e., "walking the talk") will help you provide answers to these important questions.

Strategic planning. Leadership most often uses some form of strategic planning to guide the organization's course. Sometimes this involves a formal strategic planning program. In other cases, the strategic planning may be much less formal. There are four basic questions that you need to address in the strategic planning criterion to attain continual P2 program improvement:

- How do you **identify** long-term and related short-term goals and objectives?
- How do you **develop** these goals and objectives?
- How do you **implement** these goals and objectives?
- How do these goals and objectives relate to your organization's overall business objective?

To be ideally situated, the P2 program must be important in the eyes of the senior leaders and be represented in the strategic planning process. There is a strong link between strategic planning and leadership.

To be ideally situated, the P2 program must be important in the eyes of the senior leaders and be represented in the strategic planning process.

Interested-party involvement. No organization operates in isolation. There are many other organizations that can have an impact on your P2 or EMS programs. Interested parties include a wide variety of different stakeholders in your P2 program such as customers, suppliers, contractors, regulatory agencies, non-government organizations (NGOs), environmental groups, community groups, and the public at

There are many other organizations that can have an impact on your P2 or EMS programs.

large. The questions that need to be considered for this criterion include the following:

- How does your organization involve interested parties in the development and implementation of your P2 program?
- How is your organization involved in other organizations' P2 programs?

The employees represent a special stakeholder position that has its own criterion.

Employees are a very important part of the P2 program.

Employee involvement. This criterion looks at the bottom-up portion of the P2 program, which is every bit as important as the top-down portion covered in the leadership category. Employees are a very important part of the P2 program, so it is important not to rely exclusively on outside experts and technical assistance to find P2 alternatives. Who knows the inner workings of an organization better than the employees? Questions that need to be addressed are the following:

- How does your organization prepare and involve employees in the **development** and in the **implementation** of the P2 program approaches?
- How are the employees' value and well-being considered in the P2 program?

Both the other interested-party and employee involvement criteria deal with the involvement of people in your P2 program. Now, you should turn to the process. In the past, this may have been the sole focus of the P2 program.

Process management concerns itself with how you manage all work processes in such a way that P2 behavior is facilitated.

Process management. This is the criterion that ISO 14001 or other EMSs can help an organization with its score. Process management concerns itself with how you manage all work processes in such a way that P2 behavior is facilitated. It is important to realize that the process management criterion includes both "things people do" and other organization work processes (e.g., manufacturing). The important questions to ask here are as follows:

- How does your organization identify the primary and supporting work processes that impact the P2 program?
- How does your organization analyze those work processes to understand their impacts and underlying causes?
- How does your organization manage all work processes to gain P2 program excellence?

This criterion is closely related to the information-analysis criterion.

Information analysis. Information analysis is the fuel of the P2 program. Paying attention to this criterion is the only way that clear results can be determined. The following three questions should be asked:

Information analysis is the fuel of the P2 program.

- How does your organization select information to assess the effectiveness of the P2 program?
- How does your organization collect that information?
- How does your organization use that information to make decisions?

This last question implies an important link to the strategic planning and leadership criteria. An organization that performs well makes sure that valuable information finds its way into the strategic planning process and is not used solely in the environmental program.

Results. This is the criterion with the greatest number of points in the quality model. Results measure the outcomes of all the performance changes and move the P2 program beyond anecdotal information and success stories to something that will link to all the other criteria. Remember that performance (i.e., the first six criteria) drive results. The two important considerations that need to be addressed in this criterion are as follows:

Results measure the outcomes of all the performance changes and move the P2 program beyond anecdotal information and success stories to something that will link to all the other criteria.

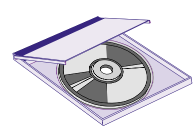
- What are your organization's planned vs. actual results related to your P2 program approach?
- What are the levels and trends as they relate to impacts on environment, other interested parties, and financial indicators?

The "how" is still involved in this criterion as you need to consider the following issues:

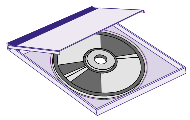
- How do you select the results you wish to track?
- How do you plan to measure them?
- How do you use the results to drive the other criteria?
- How do you trend your results for continual improvement?
- How do you trend the results of other similar organizations to benchmark your P2 program progress?

Using the Criteria

The Green Zia program makes it clear that all the criteria are linked and interrelated with the other criteria. Whenever you address one of the criteria, you need to ask how you need to leverage this by recognizing how it interacts with another criterion. The information that can be found on the CD-ROM will show many important connections between these criteria.



Another interesting fact about the Green Zia method is that there are a number of more detailed questions that can be asked within each criterion that describe what might be the best one can do (i.e., if you can answer every question in a positive manner within an example, your organization may be considered to be doing a great job in that area). A complete list of these questions can be found on the CD-ROM.



It is not important for your organization to be the best in all seven criteria areas. You will certainly do better in some than you do in others. The point is to make sure that the P2 program addresses all seven criteria in a forthright manner.

By using the proper scoring methodology, you will be able to see the areas that require more effort as you seek to improve the P2 program.

The Green Zia program assigns points to each of these criterion. These points emphasize the greater importance of results in a P2 program. By using the proper scoring methodology outlined on the CD-ROM, you will be able to see the areas that require more effort as you seek to improve the P2 program. Once you address these opportunities to improve the program using the Systems Approach tools, you can measure the amount of improvement in the overall program score. This concept will be described later in this chapter.

ELEVEN QUALITY MODEL GUIDING PRINCIPLES

You need to find a way to integrate each of the guiding principles with the proper criteria in the quality model if you wish to integrate the P2 program into the organization.

Guiding principles, often referred to as *core values*, are used to set a context for all activities in an organization. They are meant to provide guidance for decision-making at all levels in the organization. You need to find a way to integrate each of the guiding principles with the proper criteria in the quality model if you wish to integrate the P2 program into the organization. Your organization may have already published a set of guiding principles. If so, consider how P2 can be addressed within each of these areas. If your organization does not have a set of guiding principles, consider how you can introduce the following principles into the culture. Keep in mind that it may take a long time (i.e., perhaps more than two years of concerted effort) to change the culture by addressing these guiding principles in the statement of the criteria. However, once this change takes place, the P2 program will be integrated within the organization. There are 11 guiding principles that can be considered in this quality model:

1. Interested-party–driven P2
2. Leadership
3. Continual improvement and learning
4. Valuing employees
5. Fast response
6. Efficient product, service, and process design
7. Long-range view of the future
8. Management by fact
9. Partnership development
10. Public responsibility and citizenship
11. Results focus

Let’s take a look at what is meant by each of these guiding principles.

Interested-party–driven P2. P2 is judged by interested parties (i.e., customers, employees, suppliers, regulators, stockholders, the public, and the community). Thus, P2 must take into account all product and service features and characteristics that contribute value to these interested parties and lead to their satisfaction, preference, and continued interest in your organization.

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Interested-party–driven P2 is thus a strategic concept. It is directed toward organizational customer retention, market share gain, growth, and maintenance of all relationships with time. It demands constant sensitivity to changing and emerging interested-party and market requirements and the factors that drive interested-party satisfaction and attention. Interested-party–driven P2 also demands awareness of developments in technology and of competitor's offerings and rapid and flexible response to interested-party and market requirements.

Interested-party–driven P2 means much more than waste discharge and emission reduction, merely meeting regulatory requirements and specifications, or reducing complaints. Nevertheless, waste reduction and elimination of causes of dissatisfaction contribute to the interested party's view of P2 and are thus also important parts of interested-party–driven P2. In addition, the organization's success in recovering from EHS problems and waste management issues ("making things right for the interested party") is crucial to building interested-party relationships and to customer retention.

Leadership. An organization's senior leaders are the right team to set directions and create an interested-party orientation, clear and visible P2 values, and high expectations. These directions, P2 values, and expectations should address all interested parties. The leaders can ensure the creation of strategies, systems, and methods for achieving environmental excellence, stimulating innovation, and building knowledge and capabilities. The strategies and P2 values will help guide all P2 activities and decisions of the organization. The senior leaders who are committed to the development of the entire workforce will encourage participation, learning, innovation, and creativity by all employees.

An organization's senior leaders are the right team to set directions and create an interested-party orientation, clear and visible P2 values, and high expectations.

Through their behavior and personal roles in P2 planning, communications, review of P2 performance, and employee recognition, the senior leaders serve as role models, reinforcing P2 values and expectations and building leadership and initiative throughout the organization.

The term continual improvement *refers to both incremental and "breakthrough" improvement.*

Continual improvement and learning. Achieving the highest levels of P2 performance requires a well-executed approach to continual improvement and learning. The term *continual improvement* refers to both incremental and "breakthrough" improvement. The term *learning* refers to adaptation to change, leading to new goals and/or P2 approaches. Improvement and learning need to be "embedded" in the

The term learning *refers to adaptation to change, leading to new goals and/or P2 approaches.*

way the organization operates. The term *embedded* means that improvement and learning:

1. Are a regular part of daily work.
2. Are practiced at individual, work unit, and organizational levels.
3. Seek to eliminate waste at its source.
4. Are driven by opportunities to innovate and do better in the P2 program.

P2 improvement and learning include:

1. Enhancing value to interested parties through new and improved products and services.
2. Developing new business opportunities from P2 successes.
3. Reducing waste, emissions, and discharges and related costs.
4. Improving responsiveness to production and quality in waste (nonvalue added activity) reduction programs.
5. Increasing productivity and effectiveness in the use of all resources (e.g., energy, water, and materials).
6. Enhancing the organization's performance in fulfilling its public responsibilities and service as a good citizen.

Thus, improvement and learning are directed not only toward better products and services but also toward being more responsive, adaptive, and efficient—giving the organization additional marketplace and performance advantages.

An organization's P2 success depends increasingly on the knowledge, skills, innovative creativity, and motivation of its workforce.

Valuing employees. An organization's P2 success depends increasingly on the knowledge, skills, innovative creativity, and motivation of its workforce. Employee success depends increasingly on having opportunities to learn and to practice new skills. Organizations can take advantage of the workforce's potential by investing in its development through education, training, and opportunities for continuing growth. Opportunities might include enhanced P2 awareness and increased pay for demonstrated P2 awareness, knowledge, and skills. On-the-job training offers a cost-effective way to train and to better link P2 training to work processes. Education and training programs may need to utilize advanced technologies, such as computer-based learning and satellite broadcasts. Increasingly, training development needs to be tailored to a diverse workforce and to be more flexible for high performance P2 work practices.

Major challenges in the area of valuing employees include:

1. Integrating human resource practices: selection, performance, recognition, training, and career advancement.
2. Developing, cultivating, and sharing the P2 knowledge possessed by the organization's employees.
3. Aligning human resource management with strategic change processes.

Addressing these challenges requires use of employee-related data on process knowledge, skills, satisfaction, motivation, EHS knowledge, and well being. Such data can be tied to indicators of organizational or unit performance, such as interested-party satisfaction, customer retention, and productivity. Through this approach, employee contributions may be integrated and aligned with business P2 directions.

Fast response. Obtaining permits and regulatory compliance can add significant time to organizational decision-making. Success in globally competitive markets demands ever shorter cycles for introductions of new or improved products and services. Also, faster and more flexible response to interested parties is now a more important requirement. Major improvements in response time often require simplification of work units and processes together with timely incorporation of P2 into the design phase (i.e., design for the environment). To accomplish this, the P2 performance of work processes should be among the key process measures. Other important benefits can be derived from this focus on time: time improvements often drive simultaneous improvements in organizational behaviors, quality, P2, cost, and productivity. Hence, it is often beneficial to integrate response time, quality, P2, and productivity objectives.

Major improvements in response time often require simplification of work units and processes together with timely incorporation of P2 into the design phase (i.e., design for the environment).

Efficient product, service, and process design. Organizations need to emphasize P2 in the design phase—problem and waste prevention achieved through building P2 into products and services and building efficiency into production and delivery processes. P2 design includes the creation of fault-tolerant (robust) or waste-free processes and products. Costs of preventing problems at the design stage are lower than costs of correcting problems that occur "downstream." Accordingly, organizations can emphasize P2 opportunities for P2 innovation and interventions "upstream"—at early stages in processes. This approach should also take into account the organization's supply chain.

Organizations need to emphasize P2 in the design phase—problem and waste prevention achieved through building P2 into products and services and building efficiency into production and delivery processes.

The design stage is critical from the point of view of public responsibility. In manufacturing, design decisions impact the production and content of municipal and industrial wastes as well as other environmental impacts. Effective design strategies should anticipate growing environmental demands and related issues and factors.

Long-range view of the future. Pursuit of market leadership requires a strong future orientation and a willingness to make long-term com-

Major components of such a long-term P2 commitment include developing employees and suppliers as key P2 participants in the long run and fulfilling public responsibilities over this period of time.

mitments to all other interested parties. Organizations anticipate many factors in their strategic planning efforts, such as interested party expectations, new business opportunities, the increasingly global marketplace, technological developments, new customers and market segments, evolving regulatory requirements, community/societal expectations, and strategic changes by competitors. Short- and long-term P2 plans, P2 strategic objectives, and P2 resource allocations can reflect these influences. Major components of such a long-term P2 commitment include developing employees and suppliers as key P2 participants in the long run and fulfilling public responsibilities over this period of time.

P2 measurements are driven by the organization's strategy and provide critical data and information about key processes, outputs, and P2 results.

Management by fact. Organizations depend on the measurement and analysis of P2 performance. Such P2 measurements are driven by the organization's strategy and provide critical data and information about key processes, outputs, and P2 results. Many types of data and information are needed for P2 performance measurement and improvement. Performance areas should include (1) interested-party and employee satisfaction, (2) product and service offerings, (3) operations, (4) market and competitive comparisons, and (5) P2 financial benefits.

Analysis refers to extracting larger meaning from P2 data and information to support evaluation, decision-making, and operational improvement within the organization. Analysis entails using data to determine P2 trends, projections, and cause and effect—knowledge that might not be evident without analysis. Data and analysis support a variety of purposes, such as P2 planning, reviewing overall P2 performance, improving operations, and comparing P2 performance with competitors or with "best practices" benchmarks.

Organizations can better accomplish their overall goals by building internal and external P2 partnerships.

P2 partnership development. Organizations can better accomplish their overall goals by building internal and external P2 partnerships.

Internal P2 partnerships might include labor-management cooperation, such as agreements with unions. P2 agreements might entail employee development, cross-training, or new work organizations, such as worker teams. Internal P2 partnerships also might involve creating network relationships among work units to improve flexibility, responsiveness, and P2 knowledge sharing.

External P2 partnerships might be with customers, suppliers, NGOs, environmental regulatory agencies, and educational organizations for a variety of purposes, including P2 education and training. An increasingly important kind of external P2 partnership is the strategic partnership of alliance. Such P2 partnerships might offer entry into new markets or a basis for new products or services. P2 partnerships also might permit the blending of an organization's core competencies or leadership capabilities with the complementary strengths and capabilities of P2 partners, thereby enhancing overall P2 capability, including the elimination of waste from all business processes.

Internal and external P2 partners should develop longer-term waste elimination objectives, thereby creating a basis for mutual investments. P2 partners should address the key requirements for success, means of regular communication, approaches to evaluating P2 progress, and means for adapting to changing conditions.

Public responsibility and citizenship. An organization can benefit by communicating its responsibilities to the public and practicing good citizenship. These responsibilities refer to basic expectations of the organization—business ethics and protection of public health, safety, and the environment. These responsibilities apply to the organization's operations as well as the life cycles of its products and services. Organizations also can emphasize resource conservation and waste reduction at the source. P2 planning should anticipate adverse impacts from production, distribution, and transportation. The plan must provide response if problems occur and make information available and provide the support needed to maintain public awareness, safety, and confidence.

In addition to meeting all local, state, and federal laws and regulatory requirements, organizations should treat these and related requirements as opportunities for continual improvement "beyond mere compliance" or by attaining compliance through P2.

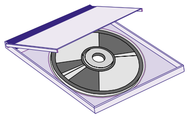
Practicing good citizenship refers to the following items: (1) improving education, (2) promoting health care in the community, (3) enhancing the local environment, (4) promoting resource conservation and recycling, (5) participating in community service, and (6) sharing nonproprietary P2 program information. Leadership as a corporate citizen also entails influencing other organizations, private and public, to partner for these same purposes. For example, individual organizations could lead efforts to help define the obligations of their industry to its communities.

Results focus. An organization's P2 performance measurements will benefit from a focus on key P2 results. Results should be focused on creating and balancing value for all interested parties—customers, employees, stockholders, suppliers, NGOs, P2 partners, and the community. To meet the sometimes conflicting and changing aims that balance implies, organizational strategy needs to implicitly include all interested-party requirements. This balance will help to ensure that P2 actions and P2 plans meet interested-party needs and avoid adverse impact on any stakeholders. The use of a balanced composite of performance measures offers an effective means to communicate short- and long-term P2 priorities, to monitor actual P2 performance, and to marshal support for improving results. It is important to remember that the first six criteria drive performance while the results criterion captures the measurement of this performance. Results in and of themselves are not performance.

An organization's P2 performance measurements will benefit from a focus on key P2 results.

Using the Guiding Principles

The criteria describe how best-in-class organizations handle each of the seven areas covered. The guiding principles show how to integrate P2 into any organization. You can learn more about how to com-



bine these quality model items by reading the Green Zia and Baldrige information on the CD-ROM. Let us now see how these items can be incorporated into a P2 Plan.

FIVE-STEP PROCESS TO IMPROVE YOUR P2 PLAN

Let's examine a simple five-step process that utilizes the quality model and the Systems Approach tools presented in the first four chapters of this guide. This process should help you integrate your P2 plan into your organization's core practices. These steps are as follows:

FIVE-STEP PROCESS

1. Plan and develop your P2 program.
2. Develop your organization's P2 opportunities.
3. Implement your revised P2 plan.
4. Maintain your P2 program.
5. Measure your progress toward zero waste and zero emissions.

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2. Develop your organization's P2 opportunities.
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4. Maintain your P2 program.
5. Measure your progress toward zero waste and emissions.

This five-step process is presented as a top-level process map in Figure 7-1. Each of these steps will be described in the following sections. You can follow along with the various process maps that were prepared to illustrate the points made in the text.

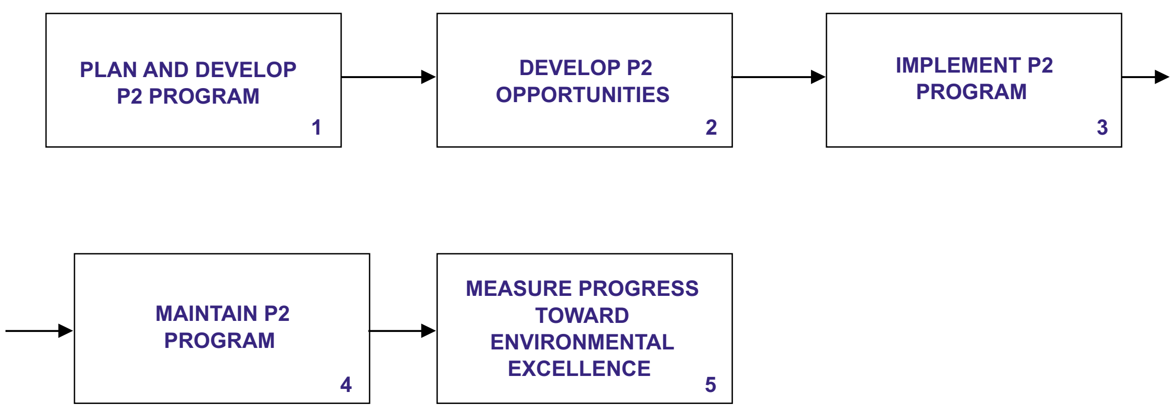
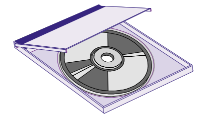


Figure 7-1. Top-level Depiction of Quality Model Approach to Pollution Prevention Implementation.

Step 1. Plan and Develop Your P2 Program

The first step in preparing a P2 program (Figure 7-2, work step 1.1) is to determine the elements of the quality model that will be addressed in the P2 planning effort. Four of the seven criteria covered in this chapter are addressed in this step: strategic planning, interested-party focus, leadership, and employee involvement. You should determine the gap that may exist between the more detailed questions that get asked in the Green Zia program for each of these criteria and what is currently going on in your organization. The Green Zia criteria questions can be found on the CD-ROM that comes with this publication. Your gap analysis should also consider how to integrate the P2 program into your core business practice using some combination of the 11 guiding principles. This step is very similar to the first step in the traditional P2 approach discussed in Chapter 5.



The consideration of the quality model criteria should not only help you make your plan more businesslike, but it should also help you better meet the requirements of any P2 planning laws.

The leadership criterion helps you prepare the management P2 policy.

The leadership criterion helps you prepare the management P2 policy. This leadership examination will look at how senior leaders actually communicate and demonstrate their commitment to continual environmental improvement and P2 to employees and to other interested parties.

The employee involvement criterion helps you prepare the employee involvement, awareness, and training requirements.

The employee involvement criterion helps you prepare the employee involvement, awareness, and training requirements. This effort looks at how the organization prepares and involves employees in the development and implementation of the P2 approaches. It also asks how the employees' value and well being are considered in these programs.

The strategic planning criterion addresses how the organization will identify, develop, and implement long-term and short-term goals and objectives for continual environmental improvement and P2.

The strategic planning criterion addresses how the organization will identify, develop, and implement long-term and short-term goals and objectives for continual environmental improvement and P2 and how these goals and objectives relate to the overall business objective.

The interested-party focus criterion determines how your organization involves all interested parties in the development and implementation of your continual environmental improvement and P2 efforts.

Finally, the interested-party focus criterion determines how your organization involves all interested parties in the development and implementation of your continual environmental improvement and P2 efforts.

In the next step (Figure 7-2, work step 1.2), the relevant processes that occur within the organization are characterized using the process-mapping tool in the Systems Approach. These maps will be used as templates for gathering information on the process. This activity helps you identify the production units that require further analysis.

Process management addresses how the organization will identify, analyze, and manage all the processes that have the ability to impact the environment or cause injury to workers.

During this work step, consideration of two other criteria is important: process management and information analysis. Process management addresses how the organization will identify, analyze, and manage all the processes that have the ability to impact the environment or cause injury to workers. Information analysis determines how the organization selects, collects, and uses information to assess the effectiveness of the program and make decisions on the basis of this information.

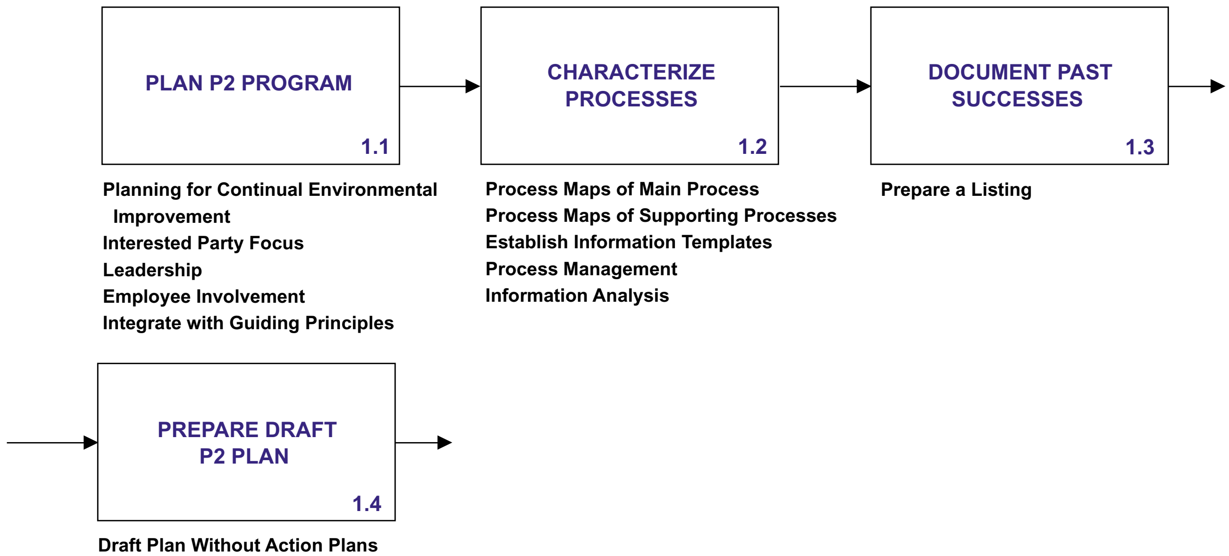


Figure 7-2. Planning and Developing a Pollution Prevention Program.

Information analysis determines how the organization selects, collects, and uses information to assess the effectiveness of the program and make decisions on the basis of this information.

You will note that six of the seven criteria and the eleven guiding principles of the quality model are incorporated into the P2 program in the first two steps. This integration should help strengthen the P2 program and integrate it into the organization's key business operations.

The third step (Figure 7-2, work step 1.3) addresses the desirability of documenting previous P2 activities. Even at the start of a P2 program, it is important to document what has been done before. The third work step examines all P2 activities that can be documented with a time frame of two to five years. Employees and management alike will be justifiably proud of these accomplishments and can build on them in this newly constituted P2 program.

Finally, after all this effort, it is time to prepare a formal P2 plan in draft form for review both internally and by the interested parties. Once the P2 action plans are prepared, the P2 plan can be finalized and distributed.

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Step 2. Develop Your Organization's P2 Opportunities

The hierarchical process maps prepared in the previous step are now used to gather information on the production units. You are now ready to develop the P2 opportunities (Figure 7-3).

In the information and analysis step (Figure 7-3, work step 2.1), every use of a toxic material represents an opportunity to eliminate that use. Every loss of a toxic material or the generation of hazardous waste represents an opportunity not to have that loss or waste. The facility will have many P2 opportunities visually depicted by the process maps. You must rank order these P2 opportunities to provide some focus to your P2 plan. Pareto analysis (also referred to as the 80/20 Rule) is used in the Systems Approach to separate the vital P2 opportunities from the “trivial many.” You may want to consider selecting between 8 and 11 opportunities for the first planning year of the program. These opportunities should be selected with a goal of completing them within that year. The P2 program needs to have some “quick wins” to help maintain the interest of management and the other interested parties. You may want to select a couple of opportunities that will take a bit longer to complete and consider them with respect to the two-year window in the planning requirements. All the opportunities that will ultimately be included in the program can also be listed at this point. Next, you will collect more information on these opportunities.

The facility will have many P2 opportunities visually depicted by the process maps. You must rank order these P2 opportunities to provide some focus to your P2 plan.

The second step (Figure 7-3, work step 2.2) begins the process of production unit analysis. For each opportunity, an employee team will work with a facilitator provided by the organization to determine the root cause for the use or loss of all resources (i.e., materials, water, and energy). They will use a cause and effect diagram to look at how materials, methods, machines (technology), and people contribute to the P2 opportunity that has been identified. This team will conduct the root cause analysis and then prepare a memorandum version of a definitive statement of the problem. The time spent by the team determining the root cause is rewarded by the generation of a higher number of

For each opportunity, an employee team will determine the root cause for the use or loss of toxic materials or hazardous waste.

The time spent by the team determining the root cause is rewarded by the generation of a higher number of alternatives.

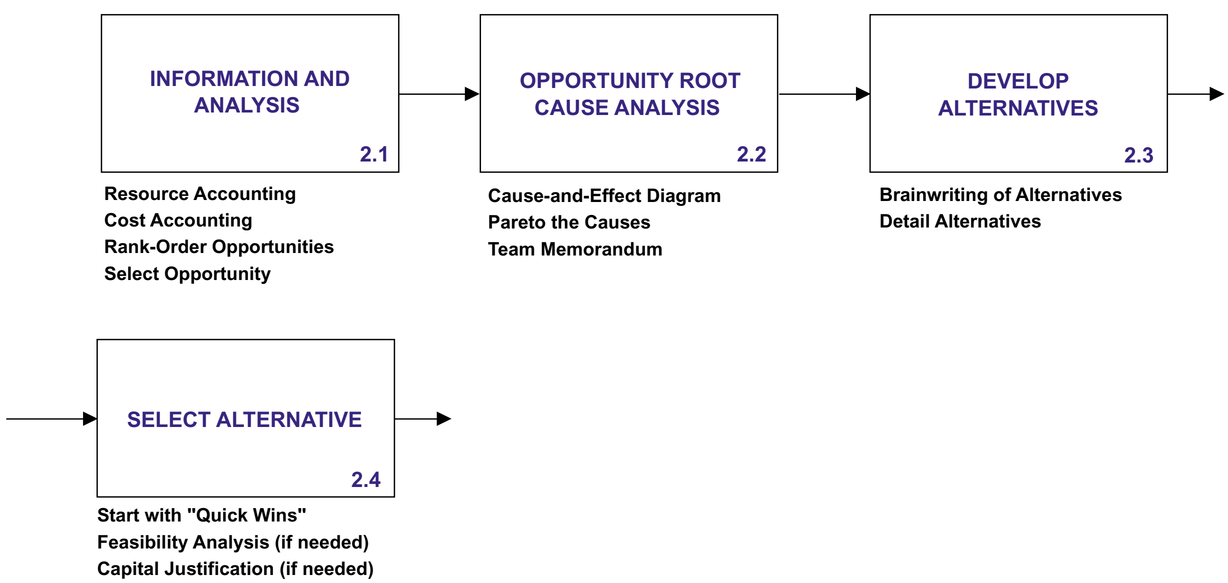


Figure 7-3. Development of Pollution Prevention Opportunities.

alternatives in the next step. Now, they are in a position to generate alternatives for realizing this opportunity by using a brainwriting tool (Figure 7-3, work step 2.3). Finally, they will select an alternative for implementation using a bubble-up/bubble-down tool (Figure 7-3, work step 2.4). These interactive problem-solving and decision-making tools will help the team gather the information needed for successful implementation and communication with management and other interested parties.

Step 3. Implement Your Revised P2 Program

The P2 program is implemented by preparing draft action plans for all the alternatives.

The P2 program is implemented (Figure 7-4) by preparing draft action plans for all the alternatives studied in the previous step. These action plans are the core of the P2 program each year and should be carefully reviewed before implementation. At this point, it is worthwhile to reconsider the relevant items in the quality model that were evaluated in the first step of the program (Figure 7-1). Recall that these criteria, as well as the guiding principles, are carefully designed to help integrate programs into core business practices. Constant effort to develop and improve on these items will keep the P2 program moving towards zero waste and emissions as a stretch goal. These criteria and guiding principles can be reinforced in the action plans and in the revisions to the P2 plan itself.

Typically, it is good to aim for 8 to 11 plans each year.

A key point, given the work done in the previous step, is employee involvement, awareness, and training. It has often been said "employees never resist their own ideas." They can become important partners in P2 when the Systems Approach is used in the program. Once all this is done, final action plans are created for implementing each P2 alternative. Typically, it is good to aim for 8 to 11 plans each year. This goal should not inhibit people from doing other P2 activities. The focus will be on the main action plans in the program. The P2 plan will provide for implementation that is subject to a P2 program oversight committee. This group should be comprised of managers and should include the organization's senior manager. The action plans should be reviewed at

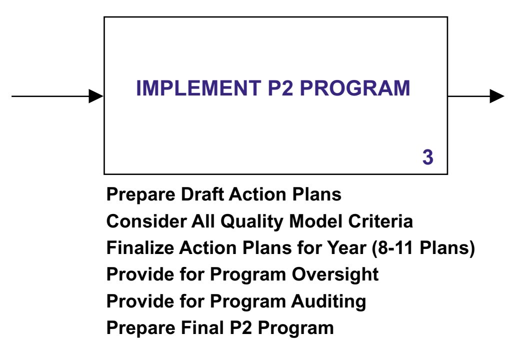


Figure 7-4. Implement the Pollution Prevention Program.

least on a quarterly basis. At the end of the year, they can be audited both internally and externally (i.e., by interested parties). The final P2 plan should now have internal plan approval and is ready for implementation.

Step 4. Maintain Your P2 Program

Once the P2 plan is implemented, it must be maintained over time (Figure 7-5). It is important to review the quality model criteria for information analysis and results. The results criterion examines your organization's real and anticipated P2 results related to your continual environmental approach to zero waste and emissions. It suggests that you consider levels and trends as they relate to impacts on the environment, worker health and safety, other interested party impacts, and key financial indicators. Managers love results and continue programs that deliver good results. Remember that "what gets measured, gets managed." P2 programs cannot survive on success stories. The information analysis criterion ensures that these results are used in running the organization and not simply sent off to the interested parties. The P2 plan must be improved with feedback received on the actual progress that is made. Each year, the sequence of preparing action plans using the Systems Approach is repeated.

Managers love results and continue programs that deliver good results. Remember that "what gets measured, gets managed." P2 programs cannot survive on success stories.

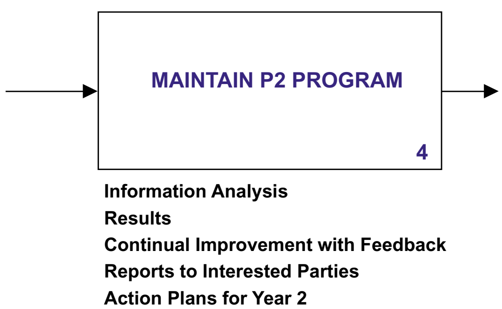


Figure 7-5. Maintain the Pollution Prevention Program.

Step 5. Measure Your Progress Toward Zero Waste and Emissions

After a few years, the P2 program can be scored in light of what it has contributed to the organization's stretch goal of zero waste and emissions (Figure 7-6). This scoring can be accomplished in a manner like the Green Zia program. It provides the ultimate scorecard for how important the P2 plan has been for the organization. Trending information helps the organization point to its accomplishments. The organization can also trend itself in comparison to other similar organizations using benchmarking techniques. This information can be used

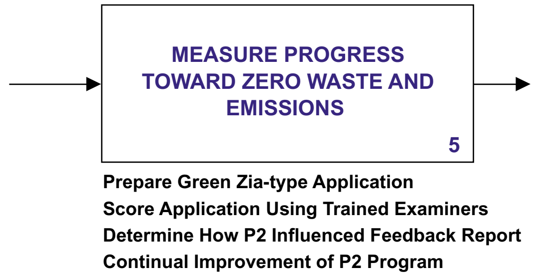


Figure 7-6. Measure Progress Toward Zero Waste and Emissions.

to continuously improve the P2 plan and other initiatives aimed at attaining zero waste and emissions.

Not only can an organization score itself, but it can also score all of its suppliers. These scores can be compared on an "apples-to-apples" basis. In this manner, the entire life cycle of a product to a customer can be scored for environmental excellence, P2, and product stewardship. Improvements can be weighed against the effect they had on the trending of these scores in time. While scoring may not be for everyone, it can be a useful tool for measuring continual improvement.

Not only can an organization score itself, but it can also score all of its suppliers. These scores can be compared on an "apples-to-apples" basis. In this manner, the entire life cycle of a product to a customer can be scored for environmental excellence, P2, and product stewardship.

USING THE QUALITY MODEL TO IMPLEMENT P2

The use of the Systems Approach and the quality model provides a means of creating a sustainable P2 plan for your organization. Is it worth the effort? If your organization already has a quality program in place, the effort is not great at all. It is likely that there is already a program in place that you can build on. The quality model criteria and guiding principles simply emphasize good business practice and should be easy to implement at any rate. Your ISO 14001, Global Reporting Initiative, CERES Principles, Responsible Care Program®, balanced scorecard, six sigma, ISO 9000, and other environmental and quality initiatives will help you score points in each of the criteria. They all help contribute to environmental excellence. This program simply provides a means of integrating these approaches with environmental performance in your organization.

Your ISO 14001, Global Reporting Initiative, CERES Principles, Responsible Care Program®, balanced scorecard, six sigma, ISO 9000, and other environmental and quality initiatives will help you score points in each of the criteria. They all help contribute to environmental excellence.

The P2 plan should be integrated with the core business practices. "Oh, that is something that the environmental coordinator is doing!"—such an attitude can only limit results. By making the P2 plan more businesslike, the possibilities for P2 within the organization and across the country are significantly enhanced.

SUPPLEMENTAL READING

"How do you measure environmental performance?" Pojasek, R.B. *Environmental Quality Management, 10(4), 2001.*

"New Mexico's Green Zia Environmental Excellence Program: Using a Quality Model for a Statewide P2 Program," 1999, Gallagher, P., Kowalski, J., Pojasek, R. B., and Weinrach, J. *Pollution Prevention Review,* 9(1): 1–14.

Green Zia Environmental Excellence Program: 2001 Program Information and Application Guidance, New Mexico Department of Environment, Santa Fe, NM, 2001.

WEB SITES

Systems Approach Tools:
http://www.Pojasek-Associates.com

Information on the Baldrige Quality Award Program:
http://www.quality.nist.gov

New Mexico Green Zia Program Information:
http://www.nmenv.state.nm.us/ (See Special Projects)

CHAPTER 8

Finding Your Own Way to Implement P2

Includes:
- ☐ Introduction
- ☐ Extent of Planning
- ☐ Leadership
- ☐ Setting P2 Goals
- ☐ Focus on Results
- ☐ Information and Analysis
- ☐ Process Management
- ☐ Employee Participation
- ☐ Focus on Interested Parties
- ☐ Guiding Principles
- ☐ P2 Program Elements
- ☐ Now It's Your Turn

INTRODUCTION

This *Guide* has presented three approaches to implementing a P2 program: traditional based, EMS based, and quality based. All three approaches can be improved by using the process characterization, problem-solving, and decision-making tools that are described in Chapter 4. Your organization may already have some type of P2 program in place. It may be seeking only to improve its existing program or may not feel that there is time to implement a brand new program following any of these three approaches. This chapter will discuss some of the items that are covered in these approaches to provide you with some ideas for planning and implementing a P2 program that is specific to your organization's requirements and culture. Let's take a look at the program elements in each of these approaches to see where they have commonality. From this analysis, the elements that your organization should strive for as it implements the P2 program may be apparent.

All three approaches can be improved by using the process characterization, problem-solving, and decision-making tools that are described in Chapter 4.

This chapter will discuss some of the items that are covered in these approaches to provide you with some ideas for planning and implementing a P2 program that is specific to your organization's requirements and culture.

We also will look at the various planning elements that were described in Chapter 3 of this *Guide* and the concept of *guiding principles* or *core values*. It will be important to see how these mesh with or remain separate from the implementation elements. The implementation elements that will be covered in this chapter are as follows:

- Extent of planning
- Leadership
- P2 goal setting
- Focus on results
- Information and analysis
- Process management
- Employee participation
- Focus on interested parties
- Guiding principles or core values
- P2 program elements

Each of these elements should be addressed in the P2 program.

EXTENT OF PLANNING

The three approaches run the full gamut of planning. You will need to determine the effort your organization wants to devote to planning as you seek to implement or improve the P2 program.

You will need to determine the effort your organization wants to devote to planning as you seek to implement or improve the P2 program.

There is some upfront planning involved in the traditional P2 program. It is modeled around assessments that are conducted in the workplace. Adding process mapping to this approach will help find more opportunities for P2. This does not greatly increase the amount of planning in the process, however. When this program was prepared in the late 1980s, many people saw a need to just get in there and get started. A program *can* be developed from these initial efforts. What happened is that the initial efforts ran out of steam, since there was no program to guide continual improvement. Once the easy issues were addressed, it was difficult for the P2 efforts to continue.

In the EMS-based implementation P2 program, much of the planning is specified in the guidance set forth in ISO 14001 or other EMS guidance documents.

In the EMS-based implementation P2 program, much of the planning is specified in the guidance set forth in ISO 14001 or other EMS guidance documents. You will recall that the EMS implementation involves employees and has action plan requirements. Also, recall that the EMS implementation includes management involvement and continual improvement. In setting the EMS objectives and targets, the organization must consider the following items: (1) its significant environmental impacts, (2) legal and other requirements, (3) the views of external parties and societal concerns, (4) technical options and operational feasibility, (5) financial requirements for paybacks, and (6) business requirements for marketability and profitability. This involves planning. Planning is very important in the EMS approach to P2. While there is no requirement that the EMS program be integrated into the strategic planning of the organization, as shown in Chapter 6 the program would be much more successful if it was so integrated.

The quality-based P2 program places more emphasis on the recognition of environmental matters in the organization's strategic plan.

The quality-based P2 program involves planning in the following areas:

1. Strategy
2. Formal action
3. Integration and implementation

This approach to P2 places more emphasis on the recognition of environmental matters in the organization's strategic plan. Even if the organization does not have a formal strategic planning capability, environmental thinking must make it into the executive suite. An entire part of the evaluation is dedicated to strategic planning. Some questions to ask of the P2 planning efforts in this regard may be found in Box 8-1. These questions, which also can be used in the traditional and EMS approaches, can help align the P2 program with the strategic thrust of your organization. Any progress made in this direction will help integrate P2 into mainstream activities.

Box 8-1. Questions to Ask About the Planning Component

strategic planning

Consider strategic planning for environmental improvement as you ask the following questions (Reference 8-1). These questions are designed to ask "***how***" so that you can compare your organization's performance to others.

How does your organization:

- Use information from the environmental management system in other organizational planning initiatives?
- Consider the long-term environmental impact of the business on its quest for sustainability?
- Anticipate and mediate external environmental impacts?
- Include employees in environmental planning?
- Involve vendors, suppliers, customers, and others?

action planning

Consider formal action planning as you ask these questions:

How are:

- Formal action plans developed to support process analysis and improvement (P2) efforts?
- Employees included in the development of action plans?
- Suppliers, vendors, customers, and other interested parties included in the development of action plans?
- Action plans assessed and improved on from year to year?

integration and implementation with other organizational programs

To determine if your P2 program fosters integration and implementation with other organizational programs, ask these questions:

How are:

- Action plans implemented, tracked, modified (for continual improvement), and communicated to all interested parties?
- The action plans linked to the strategic planning process of the organization?
- Resources aligned to support improvement (P2) efforts?
- All the results from the programs disseminated to support organizational learning and improvement of the environmental management process?
- Environmental management processes formally maintained and improved?

The quality-based P2 approach and the EMS approach require written action plans. The EMS-based approach requires environmental management programs (EMPs) as written action plans. These documents are used to track progress made during the year on all scheduled P2 projects and activities. They are auditable by independent third parties. The Systems Approach tools help gather the information needed for comprehensive action plans. At the end of the year, it is possible to perform a "lessons learned" review of each of the action plans or EMPs and a decision can be reached on what to do in the following year.

It is important that P2 activities not be restricted to the environmental professionals in an organization.

The final aspect of the quality- and EMS-based P2 approaches is the actual integration and implementation of P2 activities with other organizational programs. It is important that P2 activities not be restricted to the environmental professionals in an organization. Employee teams from different departments need to be involved. The oversight committee should be composed of senior managers representing different functions within the organization. Whenever possible, it is prudent to look at their planned activities to see which ones have potential for P2 involvement. In this manner, the planned integration will be much more effective.

An emphasis on planning is important no matter which approach your organization uses. Although your organization may choose not to have planning dominate your P2 program's implementation, you should seek to improve your planning efforts each year by asking the questions provided and enhancing the program incrementally. Your organization could gradually increase the level of planning by answering those questions. In this manner, your organization will be integrating the P2 program into the core business practices.

LEADERSHIP

All the implementation models presented require a policy statement that is endorsed by the top management of the organization.

All the implementation models presented require a policy statement that is endorsed by the top management of the organization. Some important differences exist, however.

In the traditional approach, a "top-down" focus was encouraged. Management approval was sought before the P2 program was started. This commitment to the program was communicated to the workforce using the policy statement. Management names the P2 task force. Although management often saw P2 reports and success stories, this information loop sometimes did not provide for strong support for continual improvement.

The EMS-based Implementation Approach also seeks to have top management periodically review EMS implementation and effectiveness. Experience has shown clearly that program success is largely dependent on maintaining the involvement of senior management. The EMS is a management system that allows organizations to address the environmental issues in a systematic, organized fashion based on continual improvement—just like any other area of the organization. The EMS approach described in this *Guide* focuses on all management issues, including attainment of objectives, completion of corrective actions, effectiveness of policy, and cost-driven targets.

Leadership is encouraged in the quality-based P2 approach by recognizing the importance of both senior leadership and community leadership.

Leadership is encouraged in the quality-based P2 approach by recognizing the importance of both senior leadership and community leadership. Senior leaders must demonstrate a commitment in this approach. Refer to the questions in Box 8-2 to see how to reach best-in-class status in this area. Striving to get positive answers to these questions will help the organization improve the management component of the P2 program.

How *does senior management demonstrate commitment to continual environmental improvement on par with other major organizational goals?*

Box 8-2. Questions to Ask About the Leadership Component

How does senior management:

- Demonstrate commitment to continual environmental improvement on par with other major organizational goals?
- Conduct proactive communication with all interested parties?
- Provide support for continual environmental improvement?
- Assure that continual environmental improvement is integrated, reviewed, and tracked?

Ask these questions about the community leadership components of the P2 program and ***how*** your organization accomplishes the following tasks.

How does your organization:

- Initiate and support environmental protection and sustainability efforts in the community?
- Seek to understand environmental issues specific to the community and address those issues with strategies, actions, and collaborative efforts?
- Support mentoring of other organizations in the community to promote P2 and continual improvement?
- Set affirmative procurement goals?
- Communicate your environmental performance to the community?

community leadership

Many senior managers also recognize the importance of being a good corporate citizen in the local community. In the quality approach, good corporate citizenship goes beyond giving to local charities. The P2 ideals of the organization need to be promoted to all the local interested parties as a demonstration of the senior leadership's commitment to these ideals.

Senior leadership must "walk the talk" to provide true leadership to the P2 program.

Senior leadership (i.e., those people to whom the environmental manager reports) must "walk the talk" to provide true leadership to the P2 program. A good "bottom-up" program with a results focus may help senior management go this extra distance. The literature on quality improvement and change management stresses the importance of having serious commitment from top management. Finding a way to gain this advantage will promote the implementation of your organization's P2 program.

The literature on quality improvement and change management stresses the importance of having serious commitment from top management.

SETTING P2 GOALS

In the traditional approach, the purpose of the P2 program is to meet these pre-set goals.

The EMS approach selects significant aspects and sets objectives and targets after studying the environmental impacts of the organization's activities, products, and services. Objectives are the overall environmental goals that an organization sets out to achieve.

In the quality-based P2 approach, the goals are not formally set until after the action plans are prepared.

Many believe that stretch goals of zero waste and emissions are best since it will take both continual improvement and some breakthrough thinking to get there.

In the traditional approach, senior management sets the goals for P2 *before* any formal information is gathered. This is based on the philosophy of "management by objectives." The purpose of the P2 program is to meet these pre-set goals. Much of the literature on goal setting supports this approach.

The EMS approach selects significant aspects and sets objectives and targets after studying the environmental impacts of the organization's activities, products, and services. Objectives are the overall environmental goals that an organization sets out to achieve. Action plans (EMPs) are written to meet the goals and objectives in the planned time frame.

In the quality-based P2 approach, the goals are not formally set until after the action plans are prepared. Each action plan has performance goals set for each step. The sum of the performance goals listed in the action plans are the goals for the period of time set forth in the planning sequence (i.e., typically one year). It is possible to have some action plans cover a longer time span, so that two-year goals can be set. It is important to set only continual improvement goals. Many believe that stretch goals of zero waste and emissions and continual improvement will increase the likelihood that significant strides will be made.

FOCUS ON RESULTS

Results will demonstrate whether goals have been met. Continual improvement is based on careful measurement and trending of the actual results. Maintaining top management support is based on achieving these results. A focus on results is an important part of any P2 program.

The traditional approach involves the collection of results from the various P2 activities and placing them into reports that are prepared for each effort. Sometimes the results are plotted, such as reduction in the use or emissions of certain regulated chemicals. In some cases, financial savings are given.

The EMS approach requires procedures to monitor and measure environmental performance, to record information that tracks operational controls and conformance with the objectives and targets, and to evaluate compliance with environmental regulations. Top management reviews these results on a periodic basis.

In the quality-based P2 approach, results represent the most important element. It is weighted with nearly one-third of the total evaluation points provided in the seven categories. Results are segmented into three items: environmental results; customer, supplier, employee, and other results; and financial results. The environmental results look at current levels and trends just as the other approaches do. The second segment of the results summarizes customer, employee, community, supplier, market, and other interested-party results within the context of the continual environmental improvement approach. In other words, how is their perception of your organization's environmental excellence changing? The third segment of the results summarizes the financial performance results related to the implementation of your continual environmental improvement approach.

The organization's results need to convey levels (the current level of environmental performance reported graphically), trends (multiple data points presented graphically), and comparative data (how your organization is performing with respect to similar organizations). It may take a few years to build strong results, but it is an important means of improving your organization's P2 program. The link between environmental and financial results is very important. All environmental results can be "translated" into financial results. This is the best means available to get and maintain top management leadership in the P2 program. Make establishing this connection a priority as you plan a new P2 program or seek to improve an existing one.

The link between environmental and financial results is very important. All environmental results can be "translated" into financial results. This is the best means available to get and maintain top management leadership in the P2 program.

INFORMATION AND ANALYSIS

It is necessary to examine how your organization uses information in order to identify and evaluate environmental aspects of products, services, or production processes. It is also important to determine how this information is used to assess service, product, or process performance and to identify areas for improvement (i.e., P2 opportunities) based on environmental considerations.

It is important to determine how this information is used to assess service, product, or process performance and to identify areas for improvement (i.e., P2 opportunities) based on environmental considerations.

Most of the information in the traditional approach comes from assessments performed in the workplace. Checklists are often used to gather information for the analysis of each P2 project. Everything is usually handled on a project-by-project basis.

In the EMS approach, information is gathered on the aspects of the organization and analyzed on a general level to determine the significant environmental impacts and to set EMS objectives and targets. Further information is required for each of the environmental management programs. Documentation is maintained in the EMS to track information and make it available for analysis. This is an important element in the quest for continual environmental improvement.

In the quality-based P2 approach, information and the analysis of that information play a pivotal role in the program. The information and the results should be linked and used in the planning efforts. Management can use these items to make P2 a central issue in the day-to-day operation of the organization.

In Box 8-3, there are some questions that may help determine how information is collected and analyzed in the P2 program.

Box 8-3. Questions to Ask About the Information and Analysis Component

How does your organization:

- Measure resource use efficiency and environmental losses?
- Determine environment, health, and safety requirements?
- Understand the true cost of a product, service, or production process?
- Determine the environmental impacts of a product, service, or production process through its life?
- Use information to document organization-wide environmental activities?
- Track your competitors' "green" trends and use this data in product design?
- Analyze information to prioritize areas for improvement?
- Use information and results to identify organization-wide areas for improvement (e.g., P2 opportunities)?
- Use comparative information to assess and improve its environmental performance (i.e., benchmarking)?
- Evaluate competitors and market trends in the formulation of its environmental strategies?

For the program to be results-driven, there will have to be an organized means for managing information and analysis in your P2 program.

For the program to be results-driven, there will have to be an organized means for managing information and analysis in your P2 program. The tools in Chapter 4 provide some order to the program and a good starting point. By selecting more items from the questions, you can drive continual improvement.

PROCESS MANAGEMENT

The traditional approach is project-based and does not place a great deal of emphasis on process. Assessments are used to locate opportunities for P2 and a project is set forth to minimize or prevent waste at that location. These assessments may not find other points at which the P2 opportunities can be leveraged. Furthermore, the assessments may not involve the institutionalization of P2 by changing the process of environmental management.

On the other hand, the EMS- and quality-based approaches emphasize process; both ask the type of questions that can be found in Box 8-4. A strong EMS is a vital component of the quality-based P2 approach and will help the organization attain a maximum number of points in this criterion.

Process mapping and resource accounting as described in Chapter 4 help measure and report the results of reducing your environmental impacts. The organization will benefit by addressing the issue of process management when implementing the P2 Program. Using the Systems Approach tools will provide a head start in this direction.

Box 8-4. Questions to Ask About the Environmental Process Management Component

How does your organization:

- Conduct analysis of all pertinent processes to identify environmental issues (aspects)?
- Involve employees, customers, and suppliers in process analysis?
- Use its environmental management system to manage processes in day-to-day operations?
- Conduct process analysis of corrective actions or other nonoperational problem areas?
- Improve its process analysis system?
- Systematically prioritize areas for continual improvement?
- Develop action plans to improve processes?
- Involve employees, customers, and suppliers in identifying and implementing process improvements?
- Manage processes to meet or exceed environmental performance goals?
- Communicate information on improvement projects to ensure organizational learning?
- Use benchmarking as part of ongoing process improvement activities?
- Improve its process improvement system?

EMPLOYEE PARTICIPATION

All approaches include employee involvement. Both the EMS- and quality-based approaches address employee education and skill development. The quality-based approach also emphasizes employee satisfaction and well being. As more and more organizations address the issue of sustainable development and its focus on the social aspects of environmental issues, it will become more important to pay attention to the well being of the employees.

Having a P2 policy statement hanging on the wall does not ensure that the employees will be able to participate effectively in the program.

It is always informative to walk around a facility and randomly ask employees what they know about the organization's P2 program. Having a P2 policy statement hanging on the wall does not ensure that the employees will be able to participate effectively in the program. Whenever an organization undertakes a new management program, quite a bit of time is spent preparing the employees for participation in that program. It makes sense that the same would hold true for P2.

Box 8-5 lists some questions to ask about employee participation in a P2 program.

Employee involvement plays a key role in any successful P2 program, so it is important to be diligent in promoting it.

Employee involvement plays a key role in any successful P2 program, so it is important to be diligent in promoting it.

Box 8-5. Questions to Ask About the Employee Participation Component

How does the organization:

- Assess employees' skills and determine and align their training needs to the continual environmental improvement approach?
- Promote employee input to the training program to improve environmental performance?
- Use the training program to encourage employees to share and disseminate the ethic of environmental excellence outside of the workplace?
- Assess and improve its environmental training program ?
- Involve employees in product, service, and process design for continual environmental improvement?
- Encourage and support broad employee involvement in P2 programs?
- Involve employees in the development of action plans and align human resources to implement action plans?
- Ensure that employees are up to date about the organization's P2 successes?
- Encourage employee participation to address specific community environmental issues?
- Consider the inside work environment (i.e., employee health and safety concerns) when designing work areas or making process improvement decisions?
- Gather input on the work environment from employees?
- Motivate and reward employee participation in the organization's environmental improvement program?
- Assist employees in dealing with life issues that can impact their ability to do work?
- Assess employee satisfaction?

FOCUS ON INTERESTED PARTIES

The EMS- and quality-based approaches clearly recognize the importance of having ties with regulators, customers, suppliers, and a host of other interested parties. The traditional approach provides for technology transfer, but it does not seek feedback on environmental concerns of the interested parties.

By addressing the questions asked in Box 8-6, your organization can move in the direction of involving interested parties in the P2 program. Some organizations have already begun to extend their EMS program to the supply chain. It is logical to extend this involvement to the P2 program as well. Customers need to see decisions regarding the products and services in light of what the environment, health, and safety implications may be throughout the life cycle. Other interested parties need to see how their actions affect the organization's ability to effectively implement and integrate P2 into its core business practices.

Some organizations have already begun to extend their EMS program to the supply chain. It is logical to extend this involvement to the P2 program as well.

Box 8-6. Questions to Ask About the Other Interested-Party Component

How does your organization:

- Communicate with customers to assess their needs and satisfaction regarding the environmental impact of products and services?
- Solicit and use customer feedback for environmental improvements?
- Work with customers to encourage effective product and environmental stewardship?
- Support the P2 and continual environmental improvement efforts of customers?
- Market "green" products, services, and processes?
- Develop markets for new and/or "greener" products and services?
- Involve suppliers, contractors, and vendors in the development and improvement of products, services, and processes as part of the continual environmental improvement program?
- Evaluate suppliers, contractors, and vendors for their environmental performance?
- Support the P2 or environmental improvement efforts of suppliers, consultants, contractors, and vendors?
- Work with oversight agencies to manage compliance in a mutually beneficial fashion?
- Communicate continual environmental improvement goals and action plans to interested parties to gain feedback, support, and buy-in?
- Develop systematic processes for timely reporting of reportable events/activities to appropriate interested parties?
- Work with oversight agencies to develop regulations and compliance approaches that encourage P2?
- Provide a regular, independent evaluation of successes made in the program?
- Communicate results to interested parties?

P2 cannot be thought of as a strictly internal matter. It is becoming much more important to consider other interested parties when conducting a P2 program.

P2 cannot be thought of as a strictly internal matter. It is becoming much more important to consider other interested parties when conducting a P2 program.

GUIDING PRINCIPLES

Unlike the traditional approach, the EMS- and quality-based approaches seek to align the P2 program with the organization's guiding principles or core values. Many experts feel that guiding principles are essential to the successful integration of P2 into core business practices. The guiding principles that are presented in Chapters 6 and 7 are as follows:

1. Interested-party–driven P2
2. Leadership
3. Continual improvement and learning

4. Valuing employees
5. Fast response
6. Efficient product, service, and process design
7. Long-range view of the future
8. Management by fact
9. Partnership development
10. Public responsibility and citizenship
11. Results focus
12. Prevention of pollution
13. Compliance with legal requirements

The guiding principles are used to drive the P2 program's objectives and targets.

P2 PROGRAM ELEMENTS

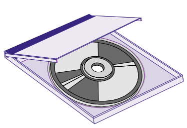
The six program elements for a P2 program using any of the approaches have a number of now-familiar items:

- Provide for top management support
- Characterize the process
- Perform periodic assessments
- Conduct program evaluations

Each of these items is covered in the implementation chapters (Chapters 5-8).

Two crucial program elements require consideration as you develop or seek to improve the P2 program. These are:

1. Maintaining a cost allocation system
2. Encouraging technology transfer

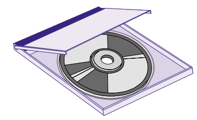


The importance of communicating with top management in financial terms is quite clear. It is important to determine the real cost of all resource use and loss in the process (including all ancillary and intermittent processes). It is important to translate environmental performance measured in volume and weight into financial terms. Some basic information on this topic can be found in Chapter 4. Additional material on this and on EPA's Environmental Accounting Project is available on the CD-ROM. The quality-based P2 approach scores the ability to evaluate costs effectively. In most cases, this evaluation is required to get and maintain top management approval for the program.

Technology transfer is very important to the propagation of P2. The Baldrige program requires winners of the award to go out and speak about what it takes to be successful with this program. Many winners give more than 100 speeches the year after they win. The EMS approach encourages organizations to mentor suppliers and contractors. Both approaches willingly share their successes so others can follow.

NOW IT'S YOUR TURN

This *Guide* has presented a number of useful P2 implementation approaches. It is up to your organization to use them and get started with a program that will work in your organization. The CD-ROM will provide you with the information needed to move forward.



This *Guide* was *not* written to provide a "one-size-fits-all" formula for starting or improving a P2 program. Its intention is to spark some ideas and provide tools that you can use to successfully complete your organization's mission.

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U.S. DEPARTMENT OF ENERGY

MODEL POLLUTION PREVENTION OPPORTUNITY ASSESSMENT GUIDANCE

Prepared under the direction of

U.S. Department of Energy
Office of Defense Programs

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United States Department of Energy
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TABLE OF CONTENTS

APPENDIX

FIGURES

LIST OF ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygienists
DOE	Department of Energy
EPA	Environmental Protection Agency
ES&H	Environmental, Safety, & Health
MNCAW	Materials Not Categorized As Waste
MSDS	Material Safety Data Sheet
NPDES	National Pollutant Discharge Elimination System
ODC	Ozone Depleting Compound
OSHA	Occupational Safety and Health Administration
PCB	Polychlorinated biphenyl
PM/WSL	Priority Material/Waste Stream List
POTW	Publicly Owned Treatment Works
PPOA	Pollution Prevention Opportunity Assessment
PWA	Process Waste Assessment
VOC	Volatile Organic Compound
WMin/PP	Waste Minimization/Pollution Prevention

ACKNOWLEDGMENT

In July, 1988, DOE Defense Programs recognized the need for a waste minimization program that would focus beyond pollution control and the traditional media-by-media approach to containment and treatment of environmental releases. Defense Programs was proactive in initiating a Waste Minimization Program that included the completion of process waste assessments as a means to identify opportunities which would reduce the generation of waste.

The Waste Minimization Program evolved to a Pollution Prevention Program through the auspices of the DOE Defense Programs' Pollution Prevention Strategic Plan issued in April, 1992. The Strategic Plan reiterated the hierarchy of preferred environmental practices outlined in the Pollution Prevention Act of 1990 (i.e. source reduction, recycling, treatment, and finally, disposal).

The first Model PWA Guidance was assembled by Defense Programs' contractors based on the published EPA guidance and previous work performed at the Y-12 Plant. The manual was originally issued in February 1990, and distributed throughout the Weapons Complex. This is the first revision to the document, and it replaces the term "PWA" with a more positive term, "Pollution Prevention Opportunity Assessment". The new term avoids the implication that assessments should be limited to process wastes, rather, they should address all releases.

The following DOE personnel and DOE contractors assisted in the suggestions for this revision. Their time and effort were greatly appreciated.

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A point of contact has been established in the DOE complex for Pollution Prevention Opportunity Assessments. If you are in need of training, assistance, and/or methodology, call or fax your requests or questions to the following:

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I. INTRODUCTION

A. PURPOSE OF GUIDANCE

The purpose of this document is to provide a guide for DOE sites to conduct pollution prevention opportunity assessments (PPOAs), commonly known through the DOE as process waste assessments (PWAs). This will avoid the implication that assessments should be limited to process wastes - PPOAs address all releases. This guidance describes those activities and methods that can be employed to characterize all waste generating processes and identifies opportunities to reduce or eliminate waste generation. The document also includes a methodology to evaluate proposed modifications to site processes and other options to minimize waste and prevent pollution.

B. GUIDANCE SCOPE AND OBJECTIVES

PPOAs will be conducted as part of an ongoing program to identify opportunities to eliminate or reduce the generation of waste. A PPOA documents the amount of material that is disposed of as waste during operations. It provides a summary of material usage, process by-products, and waste generation; and it targets those processes and operations that need to be improved or replaced to promote waste minimization and pollution prevention. The assessment also establishes a basis to prioritize modifications to site processes or other pollution prevention options that are developed during the assessment.

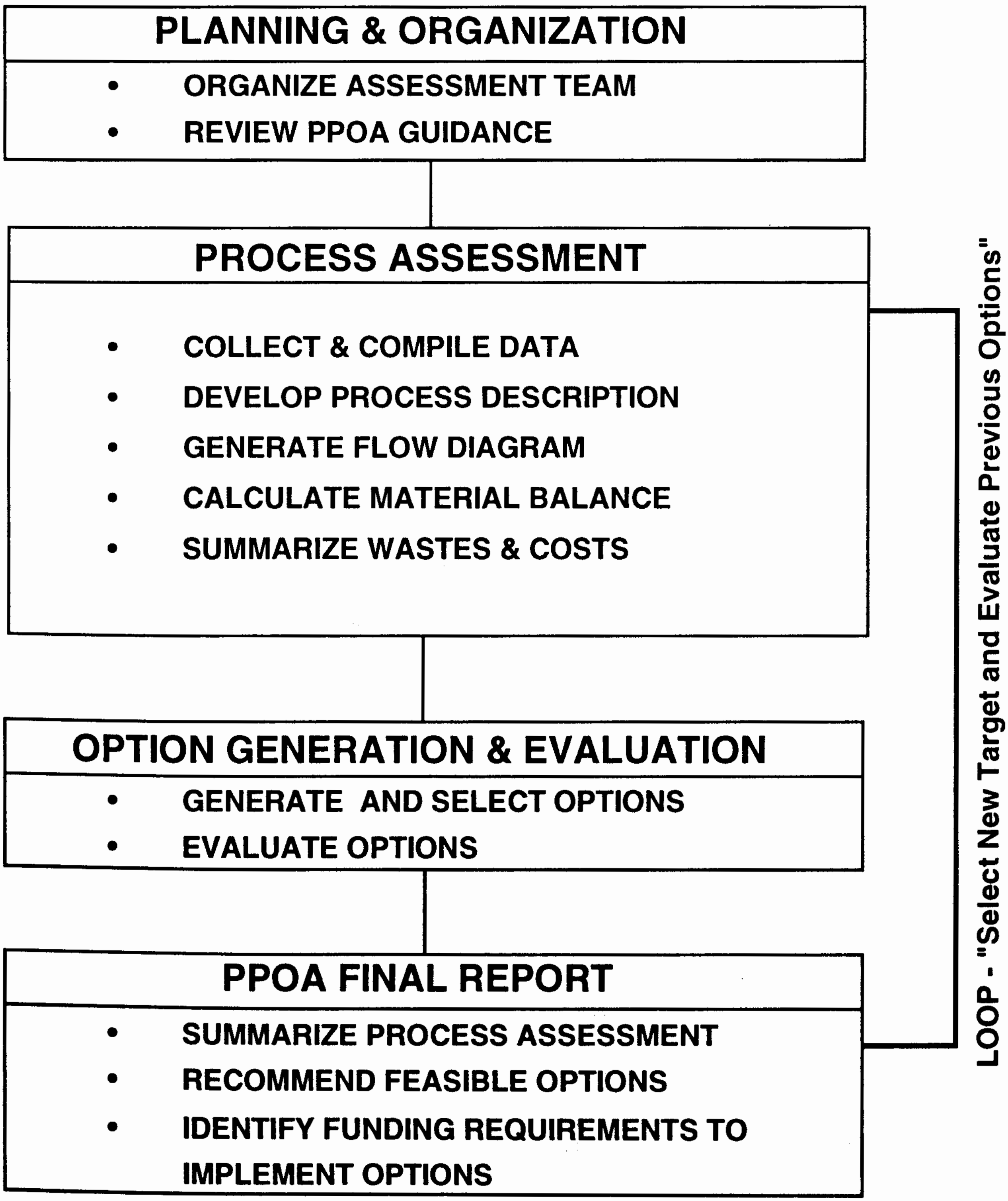
The objective of a PPOA is to document a facility's processes, operating procedures, and waste streams in a manner that will permit the identification of the best improvements to avoid or minimize waste generation. This guide shall not be used as an audit tool. The assessment consists of a systematic approach which may include the following:

- GRADED APPROACH LEVEL DETERMINATION
- ORGANIZATION OF PPOA TEAMS
- ASSESSMENT OF PROCESSES AND WASTE STREAMS
- DEVELOPMENT AND EVALUATION OF POLLUTION PREVENTION OPTIONS
- RECOMMENDATIONS OF POLLUTION PREVENTION OPTIONS & FINAL REPORT

A step-by-step process for completing a PPOA is shown in Figure 1. These steps are sequential and should be performed in that order for best results.

POLLUTION PREVENTION OPPORTUNITY ASSESSMENT FLOW CHART

FIGURE 1



II. GRADED APPROACH

A. INTRODUCTION

The DOE Complex is comprised of numerous sites located in many different states. These facilities range from single-mission to multiple-disciplinary facilities, and vary in size from quite small to very large. The facilities as a whole represent a tremendous diversity of technologies, processes and activities. Due to this diversity, there is also a wide variety and number of waste streams generated. Many of these waste streams are small and intermittent, and not of consistent composition. The value added of detailed analysis for individual, small waste streams is often not sufficient to justify the cost, nor is the analysis necessarily meaningful since many of these waste streams are constantly changing.

Although waste minimization activities have been implemented at DOE sites, these efforts are not being sufficiently documented. A DOE survey of PPOA activities across several sites indicated that these waste minimization practices need to be documented so that waste generation baselines can be more accurately established. Furthermore, the documentation can ensure that the site receives credit for accomplishing waste minimization.

The PPOA Graded Approach addresses these complexities and recognizes that processes vary in the quantity of pollution they generate, as well as in the perceived risk and hazards associated with an operation. It also recognizes the variance due to the cost and function of the final product. Therefore, the graded approach is intended to provide a **cost-effective** and **flexible** methodology which allows individual sites to prioritize their local concerns and align their efforts with the resources allocated, while also providing some consistency throughout the DOE to perform PPOAs. In order to achieve this, the approach has defined three levels of effort to satisfy the requirement of completing a PPOA. This section documents the minimum amount of effort required, Level I, Activity Characterization, and provides a systematic approach using the Weighted Sums Evaluation to determine if additional and more detailed analysis should be conducted for either a Level II, Informal Assessment, or a Level III, Formal Assessment.

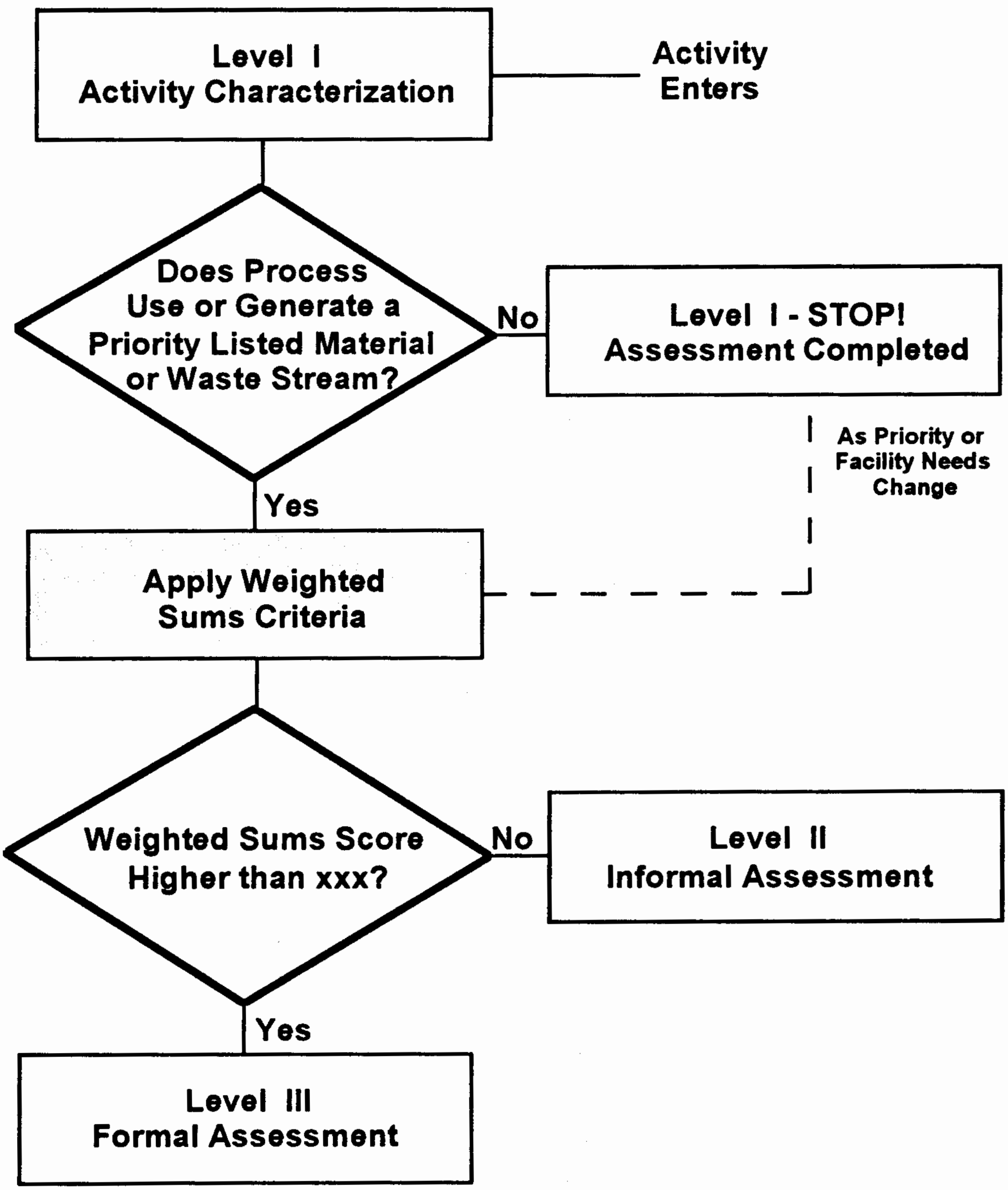
If used properly, the graded approach will allow a site to concentrate its shrinking resources on the most important waste problems first. While all of the site's waste streams and processes will be assessed, the most critical areas will be assessed first and to the greatest extent.

B. GRADED APPROACH LOGIC DIAGRAM & PRIORITY MATERIAL /WASTE STREAM LIST

Figure 2, the Graded Approach Logic Diagram, illustrates graphically how the graded approach methodology works. The diagram starts at the top with the Level I, minimum effort assessment and works down to an informal and/or formal assessment. The methodology shown in the logic diagram allows flexibility and provides a consistent

FIGURE 2

Pollution Prevention Graded Approach Logic Diagram



structure. A site must develop the priority material / waste stream list (PM/WSL) to use the graded approach. This list is not limited to the requirements specified below but can include any other additional concerns. (See Appendix A for an additional list of considerations.) The priority list provides the site an opportunity to identify their individual regulatory and/or prioritized needs to cost-effectively determine if additional, more detailed analysis is necessary. DOE has established requirements and suggestions for this list as follows.

PRIORITY MATERIAL / WASTE STREAM LIST

Required or Mandatory PM/WSL:

- Waste of any amount for which an approved disposal method does not exist (i.e., mixed wastes, classified waste, etc.)
- Waste which is equal to 5% or more of the facility's total waste stream (Total waste = Manifest records (Hazardous) + Radioactive + Mixed)
- Clean Air Act, Class I Materials (ODCs - Ozone Depleting Compounds)
- EPA's 33/50 Materials
- Known Human Carcinogens (ACGIH, Type 1)

Suggested Additions to PM/WSL:

- Federal, State, & Local Requirements
- Permitted Waste & Materials (e.g., VOCs, NPDES, POTW, etc.)
- Site Health Risks for Hazardous Materials & Hazardous Wastes (e.g., OSHA - Suspect carcinogens, teratogens, explosives, PCBs, Asbestos, etc.)
- Municipal Solid Waste
- Materials Not Categorized As Waste Inventory (MNCAW)

C. LEVEL I - ACTIVITY CHARACTERIZATION

Level I, Activity Characterization, requires a minimal amount of descriptive, quantitative, and qualitative information to document each of the facility's processes and activities which are defined as "Any existing or planned operation or activity (including remediation projects) which generates waste or pollution to the air, land, or water." In gathering this information, the facility begins the initial step to determine whether any waste reduction or pollution prevention opportunities exist. The collection of this information will also provide the basis to determine whether or not any of the facility's

processes/activities necessitate further analysis per the graded approach methodology. Therefore the principle objectives of Level I are to:

- define the process,
- document Waste Minimization / Pollution Prevention (WMin/PP) activities (past or current),
- determine the level of effort that should be performed for a cost-effective Pollution Prevention Opportunity Assessment Program, and
- provide information to determine if more analysis is necessary.

Level I Required Documentation

1. A brief process description / simple flow diagram;
2. A quantitative estimate of the material inputs, products, by-products, and wastes;
3. A preliminary evaluation of WMin/PP potential; and
4. A decision to determine if further analysis is necessary.

Level I process assessments will establish the site's baseline of operational information. These process/activity descriptions should include input materials, process products, by-products and/or waste generated. Identification of these elements and estimates of quantities is made using the best available information source, or combination of sources. Possible information sources are listed in Appendix B.

In addition to the descriptive information, the potential for WMin/PP can be initially evaluated based on the activity or process expert's knowledge. These recommendations should be included in the Level I documentation. If opportunities do exist and are easily implemented, then the actions taken or planned to be taken should be documented. Furthermore, for WMin/PP options identified and implemented, upstream / downstream impacts should also be included in the documentation.

After collecting the process/activity information, it is necessary to determine whether the process/activity continues to a Level II or III analysis as defined by the graded approach logic diagram and the site's priority material / waste stream list.

If the process does not contain any of the materials or waste streams on the priority list, then the Level I documentation satisfies the PPOA requirement. Conversely, those processes/activities which are captured by the site's priority list are included in the Weighted Sums Evaluation to determine the next level of effort to be performed.

A completed example Level I Activity Characterization is shown in Appendix C. PPOA Worksheets 1S-3S can be used to document the information required in a Level I assessment.

D. GRADED APPROACH WEIGHTED SUMS EVALUATION

The graded approach methodology continues when the site selects a core team to determine which processes require Level II and Level III assessments. The core team

should be cross-functional and consist of key site personnel with knowledge about the site's processes, waste management, and regulations. The team's objectives are to assign weights to the criteria, to determine the numeric value that distinguishes a Level II from a Level III, and to provide consistency in scoring across processes. The form to aid in this evaluation (weighted sums) is shown in Figure 3. (Appendix D contains the weighted sums form, criteria, and instructions.) First the site assigns a weight to each criteria listed in the first column of the weighted sums. Then, for each process being evaluated, the team determines a scale for the five listed criteria and a multiplier. From the products and sums, a total point value is assigned. Finally, the team determines the cut-off value for which Level II assessments will be completed versus Level III assessments. Processes identified by the Weighted Sums Evaluation which require a Level III, Formal Assessment, are those processes that are critical to the site's priorities and would benefit by the allocation of resources to examine how to best implement pollution prevention technologies to these critical areas.

E. LEVEL II - INFORMAL ASSESSMENT

After completing the Graded Approach Weighted Sums Evaluation, the facility has distinguished which processes/activities require the Level II, Informal Assessment. The principal objectives of Level II are to:

- develop and screen WMin/PP opportunities and
- recommend viable options for implementation.

This level of effort does not require the collection of new data. Much of the documentation has already been completed in the Level I assessment. However, due to some aspect of the process, the facility needs to further explore the WMin/PP opportunities available to reduce the quantity of waste or the risk/hazard associated with the operation.

<u>Level II Required Documentation</u>

{1.} Brief process description / simple flow diagram;
{2.} Quantitative estimate of the material inputs, products, by-products, and wastes;
{3.} Preliminary evaluation of WMin/PP potential;
4. WMin/PP options identification and evaluation;
5. Consideration of potential upstream / downstream impacts; and
6. Recommendations for option implementation.

{} - denotes those items already completed in Level I, Activity Characterization

Further suggested reading for Level II information can be found in sections IV: A-C and V: A-B. A completed example Level II, Informal Assessment, is shown in Appendix E. PPOA Worksheets 1S-5S can be used to complete the requirements of a Level II assessment.

Date: ________

Page ______ of ________

FIGURE 3
Pollution Prevention Opportunity Assessment Graded Approach

Weighted Sums Evaluation

Evaluation Criteria	Weight 'W'	Process: ________		Process: ________		Process: ________		Process: ________		Process: ________	
		Scale 'S'	'WxS'	Scale 'S'	'WxS'	Scale 'S'	'WxS'	Scale 'S'	'WxS'	Scale 'S'	'WxS'
Environmental, Safety, & Health Hazards	Site Assigns										
Quantity of Waste Generated	" "										
Site Liabilities	" "										
Economic Factors - Process & Waste Costs (Unit &/or Annual)	"										
Process By-Product Management	" "										
Other											
Subtotal											
WMin/PP Potential Multiplier		x		x		x		x		x	
Total											
PPOA Level											

F. LEVEL III - FORMAL ASSESSMENT

In addition to the information completed in the Level I assessment, the Level III requires considerably more documentation to complete the PPOA. For example, both the process description and a corresponding block flow diagram are required to illustrate the basis of generation. The use of narratives, calculations, photographs, illustrations, figures and/or data sufficient to convey an understanding of the process are certainly recommended. The Level III assessment also requires collection of quantitative data for a material balance. A material balance should be completed to account for all waste generated. This information, if not already available, may need to be tracked to accurately establish the current process waste generation information necessary to complete the WMin/PP options analysis.

The primary objectives of the Level III Assessment are to:

- conduct a detailed analysis of the process for WMin/PP opportunities and
- document the results of the process evaluation in a written report.

Level III Required Documentation

{1.} Brief process description / simple flow diagram;
{2.} Quantitative estimate of the material inputs, products, by-products, and wastes;
{3.} Preliminary evaluation of WMin/PP potential;
4. Process description;
5. Flow diagram;
6. Material balance;
7. WMin/PP options identification;
8. Analysis of WMin/PP options generated: economic, technical, upstream / downstream impacts, and other benefits;
9. Prioritized list of options; and
10. Formal report with documentation and recommendations for option implementation.

{} - denotes those items already completed in Level I, Activity Characterization

A completed example Level III, Formal Assessment, is shown in Appendix F.

The following sections of this guidance describe the details necessary to achieve the requirements of a Level III, Formal Assessment. Each of these sections can also be used as a reference for the information required in the Informal Assessment and Activity Characterization, Levels II and I, respectively. Blank Model Worksheets have been included in Appendix G to help guide a team through the PPOA requirements. They are only suggested forms - they are not requirements. A site may prefer to modify them to fit their individual site needs. Model PPOA Worksheets 1-10 were developed for the Level III assessment, PPOA Worksheets 1S-3S were developed for Level I, and Worksheets 1S-5S were developed for a Level II.

III. POLLUTION PREVENTION OPPORTUNITY ASSESSMENT TEAMS

The Waste Minimization and Pollution Prevention Awareness Program Plan states that assessments of all waste-generating operations at the site will be conducted by PPOA teams. The team leader should have the authority to complete the assessment, line responsibility, familiarity with the site's process and waste management operations, and proven technical and problem-solving abilities (e.g. Value Engineering Specialist).

The remainder of each assessment team should be drawn from line staff, or subcontractor organizations that can furnish the type of specialized expertise that will be needed to conduct the assessment. Each PPOA team should consist of a small core of individuals familiar with the site's operations, who will direct the assessment efforts and guide the data gathering. The careful selection of personnel to conduct the assessment is essential. Experienced people familiar with the site's operations are crucial to completing an accurate and timely assessment. Subsets of this team are satisfactory for Levels I and II of the graded approach. Other personnel with specialized skills will be used on a part-time, as-needed basis. Each team may include members who have knowledge in the following areas:

- process operations;
- federal, state, and local hazardous waste statutes and regulations;
- operation and waste minimization principles and techniques;
- quality control requirements;
- purchasing procedures;
- material control/inventory procedures; and/or
- value engineering skills.

Model Worksheets 1 and 1S can be used to record the PPOA team members and the assessment title and identification (ID) code. The PPOA ID Code should be unique for each PPOA at the site. For uniformity, the site should determine the structure of this code.

PPOA team leaders should receive training on the procedures, methodologies, techniques and documentation requirements for PPOAs before the assessments are conducted. The team leader needs to have clear authority from the WMin/PP Coordinator or line management to select other team members, obtain support services, and to direct the efforts of the assessment team in its interaction with operating personnel. The team should be given unrestricted access to all facility personnel and information that may, in the team's estimation, be relevant to the assessment.

IV. ASSESSMENT OF PROCESSES AND WASTE STREAMS

A. INITIAL DATA GATHERING

For each assigned process, the PPOA team begins with gathering data about that process and associated waste streams. The boundaries of the process must be established. The team should consider the following process boundary criteria: (1) the process must have a distinct starting and ending point, (2) the process input materials must be accounted for, (3) the time frame must be considered, and (4) the process must be manageable - an appropriate size to collect information and provide focus. The team will collect information through interviews and the review of process documents that will permit a thorough understanding of the process to be assessed and the development of a written analysis on how that process generates waste (see Appendix B for sources of additional information). The team should also visit the process areas to witness how the process is conducted and to validate the written information that has been collected.

Each PPOA team should develop and/or collect information as defined in the graded approach level. The following assessment tools may be used:

- process descriptions,
- process flow diagrams,
- material balances, and/or
- waste stream characterizations for assessment area or process.

Additional guidance may be found in the EPA *Facility Pollution Prevention Guide* (Reference #8 of Appendix H) to complete the PPOA.

PPOA team members may identify ways to reduce waste during the data collection phase. It is at this point that observations about operations, schedules, and procedures can be noted which may easily be changed to prevent waste. These changes can have a wide impact. The knowledge and experience of team members and their colleagues will help to develop these ideas into potential options. The team members should also make effective use of technical literature from equipment vendors and trade associations; the experience of plant engineers, operators, and consultants; and the databases available from environmental agencies.

B. PROCESS DESCRIPTION

The PPOA will include a general description of each process step in the waste generating operation. The narrative should describe the following:

- purpose of the process;
- material and equipment used in the process;
- equipment layout;
- personnel and their experience / training level; and
- products, by-products, and waste streams generated.

Model Worksheets 2 and 2S can be used to complete the process description. Chemicals and other materials purchased or otherwise introduced into the process should be identified. The description should also include other information that adequately describes the process and may be relevant to WMin/PP planning. For example, process or product specifications, requirements, assumptions, and upstream and downstream impacts may have a critical bearing on waste generation and should be included in the description.

To further understand the process, the team may perform a function analysis as explained in the DOE/Defense Program's *Prioritization of Pollution Prevention Options Using Value Engineering* (Reference #13 of Appendix H). The principal objective of function analysis is to discover the basic purposes of a process in contrast to its secondary or support uses. It aids the team in determining the process' primary functions and in minimizing or eliminating secondary functions which, in turn, may produce unnecessary wastes. The function analysis can help answer the question as to whether this process is actually necessary.

C. PROCESS FLOW DIAGRAM

The analytical work of the waste assessment effort starts with the development of a simple process flow diagram for the operation being assessed. The requirement for this flow diagram is based on the maxim that a picture is worth a 1000 words. It is also the foundation upon which the material balance is built. The process flow diagram should identify the major steps within an operation and diagram the flow of materials into and out of each step during the process. The diagram should indicate the following:

- process steps,
- material inputs, and
- process outputs (e.g., product, by-products and waste streams).

The diagram should also characterize the streams according to the nature of the release and waste classification, including but not limited to the following:

- air,
- liquid,
- solid,
- radioactive,
- mixed,
- hazardous, and/or
- non-hazardous.

Model Worksheets 3 and 2S can be used for the completion of the process flow diagram. There are three styles to chose from for Model Worksheet 3 depending on the complexity of the analysis and whether radioactive materials and waste streams are involved.

D. MATERIAL BALANCE

The PPOA shall account for all input materials that enter the process which are either consumed, transferred, or disposed of as waste. This accounting, which is called a "material balance", will be indicated on the process flow diagram and transferred to a spreadsheet. A material balance is a tool which is used to provide an input/output summary of the process being assessed. Closing the balance on an unknown stream can help identify the constituents in that stream. The material balance should indicate the following:

- amount of input materials introduced into the process,
- amount of materials consumed,
- amount of materials withdrawn as a product or by-product, and
- amount of materials flowing out of a process as a waste stream.

Using the best available information, the material balance should be closed (i.e., all input materials and transfers should be accounted for in the product, by-product and waste streams). The purpose of closing the balance is to identify streams which are difficult to quantify, e.g. fugitive and point-source emission streams. The material balance should show the average material flows over a representative time period which is logical for the site's operations. For example, it may be appropriate to gather data for Operation A from monthly averages, while a longer time span may be more appropriate for Operation B. Material balances performed over the duration of a complete production run are typically the easiest to construct and are reasonably accurate.

In its simplest form, the material balance is represented by the mass conservation principle:

$$\text{Mass in} = \text{Mass out} + \text{Mass Accumulated}$$

That is, materials placed into a process can be accounted for through products, by-products, air emissions, water discharges, spills, recycling streams, waste streams, scrap, out-of-shelf life materials, or out-of-specification materials. All materials (hazardous and non hazardous) should be accounted for in the input and output streams. The quantification units for the material balance should be consistent, i.e. pounds. The Material Safety Data Sheet (MSDS) can be helpful in converting materials into a common unit.

Measurement of Feed Materials: All input materials that are introduced into a process must be identified. The amount and type of the input materials can be determined by examining the following:

- procurement and inventory records;
- processing logs; and/or
- other records that show purchase, transfer, donation, or other receipt of materials by production unit.

Other examples of information sources are found in Appendix B.

Products and By-products: The material balance should indicate the amount of materials leaving the work unit as a product or by-product.

Transfer of Materials: Some materials may be used in a process and then transferred to another area or process for further processing. The material balance should account for the transfer of the materials.

E. MEASUREMENT OF WASTE

Information about the quantity and character of the waste streams is a critical component of the PPOA. Waste stream information should be obtained from sources such as:

- site tracking system,
- permits and permit applications,
- monitoring reports,
- hazardous waste manifests,
- emission factors,
- experiments,
- emission or toxic substance release inventories,
- hazardous waste reports,
- waste analyses, and/or
- environmental audit reports.

If the waste data is not available from the above sources, it may be necessary to monitor the process and record the needed information. Model Worksheet 4 can be used to record material balance data. The completed material balance should be a database of process information that represents the process area over a time period long enough to characterize that operation. The suggested time period to record this data is an annual basis to coincide with other site reporting requirements. If data was taken over a shorter time period, extrapolation can be used. The material balance will show the source of waste streams and the contribution that different activities make to the waste streams. It will serve as a baseline for tracking WMin/PP efforts and will provide data needed for evaluation of WMin/PP options. The process data used to calculate a baseline of operations should be as representative of current operations as possible.

Monitoring waste stream flows and compositions is something that should be done periodically. By tracking waste streams, seasonal variations in waste flows or single, large waste streams can be distinguished from continual, constant flows. Changes in waste generation cannot be meaningfully measured unless the information is collected both before and after a pollution prevention option is implemented.

F. WASTE STREAM CHARACTERIZATION

Each waste stream identified in the process flow diagram will be characterized, including but not limited to the following:

- source of waste;
- composition;
- rate of generation from work unit operation; and
- costs associated with treatment, storage, or disposal of wastes.

The waste stream characterization information is also part of Model Worksheet 4. The cost information for the input materials and waste streams can be recorded on Model Worksheet 5. After characterization, consideration should be given to each waste stream to determine where WMin/PP is most needed.

V. DEVELOPMENT AND EVALUATION OF WASTE MINIMIZATION/ POLLUTION PREVENTION OPTIONS

A. IDENTIFICATION OF WMIN/PP OPTIONS

Once the process and causes of waste generation are understood, the PPOA enters the creative phase. Following the collection of data and site inspections, the members of the team will have begun to identify possible ways to minimize waste or prevent pollution in the assessment process. Identifying potential options relies both on the expertise and creativity of the team members. Much of the requisite knowledge may come from their education and on-the-job experience, however, the use of technical literature, contacts, and other sources may also be employed.

The process by which pollution prevention options are identified should occur in an environment that encourages creativity and independent thinking by the members of the assessment team. The key to successful results is the deferral of any critical judgments or comments which might inhibit any of the team members. While the individual team members will suggest many potential options on their own, the process can be enhanced by using some of the common group decision techniques. These techniques allow the assessment team to identify options that the individual members might not have come up with on their own. Employees having practical experience with the process may have given thought to the process' input and output efficiencies or alternative operating methods. Therefore, creativity and brainstorming is strongly encouraged.

To identify WMin/PP options, the PPOA teams will utilize the following priorities:

- source-reduction options:
    - material substitution,
    - process changes,
    - product reformulating,
    - equipment changes,
    - operational improvements,
    - schedule changes,
    - affirmative procurement, and/or
    - administrative controls (e.g., inventory control, employee training, polices, etc.).

- recycling/reuse options

Each of these different approaches may generate many options or none, i.e., while operational improvements are a very broad approach, input or process changes may be difficult to control. Are there any processes / products upstream and downstream which could be affected by changes to the process or product? As these different approaches are discussed several questions should be repeatedly asked:

- Is this operation necessary?
- Why is this waste generated?
- Why do we do this operation in this manner?
- Why must we use these chemicals?
- Are there any non-hazardous substitutions available?

In addition to using the process expert's knowledge, there are numerous outside references to assist in developing a list of options. These include EPA publications, databases, and technical references; state and local environmental agency's publications, bibliographies, and technical assistance; as well as, published literature in technical magazines, trade journals, research briefs, vendor equipment information and chemical supplier information.

Model Worksheet 6 can be used in a team brainstorming session to generate the pollution prevention opportunities. Model Worksheets 7 and 4S can be used to record the detailed description for each of the options generated. The description should include the basic idea behind the option, affected materials and product, any roadblocks to implementation, and the anticipated reduction quantity.

B. PRELIMINARY SCREENING OF WMIN/PP OPTIONS

Many pollution prevention options will be identified in a successful assessment. At this point, it is necessary to identify those options that offer real potential to minimize waste and reduce costs. Since detailed evaluation of technical and economic feasibility is usually costly, the proposed options should be screened to identify those that deserve further evaluation. The screening procedure serves to eliminate suggested options that appear marginal, impractical, or inferior without a detailed and more costly feasibility

study. The screening procedures may include any combination of the following methods:

- information reviews by program managers,
- ballots by team members, and/or
- quantitative tools (e.g. weighted sum method).

Whatever method is used, the preliminary screening procedure should consider the following questions:

- Is implementation of the option cost effective?
- What is the principal benefit of the option?
- What is the expected change in the type or amount of waste generated (toxicity, reactivity, etc.)?
- Does it use existing technology?
- What kind of development effort is required?
- Will implementation be constrained by time?
- Does the option have a dependable performance record?
- Will the option effect product, employee health, or safety?
- What are the upstream/downstream impacts if implemented?

The results of the screening process will be a list of options that are candidates for more detailed technical and economic evaluation. It is important to document the decisions made in the screening process for future reference. Model Worksheet 7 can also be used to record the results from the initial screening process.

C. EVALUATION OF WMIN/PP OPTIONS

The PPOA team should perform an in-depth evaluation on the potential economic and technical feasibility of each option using Model PPOA Worksheets 8 and 9. The options will then be ranked in order of preferred implementation. The highest priority normally should be given to source-reduction projects, after which projects that recycle/reuse all or part of a waste stream or by-product will be considered.

Model Worksheet 8 evaluates each option from a cost perspective. The three major cost categories for weighing options are: Implementation Costs, Incremental Operating Costs, and Incremental Intangible Costs. EPA's *Pollution Prevention Benefits Manual* (Reference #12 of Appendix H) provides more detail on cost analysis and contains examples of each of these cost categories.

The following considerations must be fully evaluated to determine the recommended WMin/PP options. These include: economic evaluation including capital cost, operating cost, waste management costs and return on investment; expected change in the type or amount of waste generated (toxicity, reactivity, etc.); technical feasibility; avoided costs; effect on product, employee health and safety; permits, variances, and compliance schedule of applicable agencies; releases and discharges to all media; previous successes; implementation period; and/or ease of implementation.

This evaluation is most easily accomplished and documented by the use of a simple matrix for scoring and ranking - the suggested evaluation is the weighted sums method shown on Model Worksheet 9. The DOE/DP *Prioritization of Pollution Prevention Options Using Value Engineering* (Reference #13 in Appendix H) also demonstrates how options can be evaluated and prioritized using this method. The evaluation matrix provides a means to quantify the important criteria that affect the site and is a quick visual representation of the factors affecting various WMin/PP options. The scoring system for each criteria, used in the matrix and some rational for selection or weighting of scores should be included in the formal report. Evaluation of this matrix would complete the final requirement for prioritizing the list of options for implementation. The formal report should provide sufficient detail to allow transfer of the measure to other generators with similar processes or operations.

VI. FINAL REPORT

A final report is required for each PPOA. The final report is a compilation of essential facts about the process, pollution prevention options, feasibility of those options, upstream/downstream impacts of those options, and future implementation costs. The final report documents the work performed, assumptions made during the assessment, and identifies funding requirements necessary to implement pollution prevention options. The length of the final report will depend on the complexity of the PPOA. For Level II assessments, Model Worksheet 5S can be used to complete the requirements of the final report.

For a Formal Assessment, Level III, each option will be ranked by the PPOA team according to its economic and technical feasibility using Model Worksheets 8 & 9. Economic feasibility will be a factor, but not the determining factor, in judging the relative merit of each WMin/PP option. The PPOA team will report the results of its evaluation, including final rankings and ranking criteria, to the Waste Minimization Committee or line management. The PPOA team will indicate its preferred options in the report.

Easily implemented options will be completed and documented in the final report. Options that require additional analysis and/or approval shall be addressed via the site's Waste Minimization and Pollution Prevention Program Plan.

Documentation of the WMin/PP options and recommendations should demonstrate a good faith effort undertaken to identify alternatives and should provide a narrative description of these factors in sufficient detail to allow transfer of the measure to other generators with similar processes or operations.

The final report and associated data will be maintained as permanent records for later reference and tracking information. PPOAs should be reviewed on an annual basis after the initial PPOA is completed and should be revised if significant process changes are made.

VII. APPENDIX

APPENDIX A

GENERAL CONSIDERATIONS FOR PRIORITIZING THE ASSESSMENT OF WASTE STREAMS

- Costs savings (direct and indirect)
- Potential for (or ease of) minimization
- Potential recovery of valuable by-products
- Reduced quantity of waste
- Compliance with current and future regulations
- Hazardous properties of the waste (including toxicity, flammability, corrosivity, and reactivity)
- Other safety hazards to employees
- Potential environmental and safety liability/improvements
- Potential for removing bottlenecks in production or waste treatment

APPENDIX B

SOURCES OF MATERIAL BALANCE INFORMATION

Listed below are potential sources of information for preparing a process description, flow diagram or material balance inventory. The list is not meant to be exclusive.

- Process Expert Knowledge
- Operating Logs
- On-site Tracking Systems
- Purchasing Records
- Vendor Information
- Process Design Information
- Batch Makeup Records
- Emission Inventories
- Equipment Cleaning and Validation Procedures
- Material & Chemical Inventories
- Operating Procedures and Manuals
- Production Records
- Product Specifications
- Samples, Analyses, and Flow Measurements
- Waste Disposal Records
- Waste Manifests
- E S & H reports
- Permitting Applications
- Experiments
- Laboratory Notebooks

APPENDIX C

LEVEL I EXAMPLE PPOA

SNL/NM Organization: 7813-5 Process Name: Asbestos Brakes & Clutch Removal

DATA FORM 1

DESCRIPTION OF PROCESS/OPERATIONS

Process Location Area I,II,III,IV,V & Remote Area SNL-Albuquerque NM/SNL-Livermore CA./TTR-Las Vagas NV./KTF-Kauai
(include site, TA, building, room, as appropriate)

Describe the general operations or activities of the organization performing the process. Continue on the back of this sheet, if necessary.

The Crane and Hoist section is responsible for performing annual Inspections, Repairs, and Preventative Maintenance on Cranes and Hoists.

Describe the particular process that generates wastes and/or other pollutants, or uses hazardous materials. Describe how the hazardous materials are used, and how the wastes or pollutants are generated. (See Chapter 2 of the PWA Guidance Manual for guidelines on defining a process.) Continue on the back of this sheet, if necessary.

Asbestos Brakes and Clutches are generated waste in this process.

Asbestos Brakes and Clutches becomes a generated waste when the Asbestos Brakes and Clutches are removed and replaced with Non-Asbestos Brakes and Clutches.

Date: 7/22/93 Prepared by (MinNet Rep): Bernard Alexander Phone: 4-1365
PWA #: Process Contact: Bernard Alexander Phone: 4-1365
(to be completed by WMSC)

PROCESS DEFINITION

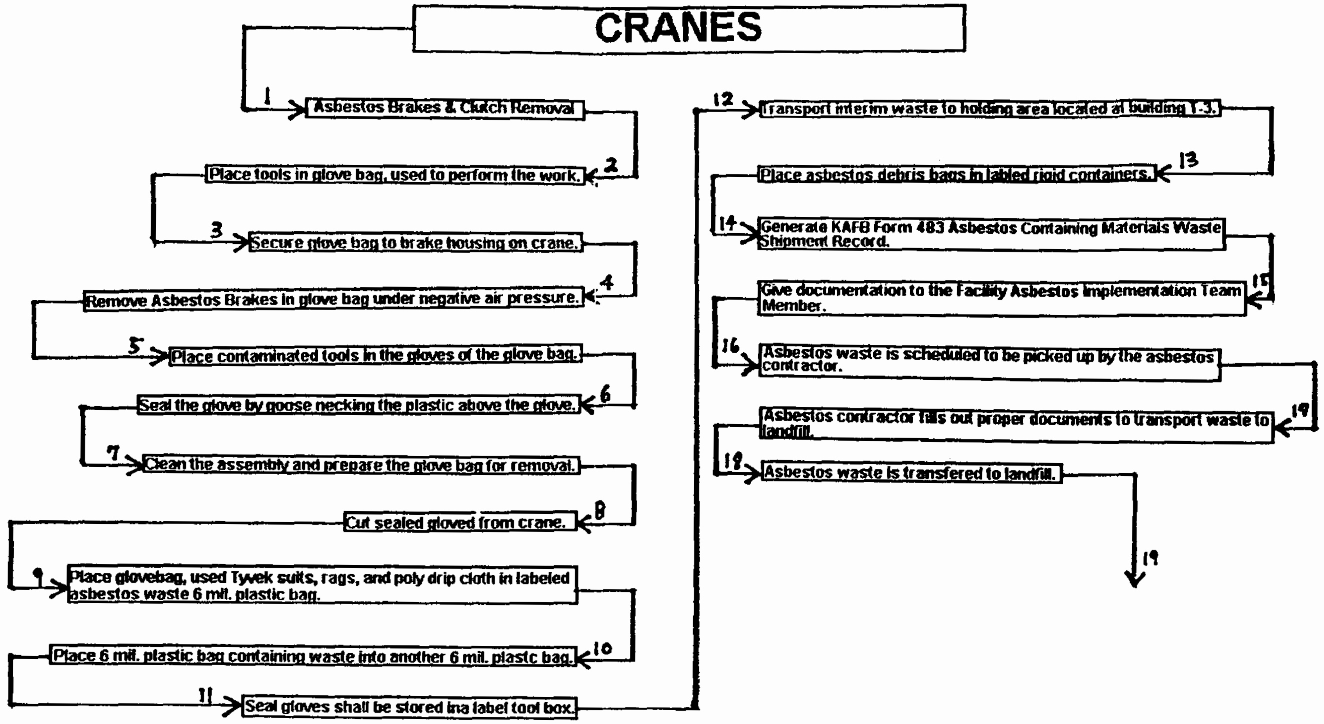
SNL/NM Organization: 7813-5 Process Name: Asbestos Brakes & Clutch Removal

Process Location: Remote Areas Area I,II,III,IV,V/TTR-Las Vegas NV./KTF-Kauai SNL-Albuquerque NM/SNL-Livermore CA.
(include site, TA, building, room, as appropriate)

DATA FORM 2

PROCESS FLOW DIAGRAM

Sketch a flow diagram of the process. Show subprocesses with materials entering the process, as well as products, materials, wastes, and other pollutants generated by the process. Show the sources of the input and destinations of the output materials.



Use additional sheets if necessary.

Date: 7/22/93
PWA #:
(to be completed by WMSC)

Prepared by (MinNet Rep): Bernard Alexander Phone: 4-1365
Process Contact: Bernard Alexander Phone: 4-1365

SNL/NM Organization: 7813-5 Process Name: Asbestos Brakes and Clutches Removal

DATA FORM 3

CALENDAR YEAR 1992 WASTE MINIMIZATION ACTIVITIES

Process Location: Area I,II,III,IV,V, & Remote Areas SNL-Albuquerque NM/SNL-Livermore CA./TTR-Las Vegas NV./KTF-Kauai
(include site, TA, building, room, as appropriate)

Have waste minimization (WM) activities been undertaken in CY92? ☒ Yes ☐ No

If No, briefly discuss factors that have prevented waste minimization activities: ______

If Yes, short name of WM activity (e.g., Increase Input Purity, Improve Rinse Process) (use other sheets if more than one activity taken): Removing and disposing of a hazardous material.

Type of WM activity (check best one that applies):

Source Reduction
- ☒ Good Operating Practice
- ☐ Inventory Control
- ☐ Spill and Leaks Prevention
- ☐ Raw Material Modification
- ☐ Production Modification
- ☐ Process Modification (Clean and Degreasing)
- ☐ Process Modification (Surface Prep and Finish)
- ☐ Process Modification (Other)
- ☐ Other (specify below)

Recycling
- ☐ Began Onsite Recycling
- ☐ Began Offsite Recycling
- ☐ Reuse in Original Process
- ☐ Reuse in Another Process

Energy Recovery
- ☐ Began Onsite Energy Recovery
- ☐ Began Offsite Energy Recovery

Treatment
- ☐ Began Onsite Treatment
- ☐ Began Offsite Treatment

Briefly describe WM activity: Removal of Asbestos Brakes and Clutches to be replace with a non-asbestos material.

Date: 7/22/93 Prepared by (MinNet Rep): Bernard Alexander Phone: 4-1365
PWA #: ______ Process Contact: Bernard Alexander Phone: 4-1365
(to be completed by WMSC)

SNL/NM Organization: 7813-5 Process Name: Asbestos Brakes and Clutches Removal

DATA FORM 3

FISCAL YEAR 1992 WASTE MINIMIZATION ACTIVITIES

Waste stream type affected: ☒ Hazardous (Chemical) Solid Waste ☐ Waste Water Discharge ☐ Radioactive/Mixed Solid Waste ☐ Air Emission

Waste stream name affected (see corresponding Data Form 2): Asbestos Brakes and Clutches

Did WM activity increase the toxicity of waste generated? ☐ Yes ☒ No

Did WM activity increase the quantity or toxicity of wastes emitted to other media (air, waste, land)? ☐ Yes ☒ No

Did WM activity reduce toxicity but not quantity? ☒ Yes ☐ No

Indicate the quantity impact of the WM activity (use most appropriate measure):

Mass before WM activity (kg/yr): ______ Mass after WM activity (kg/yr): ______
Volume before WM activity (ℓ/yr): ______ Volume after WM activity (ℓ/yr): ______
Specific activity before WM activity (Ci/kg/yr): ______ Specific activity after WM activity (Ci/kg/yr): ______

Basis of quantities (e.g., direct measurement, material balance calculation, published emission factors, engineering calculations, engineering/scientific judgment): ______

Has the WM activity been successful? ☒ Yes ☐ No
Is the activity still being used? ☒ Yes ☐ No

If unsuccessful or otherwise not being used, describe why: ______

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PWA #: ______ Process Contact: Bernard Alexander Phone: 4-1365
(to be completed by WMSC)

SNL/NM Organization: 7813-5 Process Name: Asbestos Brakes and Clutches

DATA FORM 4

HAZARDOUS/RADIOACTIVE MATERIAL INPUTS

Name of Hazardous/Radioactive Material	Input Stream Number	Predicted Frequency of Usage[1]	Average Annual Usage Rate (kg/yr)
Asbestos	1		
Glove Bag	2		
Tyvek Suits,Rags,Drip Cloth	9		

[1]Indicate usage as Continuously (C), Daily (D), Weekly (W), Monthly (M), Quarterly (Q), or Annually (A)

Date: 7/22/93 Prepared by (MinNet Rep): Bernard Alexander Phone: 4-1365

PWA #: Process Contact: Bernard Alexander Phone: 4-1365

(to be completed by WMSC)

SNL/NM Organization: 7813-5 Process Name: Asbestos Brakes and Clutches

DATA FORM 5

HAZARDOUS (CHEMICAL) SOLID WASTE

Waste Stream Number (from Worksheet 1): 1,2,9,10

Waste Stream Name (from Data Form 2/Worksheet 1): Asbestos,tyvk suits,rags,drip cloth, plastic bag

Location of waste generation (TA, building, room): SNL-Alb/SNL-CA/TTR-NV/KTF-Kauai

Inside RMMA? ☐ Yes ☒ No

Briefly describe how waste is generated: Asbestos Brakes and Clutches are removed and replaced with non-asbestos material. Glove bages,tyvek suits rags, and drip cloth are used in th removal process to remove the generated waste.

Frequency of waste generation: ☐ Continuously ☐ Daily ☐ Weekly ☒ Monthly ☐ Quarterly ☐ Annually

Which description fits the process step that generates the waste (check best one):

☒ A regularly scheduled process step that is likely to be repeated several times during the upcoming year.
☐ A one-time activity that is not likely to be repeated during the upcoming year.

Predicted average quantity of waste generated annually – normal operations (kg): 200 lbs.

Predicted min/max quantity generated annually – normal operations (kg): Min ______ Max ______

List (describe) all hazardous constituents (e.g., mercury inside switches, benzene-tainted glassware) or brand names (e.g., WD-40) that could be in the waste:

Asbestos

Do the hazardous constituents of the waste stream listed above vary (e.g., sometimes contains lead, sometimes contains lead and cadmium)? ☐ Yes ☒ No If yes, describe how the waste varies:

Describe physical characteristics of wastes (e.g., aqueous solution, solid, sludge, oil, containerized compressed gas - include % of solids or % moisture, if applicable): Solid

Date: 7/22/92 Prepared by (MinNet Rep): Bernard Alexander Phone: 4-1365

PWA #: ______ Process Contact: Bernard Alexander Phone: 4-1365

(to be completed by WMSC)

SNL/NM Organization: 7813-5 Process Name: Asbestos Brakes and Clutches

DATA FORM 5

HAZARDOUS (CHEMICAL) SOLID WASTE

The pH of the waste stream may range from N/A to N/A (answer if appropriate)

Is the waste ignitable? (see Guidance Manual for clarification) ☐ Yes ☒ No ☐ Unknown
Is the waste corrosive? (see Guidance Manual for clarification) ☐ Yes ☒ No ☐ Unknown
Is the waste reactive? (see Guidance Manual for clarification) ☐ Yes ☒ No ☐ Unknown

Does the waste stream contain any of the following toxic metals: ☐ Yes ☒ No (check all that apply)

☐ Arsenic ☐ Barium ☐ Cadmium ☐ Chromium
☐ Lead ☐ Mercury ☐ Selenium ☐ Silver

Does the waste stream contain a toxic volatile, semi-volatile, or pesticide listed in Table 3-2?
☐ Yes ☒ No If yes, list: ______

Does the waste stream contain any of the spent solvents listed in Table 3-3? ☐ Yes ☒ No
If yes, list: ______

Does the waste stream contain, or is it generated from the production of, any of the following benzene derivatives? ☐ Yes ☒ No (check all that apply)

☐ trichlorophenol
☐ tetrachlorophenol
☐ pentachlorophenol
☐ tetrachlorobenzene
☐ pentachlorobenzene
☐ hexachlorobenzene

Is the waste any of the following? ☐ Yes ☒ No (check all that apply)

☐ waste water treatment sludge
☐ petroleum refining waste
☐ wood preserving process waste
☐ leachate from treatment, storage, or disposal of waste

Does the waste contain cyanide or is cyanide used in the process? ☐ Yes ☒ No

Is the waste any of the following? ☐ Yes ☒ No (check all that apply)

☐ waste from the production of inorganic pigments
☐ waste from the production of inorganic chemicals
☐ waste from the production of organic chemicals
☐ waste from the production of explosives
☐ waste from the production of ink formulations
☐ waste from the production of pesticides
☐ waste from the production of metals
☐ waste from the production of pharmaceuticals
☐ coking waste
☐ petroleum refining waste

Date: 7/22/93 Prepared by (MinNet Rep): Bernard Alexander Phone: 4-1365
PWA #: ______ Process Contact: Bernard Alexander Phone: 4-1365
(to be completed by WMSC)

SNL/NM Organization: 7813-5 Process Name: Asbestos Brakesand Clutches

DATA FORM 5

HAZARDOUS (CHEMICAL) SOLID WASTE

Based on the above description of how the waste is generated, select the single best summary of the waste-generating process step.

CLEANING AND DEGREASING

- ☐ Stripping (A01)
- ☐ Acid cleaning ((A02)
- ☐ Caustic (Alkali) cleaning (A03)
- ☐ Flush rinsing (A04)
- ☐ Dip rinsing (A05)
- ☐ Spray rinsing (A06)
- ☐ Vapor degreasing (A07)
- ☐ Physical scraping and removal (A08)
- ☐ Clean out process equipment (A09)
- ☐ Other cleaning and degreasing (A19)

SURFACE PREPARATION AND FINISHING

- ☐ Painting (A21)
- ☐ Electroplating (A22)
- ☐ Electroless plating (A23)
- ☐ Phosphating (A24)
- ☐ Heat treating (A25)
- ☐ Pickling (A26)
- ☐ Etching (A27)
- ☐ Other surface coating/preparation (A29)

PROCESSES OTHER THAN SURFACE PREPARATION

- ☐ Product rinsing (A31)
- ☐ Product filtering (A32)
- ☐ Product distillation (A33)
- ☐ Product solvent extraction (A34)
- ☐ By-product processing (A35)
- ☐ Spent catalyst removal (A36)
- ☐ Spent process liquids removal (A38)
- ☐ Tank sludge removal (A38)
- ☐ Slag removal (A39)
- ☐ Metal forming (A40)
- ☐ Plastics forming (A41)

PRODUCTION OR SERVICE DERIVED ONE-TIME AND INTERMITTENT PROCESSES

- ☐ Leak collection (A51)
- ☐ Cleanup of spill residues (A53)
- ☐ Oil changes (A54)
- ☐ Filter/battery replacement (A55)
- ☐ Discontinue use of process equipment (A56)
- ☒ Discarding off-spec material (A57)
- ☐ Discarding out-of-date products or chemicals (A58)
- ☐ Other production-derived on-time and intermittent processes (A59)
- ☐ Sludge removal (A60)

REMEDIATION DERIVED WASTE

- ☐ Superfund Remedial Action (A61)
- ☐ Superfund Emergency Response (A62)
- ☐ RCRA Corrective Action at solid waste management unit (A63)
- ☐ RCRA closure of hazardous waste management unit (A64)
- ☐ Underground storage tank cleanup (A65)
- ☐ Other remediation (A69)

POLLUTION CONTROL OR WASTE TREATMENT PROCESSES

- ☐ Filtering/screening (A71)
- ☐ Metals recovery (A72)
- ☐ Solvents recovery (A73)
- ☐ Incineration/thermal treatment (A74)
- ☐ Wastewater treatment (A75)
- ☐ Sludge dewatering (A76)
- ☐ Stabilization (A77)
- ☐ Air pollution control devices (A78)
- ☐ Leachate collection (A79)
- ☐ Other pollution control or waste treatment (A89)

OTHER PROCESSES

- ☒ Clothing and personal protective equipment (A91)
- ☒ Routine cleanup wastes (e.g., floor sweepings) (A92)
- ☐ Closure of hazardous waste management unit(s) or equipment other than by remediation (A93)
- ☐ Laboratory wastes (A94)
- ☐ Other (A99)

Date: 7/22/93 Prepared by (MinNet Rep): Bernard Alexander Phone: 4-1365

PWA #: ______ Process Contact: Bernard Alexander Phone: 4-1365

(to be completed by WMSC)

APPENDIX D

PPOA GRADED APPROACH WEIGHTED SUMS FORM, CRITERIA, AND INSTRUCTIONS

Date: ________

Page ______ of ________

Pollution Prevention Opportunity Assessment Graded Approach

Weighted Sums Evaluation

Evaluation Criteria	Weight 'W'	Process: ______		Process: ______		Process: ______		Process: ______		Process: ______	
		Scale 'S'	'WxS'	Scale 'S'	'WxS'	Scale 'S'	'WxS'	Scale 'S'	'WxS'	Scale 'S'	'WxS'
Environmental, Safety, & Health Hazards	Site Assigns										
Quantity of Waste Generated	" "										
Site Liabilities	" "										
Economic Factors - Process & Waste Costs (Unit &/or Annual)	"										
Process By-Product Management	" "										
Other											
Subtotal											
WMin/PP Potential Multiplier		x		x		x		x		x	
Total											
PPOA Level											

Date: ________

Page ______ of ________

Pollution Prevention Opportunity Assessment Graded Approach

Weighted Sums Evaluation

Evaluation Criteria	Weight 'W'	Process: ______ Scale 'S'	'WxS'	Process: ______ Scale 'S'	'WxS'	Process: ______ Scale 'S'	'WxS'	Process: ______ Scale 'S'	'WxS'	Process: ______ Scale 'S'	'WxS'
Environmental, Safety, & Health Hazards	Site Assigns										
Quantity of Waste Generated	" "										
Site Liabilities	" "										
Economic Factors - Process & Waste Costs (Unit &/or Annual)	"										
Process By-Product Management	" "										
Other											
Subtotal											
WMin/PP Potential Multiplier		x		x		x		x		x	
Total											
PPOA Level											

Graded Approach Worksheet

The purpose of this worksheet is to determine the PPOA level for each of the facility processes. To begin, a list of these processes or areas should be generated for each facility. Then for each item listed, complete one column on this worksheet. For consistency, each facility should establish site-specific weights for each of the criteria. Once each item has received a weighted sum value, then each facility should establish the dividing line from which to require informal (Level II) or formal PPOAs (Level III).

Weighted Sums Instructions:

a. The values in the Weight column (designated by 'W') represent the facility's priority for the criteria.

b. In the Scale column for each process (designated by 'S'), rate each criteria by assigning a value from 0-10 (lowest to highest).

c. In the 'W x S' column for each process, enter the product of the weight and scale.

d. Sum the 'W x S' column for each process to obtain a subtotal.

e. Calculate the process ratio for waste generated/input material used (0 - 1). This is the multiplier.

f. Multiply the subtotal by the multiplier and enter the product in the Total column for each process.

g. Determine the level of PPOA required by comparing the Total weighted sums value with the site guidelines in the following table.

Weighted Sums Total	PPOA Level Required
If 0 to (?)	Level II Informal PPOA
If ≥ (?)	Level III Formal PPOA

APPENDIX E

LEVEL II EXAMPLE PPOA

PPOA-1

Original Issue Date: 8/31/91
Revision No.: ____
Revision Date: ____

Pollution Prevention Opportunity Assessment

Team & Scope

Assessment ID Code: SNL/CA MS001

Assessment Title: Machine and Fabrication Shop

Name	Job Classification	Phone
* Alice Johnson-Duarte	WMin Coordinator	4-3266
Andy Cardiel	Shop Supervisor	4-2544
Charlie Schmitz	Machinist	4-2315
Kim Shepodd	Waste Manager	4-1475

* Team Leader

Assessment Scope:

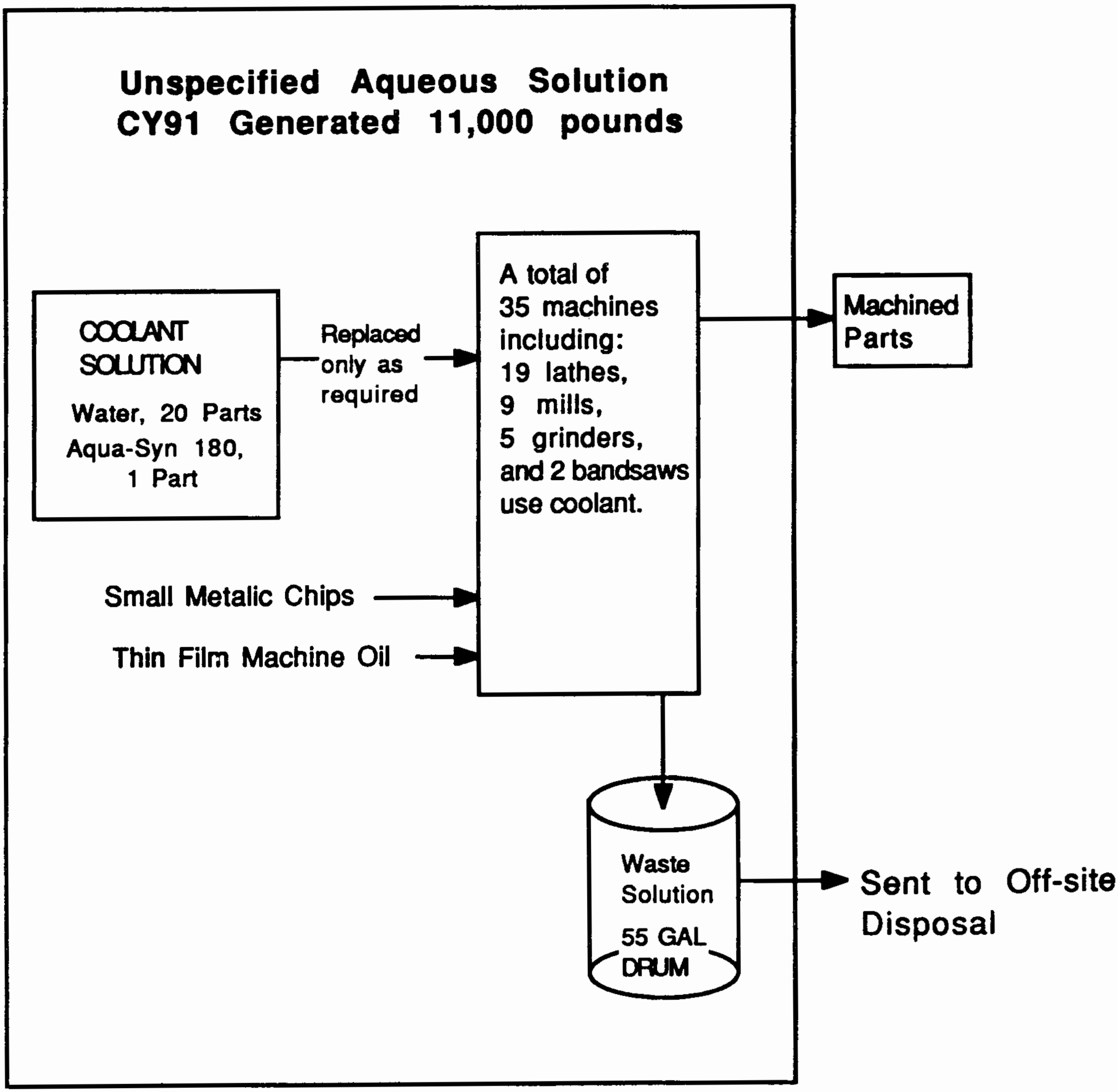
The Machining and Fabrication Shop is a support function whose principal purpose is machining parts requiring a quick turn-around, restriction of access due to classification, and/or close liaison with the designer and engineer. The shop maintains equipment suitable to perform turning, milling and grinding operations. The major hazardous waste stream generated by this facility is the spent coolant used in the machining process. The diluted Aqua-Syn 180 itself is a non-hazardous material per 29CFR 1910.1200(c); however, in the machining process it is mixed with small amounts of machine oil and metal shavings. The coolant is routinely changed after 3 to 4 months of service except as noted in the shop's operating procedures.

Potential for Pollution Prevention / Waste Minimization or Recommendations:

There are limited operational and administrative pollution prevention opportunities to reduce the spent coolant waste.

POLLUTION PREVENTION OPPORTUNITY ASSESSMENT
PROCESS FLOW DIAGRAM

PWA ASSESSMENT ID CODE: SNL/CA MS001
TITLE: Machine and Fabrication Shop



PPOA-2

Pollution Prevention Opportunity Assessment

Material & Waste Stream Summary

Assessment ID Code: SNL/CA MS001

Title: Machine and Fabrication Shop

Input Material Name/No.	Annual Quantity Used	% Product	% Recycled	Total Releases % Air	Total Releases % Liquid	Total Releases % Solid
Water	10400.0			5	95	
Aqua-Syn	520.0			1	99	
Metalic chips	65.0					100
Machine oil	15.0				100	

Totals/Page: 11000.0

Total Annual Quantity 11000.0

Does the process require further analysis based on the site's Priority Material/Waste Stream List?

● Yes ○ No

☒ Level II ☐ Level II

9/16/93

PPOA-3

Pollution Prevention Opportunity Assessment

Option Summary

Assessment ID Code: SNL/CA MS001

Title: Machine and Fabrication Shop

Option No. 1

Description

One consideration for an operational improvement would be to recycle the spent coolant. According to industrial sources, a reduction of approximately 50% in the present amount of coolant disposed of.

Type	Consider?	Feasibility	Estimated Cost	Estimated Savings	Anticipated Reduction Qty
Recycling	● Yes ○ No	Fair	$25,000.00	$100.00	5,000.00

Option No. 2

Description

Analyze the spent coolant solution for containminants and determine if it is indeed hazardous.

Type	Consider?	Feasibility	Estimated Cost	Estimated Savings	Anticipated Reduction Qty
Disposal	○ Yes ● No	Poor	$5,000.00	$100.00	1,0000

PPOA-4

Date
8/31/91

Pollution Prevention Opportunity Assessment

Final Summary

Assessment ID Code SNL/CA MS001

Title: Machine and Fabrication Shop

Assessment:

A Level I and Level II PWA were completed on the Machining and Fabrication Shop coolant waste stream. The machinist responsible for the operational maintenance of the machine shop equipment had limited suggestions for reducing the amount of spent coolant generated. Recycling and treatment options were generated and evaluated. Assumptions made during this assessment were: the level of activity of the machine shop is relatively stable; the coolant must be changed on a periodic basis which is dependent on use and/or time and; disposal costs are relatively stable.

Conclusions:

The PWA team concluded the options are not economically feasible at this time since: 1) option one would require a considerable investment with the possibility of increasing the actual amount of coolant waste caused by contamination; 2) the recycling equipment presently available is not designed to treat the small quantity of spent coolant generated; 3) a conservative approach regarding waste management is consistent with the site's policy.

Recommendations:

The Line Management will continue monitoring the amount of waste generated and the availability of recycling equipment for improvement in the economical feasibility of implementation.

APPENDIX F

LEVEL III EXAMPLE PPOA

Worksheet 1

Level III

Original Issue Date: 01-Dec-1993
Revision No.: 0
Revision Date:

Pollution Prevention Opportunity Assessment

PPOA Team

PPOA Title: Polyurethane Foam Mixing and Curing

PPOA ID Code(s): G517-034-Machine_Mix

Name	Job Classification	Phone
*Bill Harrison	Process Engineer	X1234
John Taylor	Area Supervisor	X1235
Albert Green	Foam Machine Operator	X1235
Mary White	Foam Machine Operator	X1235
Violet Jones	Area Production Planner	X1236

*Team Leader

Additional Resources	Name	Phone
PPOA Coordinator	Nancy Notrebmep	X5432
Waste Management	Hakim Senoj	X5433
Industrial Hygiene		
Environmental Protection	Tim Sregge	X5434
Safety		
Fire Protection		
Process Engineering		
Materials Engineering		
Utilities Engineering		
Facilities Engineering		
Maintenance (Equipment)		
Analytical Lab Testing	Dottie Muldune	X5431
Scheduling		
Purchasing		

Worksheet 2

Level III

Revision No.: _____

Revision Date: _____

Pollution Prevention Opportunity Assessment

Process Description

PPOA Title: Polyurethane Foam Mixing and Curing

PPOA ID Code(s): G517-034-Machine_Mix

Process Location: Main Building #105, Post FN33

Process Description:

The foam mixing process is a process in which the required material components are metered and mixed at a defined ratio. The ratio of the two component streams is set and calibrated by production personnel. The materials are then mixed during the dispense cycle by the action of a motorized impeller. The mixed material "foam" is transferred manually to a mold and cured at temperatures from 165 to 350 deg. F. for four to six hours. Input materials include polyol resins, isocyanates, cleaning solvent and processing supplies. Five foam dispensing units are used. They range in age from four to fifteen years. The cure ovens are ventilated as is the foam pouring area. The foam machine operators have sufficient training to operate the dispensing units. Their previous training did not emphasize pollution prevention.
Waste streams include solid and liquid waste from the foaming operations as well as air emissions from the foam pouring and curing activities.

Description of Major Product(s) of Process:

Molded Polyurethane Foam Products

Worksheet 3
Style 1
Level III

Revision No. : 0
Revision Date: ____________

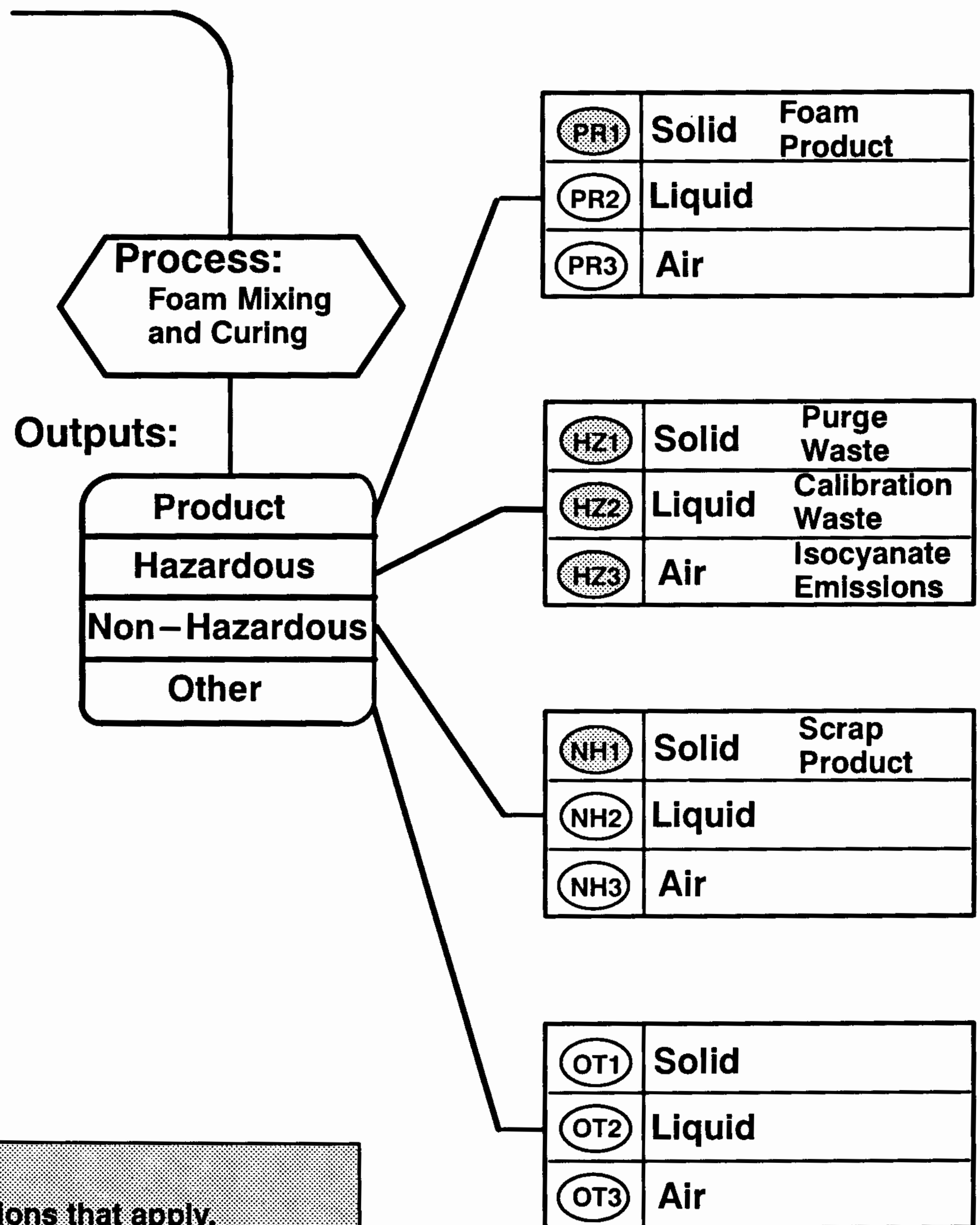
Pollution Prevention Opportunity Assessment

Process Flow Diagram

PPOA Title or PPOA ID Code(s): G517–034–Machine_Mix

Inputs:

- Isocyanate Comp.
- Resin Component
- Solvent
- Supplies



Highlight those sections that apply.
Use Worksheet 4 to identify and quantify the appropriate stream.

Worksheet 4

Level III

Pollution Prevention Opportunity Assessment

Material Balance Summary

Revision No.: 0
Revision Date:

Time frame
From: 01–Jan–92
To: 31–Dec–92

PPOA Title or PPOA ID Code(s): G517–034–Machine_Mix

Material Description	Total Input	OUTPUT QUANTITY (Units: lbs.) Total Output									
			Stream ID Code Foam Product PR1	Stream ID Code Purge Waste HZ1	Stream ID Code Calibration Waste HZ2	Stream ID Code Isocyanate Emissions HZ3	Stream ID Code Scrap Product NH1	Stream ID Code	Stream ID Code	Stream ID Code	Stream ID Code
Isocyanate	313.6	124.5		98.3	24.4	1.8					
Resin	186.4	73.5		58.9	14.6						
Solvent	80.0	80.0		80.0							
Supplies	94.0	94.0		94.0							
Foam	0.0	302.0	237.0				65.0				
Totals/Subtotals	674.0	674.0	237.0	331.2	39.0	1.8	65.0				

Worksheet 5

Level III

Revision No.: 0

Revision Date: ______

Pollution Prevention Opportunity Assessment

Material Cost

PPOA Title or PPOA ID Code(s): G517-034-Machine_Mix

Material	Stock Number (if applicable)	Cost Per Unit	Annual Cost
Isocyanate Component		$1.96/lb	$614.65
Resin Component		$2.25/lb	$419.40
Solvent		$0.27/lb	$ 21.60
Supplies (paper cups, etc.)		$0.57/lb	$ 53.60
		Total / Subtotal	$1109.25

Waste Disposal Cost:

Material / Waste Stream	Waste Stream Category	Cost Per Unit	Annual Cost
Waste Liquid	Haz. Liquid	$4.60/lb	$179.40
Waste Solid	Haz. Solid	$2.97/lb	$983.66
Scrap Product	Non Haz. Solid	$0.69/lb	$ 44.85
		Total / Subtotal	$1207.91

Worksheet 6

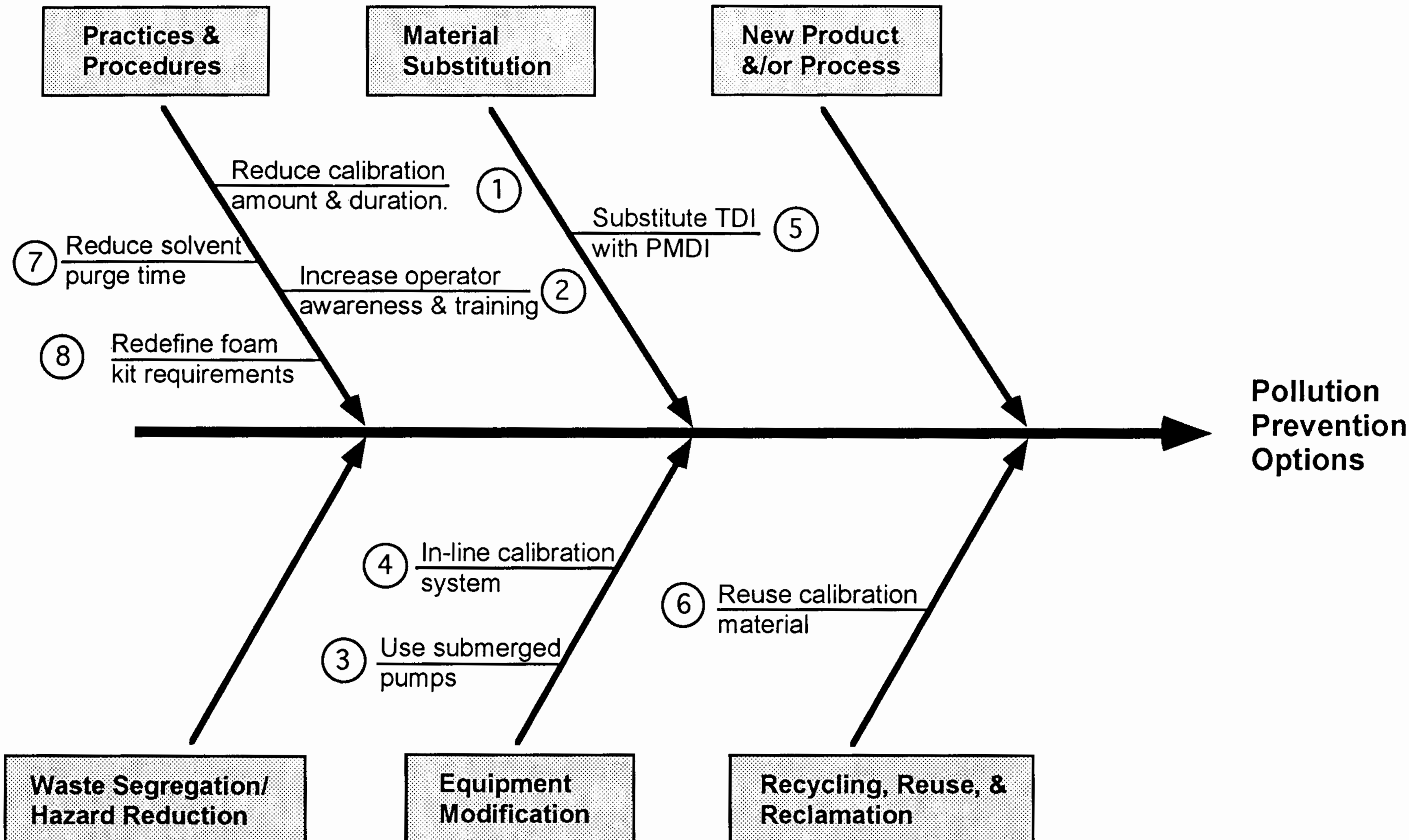
Level III

Revision No.: 0
Revision Date: ______

Pollution Prevention Opportunity Assessment

Option Generation

PPOA Title or PPOA ID Code(s): G517-034-Machine-Mix



Worksheet 7

Level III

Pollution Prevention Opportunity Assessment

Option Description

PPOA Title or PPOA ID Code(s): G517-034-Machine_Mix

Option Name and Description
(Include input materials, products affected, and anticipated reduction quantity.)

Option No. 1 : Calibration Reduction. Reduce the amount and duration of the calibration shots for the foam dispensers. Use new analytical methods "nitrogen testing" to justify the reduced level.

Consider: Yes X No__

Practices & Procedures X
Material Substitution ______
New Product &/or Process ______
Waste Segregation/Hazard Reduction ______
Equipment Modification ______
Recycling, Reuse, & Reclamation ______

Option No. 2 : Increase Awareness and Training. Conduct training session to increase pollution prevention awareness. Instruct in the importance of the individual in the waste generation process.

Consider: Yes X No__

Practices & Procedures X
Material Substitution ______
New Product &/or Process ______
Waste Segregation/Hazard Reduction ______
Equipment Modification ______
Recycling, Reuse, & Reclamation ______

Option No. 3 : Use Submerged Pumps. Replace gear pumps on foam machines with in-tank pumps. Leakage will be into material tanks. This will eliminate material waste and exposure as the result of clean-up

Consider: Yes X No__

Practices & Procedures ______
Material Substitution ______
New Product &/or Process X
Waste Segregation/Hazard Reduction ______
Equipment Modification ______
Recycling, Reuse, & Reclamation ______

Option No. 4 : In-Line Calibration System. Purchase new foam equipment with "in-line" calibration capability. This would replace the open cup method and would reduce the liquid and solid waste streams

Consider: Yes X No__

Practices & Procedures ______
Material Substitution ______
New Product &/or Process ______
Waste Segregation/Hazard Reduction ______
Equipment Modification X
Recycling, Reuse, & Reclamation ______

Worksheet 7

Level III

Pollution Prevention Opportunity Assessment

Option Description

PPOA Title or PPOA ID Code(s): G517-034-Machine_Mix

Option Name and Description
(Include input materials, products affected, and anticipated reduction quantity.)

Option No. 5 : Substitute for TDI. Lessen the toxicity of the waste stream by replacing TDI isocyanate with a PMDI based foam system. PMDI is not a carcinogen and is not a RCRC Hazardous waste.

Consider: Yes X No__

Practices & Procedures ________ Waste Segregation/Hazard Reduction ______
Material Substitution X Equipment Modification ______
New Product &/or Process ______ Recycling, Reuse, & Reclamation ______

Option No. 6 : Reuse Calibration Material. Retain spent calibration material for use on low end product requirements. This could include machine tryout parts, or foam billets used as base material for holding fixtures.

Consider: Yes X No__

Practices & Procedures ________ Waste Segregation/Hazard Reduction ______
Material Substitution ________ Equipment Modification ______
New Product &/or Process ______ Recycling, Reuse, & Reclamation X

Option No. 7 : Reduce Solvent Purge Time. Reset the solvent timers on the foam machine to the absolute minimum to flush the mix head. Subsequent soaking of mixer blade and housing can also reduce the required amount.

Consider: Yes X No__

Practices & Procedures X Waste Segregation/Hazard Reduction ______
Material Substitution ________ Equipment Modification ______
New Product &/or Process ______ Recycling, Reuse, & Reclamation ______

Option No. 8 : Redefine Foam Kit Requirements. Set-up separate material numbers for resin and isocyanate components so ratio/usage of material will be balanced. Current "matched set" distribution result in waste of excess component.

Consider: Yes X No__

Practices & Procedures X Waste Segregation/Hazard Reduction ______
Material Substitution ________ Equipment Modification ______
New Product &/or Process ______ Recycling, Reuse, & Reclamation ______

Worksheet 8

Level III

Revision No.: 0
Revision Date: ______
Page 1 **of** 2

Pollution Prevention Opportunity Assessment

Options Cost Evaluation

PPOA Title or PPOA ID Code(s): G517-034-Machine_Mix

	Option No.: 1	Option No.: 2	Option No.: 3	Option No.: 4	Option No.: 5
Implementation Costs					
Purchased Equipment			$500	$75,000	
Installation			$100	$10,000	
Materials					
Utility Connections				$2000	
Engineering	$250	$100	$150	$3000	$1000
Development					$500
Start up / Training	$100	$100	$150	$5000	
Administrative	$50	$50			
Other					
Total Implementation Cost	$400	$250	$900	$95,000	$1500
Incremental Operating Costs					
Change in Raw Materials	$215	$100	$150	$750	$500
Change in Maintenance			($150)		
Change in Labor	$500			$500	
Change in Disposal	$50	$50	$100	$600	$500
Other					
Annual Operating Savings/(Cost)	$765	$150	$100	$1850	$1000
Incremental Intangible Costs					
Penalties and Fines					
Future Liabilities					
Other					
Annual Intangible Savings/(Cost)	$0	$0	$0	$0	$0
Total Annual Savings/(Cost)	$765	$150	$100	$1850	$1000
Payback Period	0.5 yrs	1.6 yrs	9.0 yrs	51 yrs	1.5 yrs

Worksheet 8
Level III

Revision No.: 0
Revision Date: ______

Pollution Prevention Opportunity Assessment

Options Cost Evaluation

PPOA Title or PPOA ID Code(s): G517-034-Machine_Mix

	Option No.: 6	Option No.: 7	Option No.: 8	Option No.:	Option No.:
Implementation Costs					
Purchased Equipment					
Installation					
Materials					
Utility Connections					
Engineering	$200	$150	$150		
Development					
Start up / Training		$150			
Administrative			$150		
Other					
Total Implementation Cost	$200	$300	$300		
Incremental Operating Costs					
Change in Raw Materials		$15			
Change in Maintenance					
Change in Labor					
Change in Disposal	$180	$125	$350		
Other					
Annual Operating Savings/(Cost)	$180	$140	$350		
Incremental Intangible Costs					
Penalties and Fines					
Future Liabilities					
Other					
Annual Intangible Savings/(Cost)	$0	$0	$0		
Total Annual Savings/(Cost)	$180	$140	$350		
Payback Period	1.1 yrs	2.1 yrs	0.9 yrs		

Worksheet 9

Level III

Revision No.: 0
Revision Date:

Pollution Prevention Opportunity Assessment

Weighted Sums Option Evaluation

PPOA Title or PPOA ID Code(s): G517-034-Machine_Mix

Criteria	Weight 'W'	Option No.: 1 Scale 'S'	'WxS'	Option No.: 2 Scale 'S'	'WxS'	Option No.: 3 Scale 'S'	'WxS'	Option No.: 4 Scale 'S'	'WxS'	Option No.: 5 Scale 'S'	'WxS'
Public Health, Safety, & Environment	10	8	80	6	60	6	60	7	70	8	80
Employee Health & Safety	10	8	80	7	70	5	50	8	80	9	90
Regulatory Compliance	8	7	56	7	56	8	64	7	56	9	72
Economic	6	8	48	9	54	7	42	5	30	8	48
Implementation Period	4	7	28	9	36	6	24	6	24	7	28
Improved Operation / Product	2	5	10	8	16	7	14	8	16	8	16
Other											
Subtotal			302		292		254		276		334
Likelihood of Technical Success (Multiplier)		X	0.8	X	1.0	X	0.9	X	0.9	X	1.0
Likelihood of Useful Results (Multiplier)		X	0.9	X	0.9	X	0.9	X	0.9	X	1.0
Total			217		262		205		224		339
Rank			7		4		8		5		1

Worksheet 9

Level III

Revision No.: 0
Revision Date: ______
Page 2 of 2

Pollution Prevention Opportunity Assessment

Weighted Sums Option Evaluation

PPOA Title or PPOA ID Code(s): G517-034-Machine_Mix

Criteria	Weight 'W'	Option No.: 6 Scale 'S'	'WxS'	Option No.: 7 Scale 'S'	'WxS'	Option No.: 8 Scale 'S'	'WxS'	Option No.: ___ Scale 'S'	'WxS'	Option No.: ___ Scale 'S'	'WxS'
Public Health, Safety, & Environment	10	6	60	8	80	6	60				
Employee Health & Safety	10	7	70	8	80	7	70				
Regulatory Compliance	8	6	48	7	56	7	56				
Economic	6	7	42	9	54	8	48				
Implementation Period	4	7	28	9	36	8	32				
Improved Operation / Product	2	7	14	6	12	9	18				
Other											
Subtotal			262		318		284				
Likelihood of Technical Success (Multiplier)		X	0.9	X	1.0	X	1.0	X		X	
Likelihood of Useful Results (Multiplier)		X	0.9	X	0.9	X	1.0	X		X	
Total			212		286		284				
Rank			6		2		3				

Worksheet 10

Level III

Revision No.: 0 .
Revision Date: ______
Page 1 of 1

Pollution Prevention Opportunity Assessment

Final Report Check Sheet

PPOA Title or PPOA ID Code(s): G517-034-Machine_Mix

Requirement	***Completed***
Title Page	X
PPOA Title	
PPOA ID Code(s)	
Team members	
Issue date/revision date/revision no.	
Executive Summary	X
Process description	
Process assessment	
Option summary and analysis	
Conclusions	
Recommendations	
Introduction	X
Background of evaluation	
Process Description	X
Associated equipment	
Process flow diagram	
Process Assessment	X
Methodology	
Material Balance	
Unusual occurrences	
Option Summary and Analysis	X
Option description and rank	
Upstream/Downstream impacts	
Material usage	
Anticipated reduction	
Estimated costs	
Estimated benefits	
Feasibility	
Waste streams affected	
Conclusion	X
Concluding evaluation	
Option analysis decisions	
Concerns	
Options already implemented	
Lessons learned	
Recommendations	X
Future work	
New equipment	
Implementation strategies	
Worksheets	X
1-10	

APPENDIX G

MODEL PPOA WORKSHEETS

Worksheet 1

Level III

Original Issue Date: ________
Revision No.: ________
Revision Date: ________

Pollution Prevention Opportunity Assessment

PPOA Team

PPOA Title: ______________________________

PPOA ID Code(s): ______________________________

Name	Job Classification	Phone
*		

*Team Leader

Additional Resources	Name	Phone
PPOA Coordinator		
Waste Management		
Industrial Hygiene		
Environmental Protection		
Safety		
Fire Protection		
Process Engineering		
Materials Engineering		
Utilities Engineering		
Facilities Engineering		
Maintenance (Equipment)		
Analytical Lab Testing		
Scheduling		
Purchasing		

Worksheet 1

Worksheet 1 provides the identification of the PPOA assessment team. For the PPOA to be successful, employees involved with the process should be members of the team. The assessment team needs a leader, members, and additional resources, as required.

The team leader should have technical knowledge of the process, knowledge of the current production operations, and the personnel involved. The leader shall assemble the team to perform the assessment. Team members may include process engineers, product engineers, knowledgeable department personnel such as production operator(s), and material experts. Additional resources may be called in to provide information not available within the team. The size of the team may be large for complicated processes, but should be kept to a minimum to maintain focus.

1. **Original Issue Date:** List the original issue date of the PPOA.

2. **Revision No.:** List the revision number for this worksheet. {Original issue = 0.}

3. **Revision Date:** List the most recent revision date for this worksheet.

4. **PPOA Title:** List the PPOA title selected by the team.

5. **PPOA ID Code(s):** List the PPOA ID Code(s) selected by the team.

6. **Name, Job Classification, Phone:** To facilitate team meetings and for future reference, this information should be completed when the PPOA team is formed.

Worksheet 2

Level III

Revision No.: ________

Revision Date: ________

Pollution Prevention Opportunity Assessment

Process Description

PPOA Title: ______________________________

PPOA ID Code(s): ______________________________

Process Location: ______________________________

Process Description: ______________________________

Description of Major Product(s) of Process: ______________________________

Worksheet 2

Worksheet 2 provides a brief description of the process. The main elements of the process description are the process location, input materials, equipment, summary of operations performed, process controls, operator training, major products, and the waste streams affected.

1. **Revision No.:** List the revision number for this worksheet.

2. **Revision Date:** List the most recent revision date for this worksheet.

3. **PPOA Title:** List the PPOA Title given on Worksheet 1.

4. **PPOA ID Code(s):** List the PPOA ID Code(s) given on Worksheet 1.

5. **Process Location:** List the best descriptor of the process location. It may be a department, building, room, etc..

6. **Process Description:** The process description should detail important attributes of the process. Equipment, summary of operations performed, process controls, input materials, and operator training (qualification or certification) should be included.

7. **Description of Major Product(s) of Process:** Describe the major products which result from this process or the reason the process is being perfromed.

Worksheet 3
Style 1
Level III

Revision No. : ____________
Revision Date: ____________

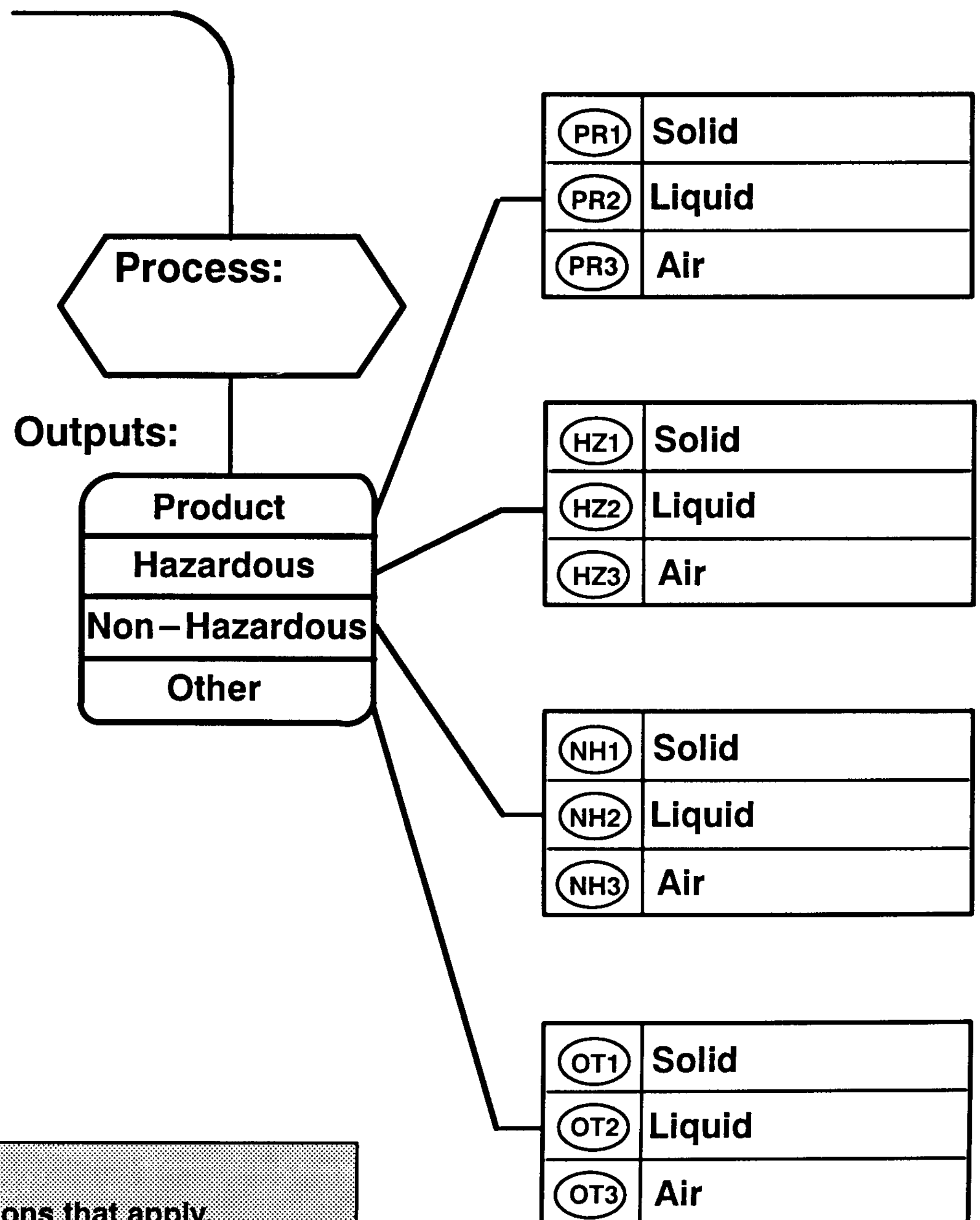
Pollution Prevention Opportunity Assessment

Process Flow Diagram

PPOA Title or PPOA ID Code(s): ____

Inputs:

____
____
____
____
____
____
____



Highlight those sections that apply.
Use Worksheet 4 to identify and
quantify the appropriate stream.

Worksheet 3

Worksheet 3 provides a process flow diagram for the PPOA. The flow diagram should identify all PPOA ID Code(s) associated with the process, all input materials, and outputs (products/wastes). The flow diagram should track materials from the time they enter the process boundary until they leave. This diagram represents a very simplistic flow model; a more detailed diagram may be required to identify all waste streams, especially for complex, multi-step processes.

1. **Revision No.:** List the revision number for this worksheet.

2. **Revision Date:** List the most recent revision date for this worksheet.

3. **PPOA Title or PPOA ID Code(s)**: List the PPOA Title or PPOA ID Code(s) given on Worksheet 1.

4. **Process Flow Diagram**: List the input materials on the lines provided. Fill in the Process Name box. Then highlight those outputs that are applicable to the process (e.g. Product, Hazardous, etc.). Then sub-categorize those outputs into solid, liquid, or air emission streams by highlighting the corresponding output stream. A **Stream ID Code** is provided for each sub-category of waste.

5. **Outputs:** The Stream ID Code provides a uniform coding scheme for the release information requested on Worksheet 4. A brief waste description may be recorded in the box to the right of the Stream ID Code.

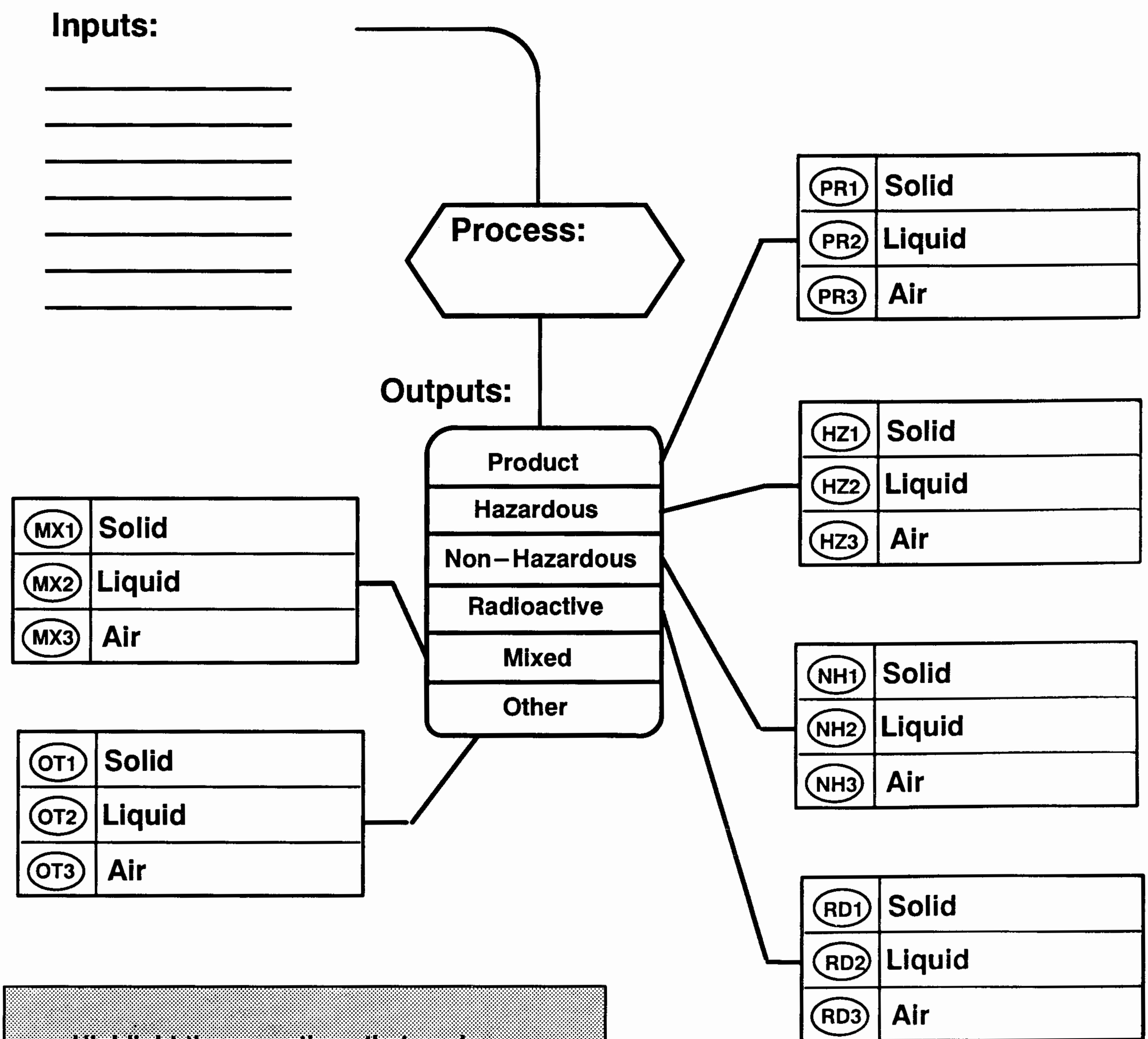
Worksheet 3
Style 2
Level III

Revision No.: ________
Revision Date: ________

Pollution Prevention Opportunity Assessment

Process Flow Diagram

PPOA Title or PPOA ID Code(s): ____



Highlight those sections that apply.
Use Worksheet 4 to identify and quantify the appropriate stream.

Worksheet 3

Worksheet 3 provides a process flow diagram for the PPOA. The flow diagram should identify all PPOA ID Code(s) associated with the process, all input materials, and outputs (products/wastes). The flow diagram should track materials from the time they enter the process boundary until they leave. This diagram represents a very simplistic flow model; a more detailed diagram may be required to identify all waste streams, especially for complex, multi-step processes.

1. **Revision No.:** List the revision number for this worksheet.

2. **Revision Date:** List the most recent revision date for this worksheet.

3. **PPOA Title or PPOA ID Code(s)**: List the PPOA Title or PPOA ID Code(s) given on Worksheet 1.

4. **Process Flow Diagram**: List the input materials on the lines provided. Fill in the Process Name box. Then highlight those outputs that are applicable to the process (e.g. Product, Hazardous, etc.). Then sub-categorize those outputs into solid, liquid, or air emission streams by highlighting the corresponding output stream. A **Stream ID Code** is provided for each sub-category of waste.

5. **Outputs:** The Stream ID Code provides a uniform coding scheme for the release information requested on Worksheet 4. A brief waste description may be recorded in the box to the right of the Stream ID Code.

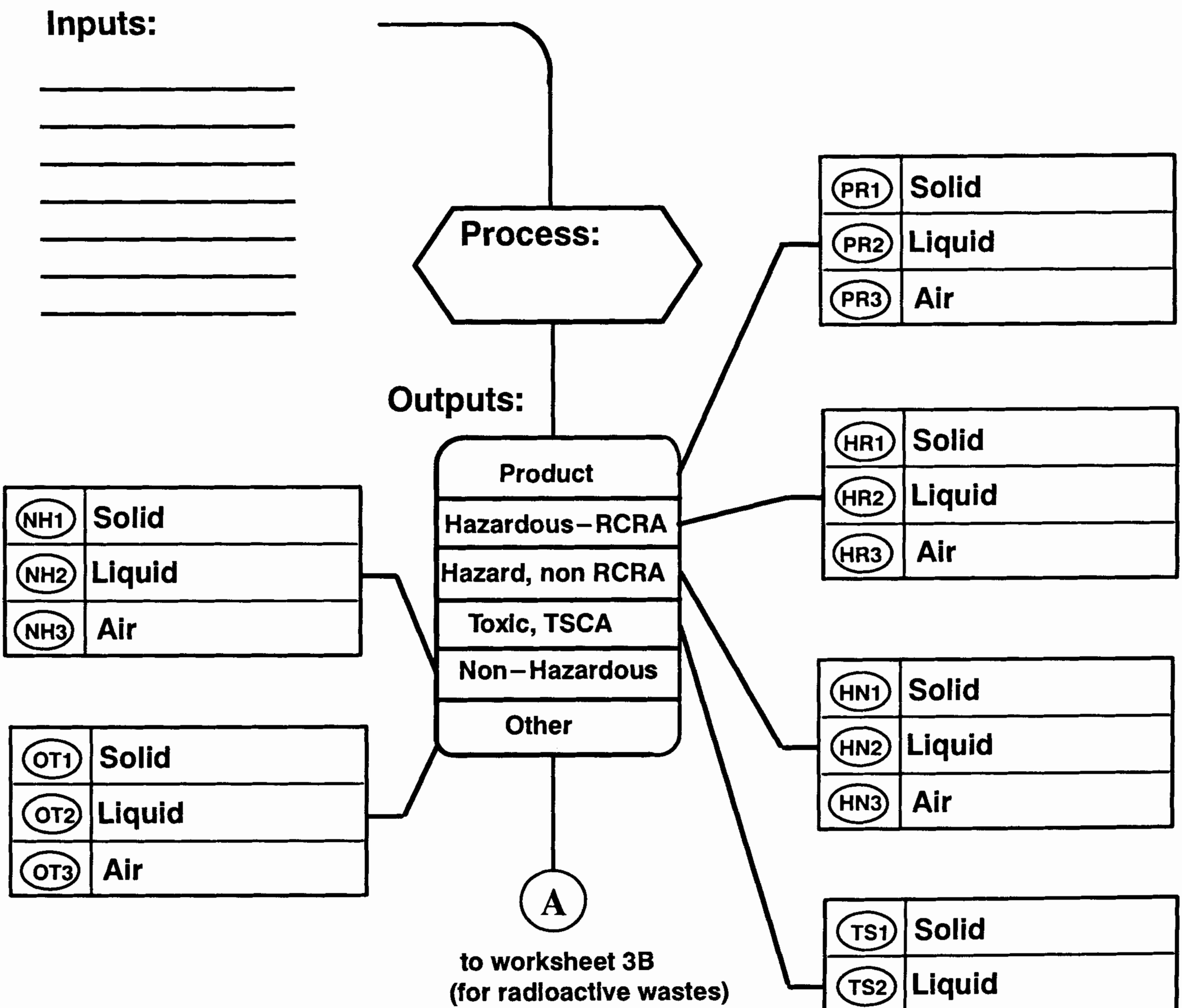
Worksheet 3A
Style 3
Level III

Revision No.: ____________
Revision Date: ____________

Pollution Prevention Opportunity Assessment

Process Flow Diagram

PPOA Title or PPOA ID Code(s): ______________________________



**Highlight those sections that apply.
Use Worksheet 4 to identify and
quantify the appropriate stream.**

11/93

Worksheet 3A

Worksheet 3 provides a process flow diagram for the PPOA. The flow diagram should represent all PPOA ID Code(s) associated with the process, all input materials, and outputs (products/wastes). The flow diagram should track materials from the time they enter the process boundary until they leave. This diagram represents a very simplistic flow model; a more detailed diagram may be required to identify all waste streams, especially for complex, multi-step processes.

1. **Revision No.:** List the revision number for this worksheet.

2. **Revision Date:** List the most recent revision date for this worksheet.

3. **PPOA Title or PPOA ID Code(s)**: List the PPOA Title or PPOA ID Code(s) given on Worksheet 1.

4. **Process Flow Diagram**: List the input materials on the lines provided. Fill in the Process Name box. Then highlight those outputs that are applicable to the process (e.g. Product, Hazardous, etc.). Then categorize those outputs into solid, liquid, or air emission streams by highlighting the corresponding output stream. A **Stream ID Code** is provided for each category of waste.

5. **Outputs:** The Stream ID Code provides a uniform coding scheme for the release information requested on Worksheet 4. A brief waste description may be recorded in the box to the right of the Stream ID Code.

DOE Definitions:

Hazardous Waste - Waste, which because of its quantitiy, concentration, or physical, chemical or infectious nature may (a) cause or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible illness, or (b) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, disposed of, or otherwise managed. Hazardous waste can be further defined as:

RCRA-regulated - solid waste not specifically excluded from regulation under 40 CFR 261.4, or delisted by petition, that is either a listed hazardous waste (40 CFR 261.30 - 261.33) or exhibits the characteristics of a hazardous waste (40 CFR 261.20 - 261.24).

Non RCRA-regulated - any other hazardous waste not specifically regulated under TSCA or RCRA, which may be regulated by the state or local authorities, such as used oil.

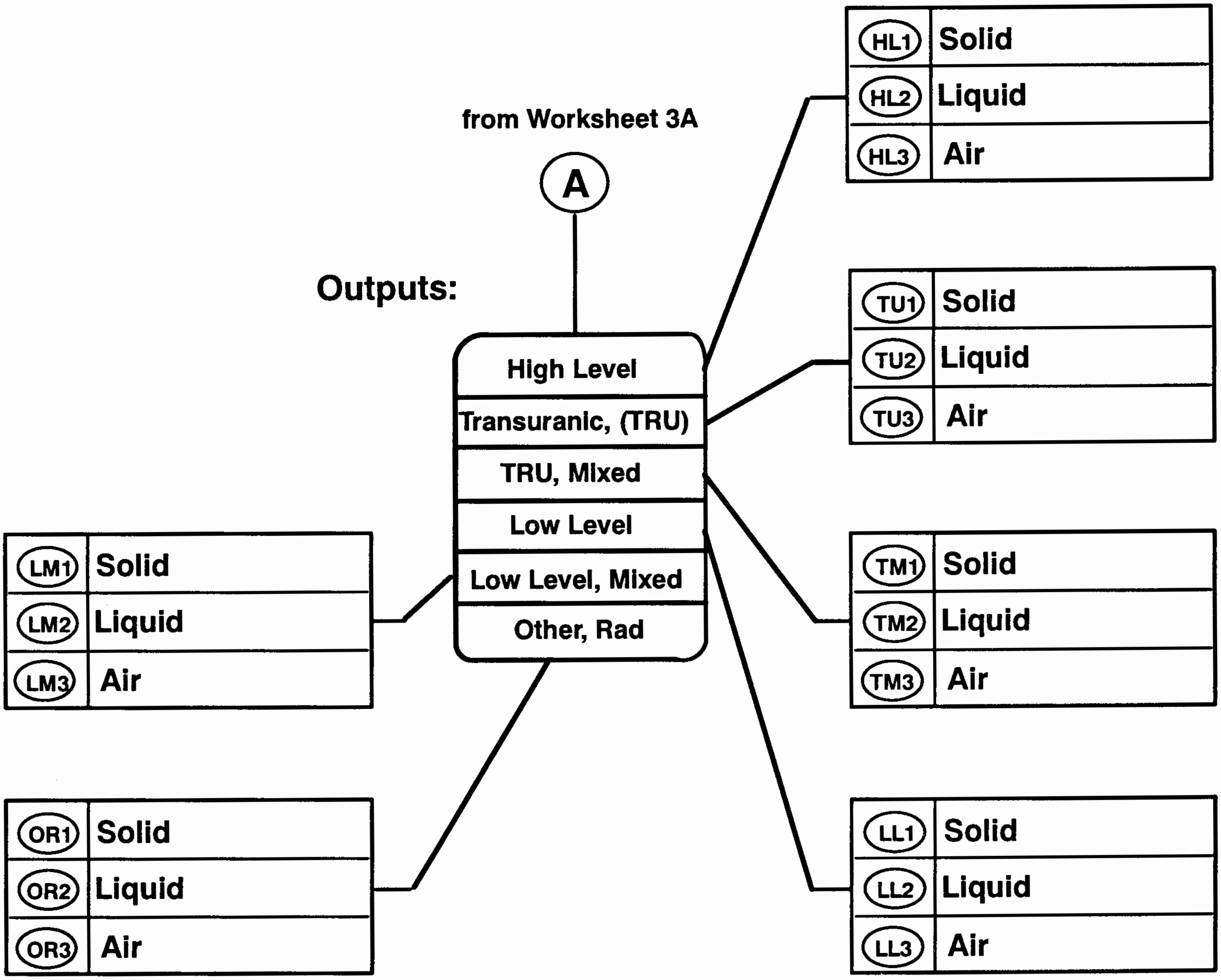
TSCA Waste - Individual chemical wastes (both liquid and solid), such as polychlorinated biphenyls (PCBs).

Worksheet 3B
Style 3
Level III

Revision No. : ____________
Revision Date: ____________

Pollution Prevention Opportunity Assessment
Process Flow Diagram

PPOA Title or PPOA ID Code(s): ______________________________



Highlight those sections that apply. Use Worksheet 4 to identify and quantify the appropriate stream.

Worksheet 3B

Worksheet 3 provides a process flow diagram for the PPOA. The flow diagram should represent all PPOA ID Code(s) associated with the process, all input materials, and outputs (products/wastes). The flow diagram should track materials from the time they enter the process boundary until they leave. This diagram represents a very simplistic flow model; a more detailed diagram may be required to identify all waste streams, especially for complex, multi-step processes.

1. **Revision No.:** List the revision number for this worksheet.

2. **Revision Date:** List the most recent revision date for this worksheet.

3. **PPOA Title or PPOA ID Code(s)**: List the PPOA Title or PPOA ID Code(s) given on Worksheet 1.

4. **Process Flow Diagram**: List the input materials on the lines provided. Fill in the Process Name box. Then highlight those outputs that are applicable to the process (e.g. Product, Hazardous, etc.). Then categorize those outputs into solid, liquid, or air emission streams by highlighting the corresponding output stream. A **Stream ID Code** is provided for each category of waste.

5. **Outputs:** The Stream ID Code provides a uniform coding scheme for the release information requested on Worksheet 4. A brief waste description may be recorded in the box to the right of the Stream ID Code.

DOE Definitions:

High Level Waste- Irradiated reactor fuel, liquid wastes resulting from operation of the first cycle solvent extraction system, or equivalent, and the concentrated wastes from subsequent extraction cycles, or equivalent, in a facility for reprocessing irradiated reactor fuel, and solids into which such liquid wastes have been converted. (10 CFR 60.2)

Transuranic Waste - Waste that is contaminated with alpha-emitting radionuclides with (1) an atomic number greater than 92 (heavier than uranium); (2) half-lives greater than 20 years; and (3) concentrations greater than 100 nanocuries per gram of waste.

Transuranic Mixed Waste: - Waste which contains both transuranic waste and hazardous components, as defined by the Atomic Energy Act and RCRA, respectively.

Low Level Waste: - Radioactive Waste not classified as high level waste, transuranic waste, spent nuclear fuel, or by-product material [specified as uranium or thorium tailings and waste in accordance with DOE Order 5820.2A].

Low Level Mixed Waste: - Waste which contains both low level waste and hazardous components, as defined by the Atomic Energy Act and RCRA, respectively.

Worksheet 4

Level III

Pollution Prevention Opportunity Assessment

Mass Balance Summary

Revision No.: ____________

Revision Date: ____________

Page ________ of ________

Time frame

From: ________

To: ________

PPOA Title or PPOA ID Code(s): ______________________________

Material Description	Total Input	OUTPUT QUANTITY (Units: _____)									
		Total Output	Stream ID Code ◯	Stream ID Code ◯	Stream ID Code ◯	Stream ID Code ◯	Stream ID Code ◯	Stream ID Code ◯	Stream ID Code ◯	Stream ID Code ◯	Stream ID Code ◯
Totals/Subtotals											

Worksheet 4

A material balance is a summation of the total quantity of input material to a process and the releases to the environment, another process, or made into product. The purpose of Worksheet 4 is to tabulate this information and total the inputs and outputs for all streams.

1. **Revision No.:** List the revision number of the PPOA.

2. **Revision Date**: List the most recent revision date for the PPOA worksheet.

3. **PPOA Title/PPOA ID Code(s)**: List the PPOA Title or ID Code(s) given on Worksheet 1.

4. **Page ____of ____:** Indicate the page number for this worksheet and the number of pages for this worksheet.

5. **From/To**: Report the dates (month and year) for the time period covered. An annual period is suggested for purposes of averaging and documenting performance toward facility goals.

6. **Material Description:** List the material name and stock number (optional) or the output product if different than originating material.

7. **Units ____:** Enter the unit of measure for the input/output summary. A consistent unit of measurement is suggested. If requirements dictate mixing units, designate the units for a particular column under the Stream ID Code heading.

8. **Total Input:** For the material described in the far left column enter the weight of material used in the process during the time frame specified.

9. **Total Output:** For the material specified in the Material Description column enter the weight of the output. This is the sum of all waste streams and any product generated. For processes where chemical reactions take place, input materials are consumed or changed to different compounds, a separate entry in the Material Description column is required to adequately define the output. In these cases, the input and output quantities will not balance for the listed material in that row.

10. **Output Quantity:** Use these columns to break down the total output into output categories. Refer to Worksheet 3 for the appropriate Stream ID Code for the output type. Enter the Stream ID Code at the top of the column (e.g., HZ1 for a hazardous solid waste stream), then enter the discharge amount for the material described in the Material Description column that relates to that Stream ID Code. Continue across the worksheet for all Stream ID Code(s) utilized in Worksheet 3.

11. **Totals/Subtotals:** Sum the Total Input, Total Output, and Output columns. Record the sum at the bottom row of the last worksheet. Subtotals are recorded at the bottom row for other pages of the worksheet. The Total Input column should equal the Total Output column unless there is system accumulation. The Total Output column should also be the sum of all the Stream ID Code output streams.

Stream ID Codes:

Designator	Style 1	Style 2	Style 3
Product	PR	PR	PR
Hazardous	HZ	HZ	
Non-Hazardous	NH	NH	NH
Radioactive		RD	
Mixed		MX	
Other	OT	OT	OT
Hazardous, RCRA			HR
Hazardous, Non-RCRA			HN
Toxic, TSCA			TS
High Level			HL
Transuranic, TRU			TU
TRU, Mixed			TM
Low Level			LL
Low Level, Mixed			LM
Other, Radioactive			OR

Solid Stream = 1, Liquid Stream = 2, Air Stream = 3

Style refers to the version of Worksheet 3 used.

Worksheet 5

Level III

Revision No.: ______
Revision Date: ______
Page _____of ______

Pollution Prevention Opportunity Assessment

Material Cost

PPOA Title or PPOA ID Code(s): ____

Input Material Cost:

Material	Stock Number (if applicable)	Cost Per Unit	Annual Cost
		Total / Subtotal	

Waste Disposal Cost:

Material / Waste Stream	Waste Stream Category	Cost Per Unit	Annual Cost
		Total / Subtotal	

Worksheet 5

Worksheet 5 details the cost of the PPOA input materials (use the quantities from Worksheet 4) and the cost of disposal for these materials. The material cost may be obtained from Purchasing or Stores. The cost of disposal may be obtained from Waste Management or Accounting. Annual Cost is calculated from the amount of material placed in the process or from the amount of disposed material, multiplied by the cost per unit.

1. Revision No.: List the revision number for this worksheet.

2. Revision Date: List the most recent revision date for this worksheet.

3. Page_____of_____: Indicate the number of this page and the total number of pages for this worksheet.

4. PPOA Title or PPOA ID Code(s): List the PPOA Title or PPOA ID Code(s) given on Worksheet 1.

5. Input Material Cost: List the material, stock number (if applicable), cost per unit ($/lb., $/gal, etc.), and the annual cost for this process.

6. Waste Disposal Cost: List the material or waste stream, waste stream category, (e.g., hazardous liquid), stock number if applicable, the cost per unit ($/lb., $/gal, etc.) , and annual cost.

7. Totals / Subtotals: Record the sum of the annual costs for the materials or waste streams listed. There will be a total for both the input material cost and waste disposal cost.

Worksheet 6

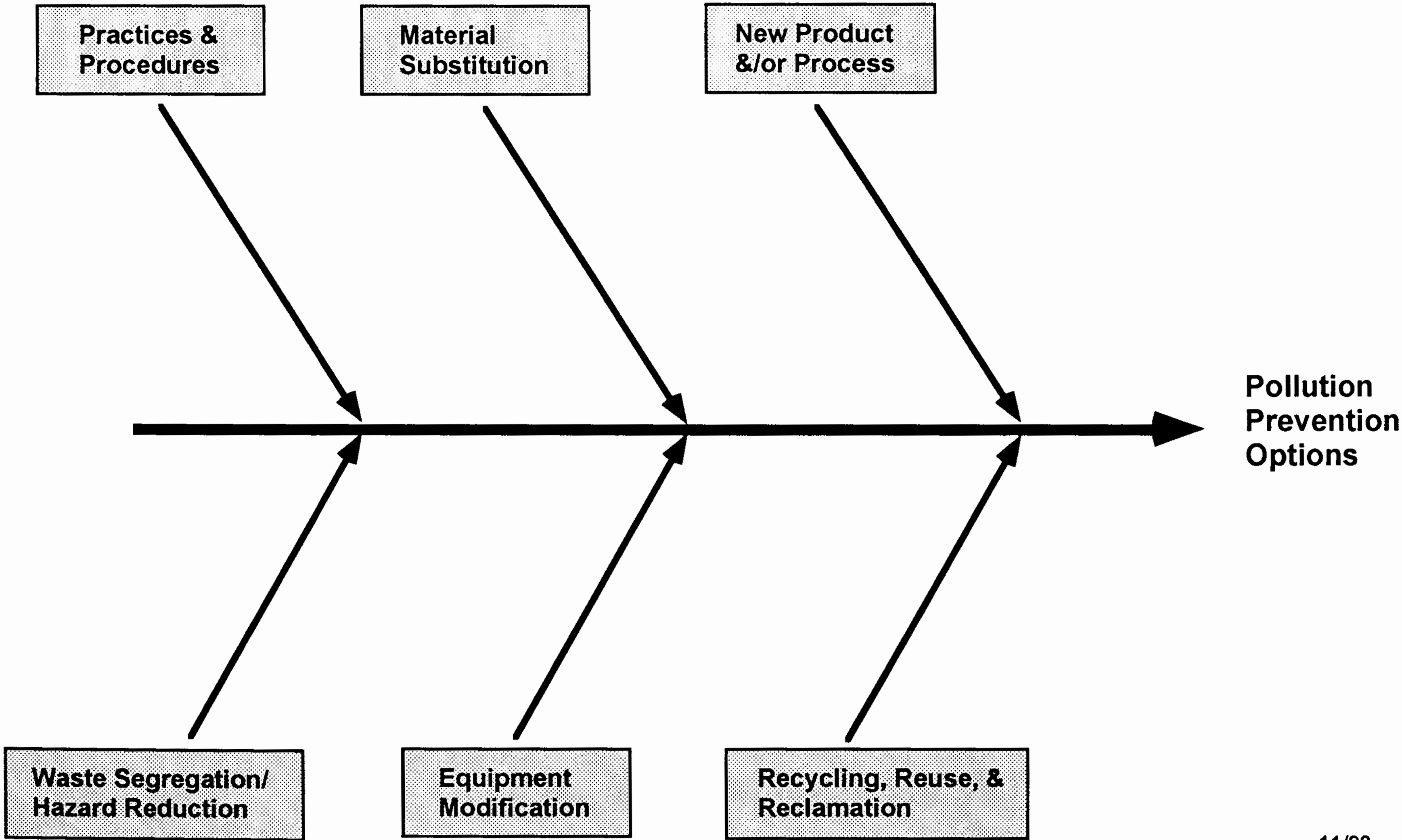
Level III

Revision No.: ____________
Revision Date: ____________

Pollution Prevention Opportunity Assessment

Option Generation

PPOA Title or PPOA ID Code(s): ______________________________



Worksheet 6

Worksheet 6 provides a tool for option generation. The purpose of this diagram (sometimes referred to as a Fishbone Diagram) is to help generate pollution prevention ideas. It is especially useful in a brainstorming session to group ideas undersimilar pollution prevention categories. It also helps insure that all of the pollution prevention categories are considered.

1. **Revision No.:** List the revision number for this worksheet.

2. **Revision Date:** List the most recent revision date for this worksheet.

3. **PPOA Title or PPOA ID Code(s):** List the PPOA title or PPOA ID Code(s) given on Worksheet 1.

4. **Brainstorming ideas:** Using the Fishbone Diagram, briefly document ideas for pollution prevention.

The following definitions clarify each of the major categories.

Practices & Procedures -- Good operating practices and procedures apply to the human aspect of operations. They are largely efficiency improvements. Examples are: Pollution Prevention Programs, personnel training, material handling & inventory practices, material loss prevention, scrap reduction, cost accounting, production scheduling, etc.

Material Substitution -- Changes to the input materials of the process. The result is a reduction or elimination of a pollutant or hazard.

New Product &/or Process -- Product changes which result in the reduction or elimination of waste. In addition, a different process can be used to create the same product with the intent of minimizing waste.

Waste Segregation/Hazard Reduction -- Actions taken to segregate waste streams to prevent nonhazardous waste from being designated and handled as hazardous. Hazard reduction can result from changes to the physical, chemical, or biological character or composition of the waste. These include neutralization, toxicity reduction, or volume reduction.

Equipment Modification -- Changes that occur to the equipment used in a process. These could include minor adjustments, additions, or complete replacements.

Recycling -- A material is recycled if it is used, reused, or reclaimed: (1) if it is used for something other than its original purpose, (2) if it goes back into the original process, or (3) if it is chemically or physically treated for use or reuse.

Worksheet 7
Level III

Revision No.: _____
Revision Date:_____
Page _____of_____

Pollution Prevention Opportunity Assessment

Option Description

PPOA Title or PPOA ID Code(s): ____________________

Option Name and Description
(Include input materials, products affected, and anticipated reduction quantity.)

Option No. _____ : ____________________

Consider: Yes__No__

Practices & Procedures _______ Waste Segregation/Hazard Reduction _____
Material Substitution _________ Equipment Modification _____
New Product &/or Process _____ Recycling, Reuse, & Reclamation _____

Option No. _____ : ____________________

Consider: Yes__No__

Practices & Procedures _______ Waste Segregation/Hazard Reduction _____
Material Substitution _________ Equipment Modification _____
New Product &/or Process _____ Recycling, Reuse, & Reclamation _____

Option No. _____ : ____________________

Consider: Yes__No__

Practices & Procedures _______ Waste Segregation/Hazard Reduction _____
Material Substitution _________ Equipment Modification _____
New Product &/or Process _____ Recycling, Reuse, & Reclamation _____

Option No. _____ : ____________________

Consider: Yes__No__

Practices & Procedures _______ Waste Segregation/Hazard Reduction _____
Material Substitution _________ Equipment Modification _____
New Product &/or Process _____ Recycling, Reuse, & Reclamation _____

Worksheet 7

The purpose of this worksheet is to further document the pollution prevention options identified on Worksheet 6. The process by which options are identified should occur in an environment that encourages creativity and independent thinking. Brainstorming sessions are effective ways for individuals to generate options. Consideration of the options generated in a brainstorming session can lead to questions. Answering these questions may require additional research. Listed below are some of the sources that can help to answer questions and/or generate additional options.

- Literature searches
- Technical conferences
- Equipment exhibitions
- Trips to other plants
- Vendor surveys
- Contact with design engineers
- Contact with personnel in other departments who have participated in similar PPOAs
- Materials engineers
- Benchmarking

1.Revision No.: List the revision number for this worksheet.

2. Revision Date: List the most recent revision date for this worksheet.

3. PPOA Title or PPOA ID Code: List the PPOA Title or PPOA ID Code given on Worksheet 1.

4. Page ___ of ___: Indicate the number of this page and the total number of pages for this worksheet.

5. Option: Options generated should be numbered consecutively and placed on this worksheet (reference Worksheet 6). They may or may not be evaluated. Briefly describe each option, affected materials and product, any roadblocks to implementation, upstream and downstream impacts if implemented, and anticipated reduction quantity.

6. Consider Yes/No: If the suggestion is worth further consideration, check 'Yes'. If the suggestion will not be pursued, check 'No' and indicate briefly in the Option Description why not.

7. Practices & Procedures, Material Substitution, New Product &/or Process, Waste Segregation/ Hazard Reduction, Equipment Modification, and Recycling, Reuse, & Reclamation: Check the appropriate descriptions. See Worksheet 6 for definitions.

Worksheet 8
Level III

Revision No.: ________
Revision Date: ________
Page ________ of ________

Pollution Prevention Opportunity Assessment

Options Cost Evaluation

PPOA Title or PPOA ID Code(s): ____________________

	Option No.:	Option No.:	Option No.:	Option No.:	Option No.:
Implementation Costs					
Purchased Equipment					
Installation					
Materials					
Utility Connections					
Engineering					
Development					
Start up / Training					
Administrative					
Other					
Total Implementation Cost					
Incremental Operating Costs					
Change in Raw Materials					
Change in Maintenance					
Change in Labor					
Change in Disposal					
Other					
Annual Operating Savings/(Cost)					
Incremental Intangible Costs					
Penalties and Fines					
Future Liabilities					
Other					
Annual Intangible Savings/(Cost)					
Total Annual Savings/(Cost)					
Payback Period					

Worksheet 8

This worksheet provides a method to compare and contrast the pollution prevention options generated on Worksheet 6 from a cost perspective. The three major cost categories for weighing options are: Implementation Costs, Incremental Operating Costs, and Incremental Intangible Costs. These costs are totaled for each option considered from Worksheet 7. This worksheet will aid in completing the economic evaluation portion of Worksheet 9.

1. **Revision No.:** List the revision for this worksheet.

2. **Revision Date:** List the most recent revision date for this worksheet.

3. **Page ____of____:** Indicate the number of this page and the total number of pages for this worksheet.

4. **PPOA Title or PPOA ID Code(s):** List the PPOA Title or PPOA ID Code(s) given on Worksheet 1.

5. **Implementation Cost:** These are the one-time, first-year costs associated with the implementation of each option. Installation costs should be reported as an estimate. Implementation Cost may include materials, utility connections, site preparation, installation, engineering, procurement, start-up, training, permitting, initial catalysts and chemicals, and working capital; minus the salvage value of any existing equipment.

6. **Annual Operating Savings/(Costs):** These are the costs associated with day-to-day operations. List the incremental costs compared to the current process costs (positive for savings or negative for increased costs) that would be incurred if this option is implemented. Incremental operating costs could include waste disposal, raw material consumption, ancillary catalysts and chemicals, labor, maintenance and supplies, insurance, incremental revenues from increased / decreased production, and incremental revenues from marketable by-products.

7. **Annual Intangible Savings/(Cost):** These include hidden, liability, and other costs not immediately obvious for each option. List the incremental costs compared to the current process costs (positive for savings or negative for increased costs) that would be incurred if this option is implemented. These costs could include penalties and fines, future liabilities (storage, transportation, and disposal of hazardous waste), reporting, consulting fees, monitoring/testing, record keeping, preparedness and protective equipment, medical surveillance, manifesting, inspections, and corporate/public image.

8. **Total Annual Cost/Savings:** This is the sum of the **Annual Operating Savings/(Cost)** and the **Annual Intangible Savings/(Cost)**.

9. **Payback Period:** Divide the **Total Implementation Cost** by the **Total Annual Savings/(Cost)**.

Worksheet 9

Level III

Revision No.: ________
Revision Date: ________
Page ______ of ________

Pollution Prevention Opportunity Assessment

Weighted Sums Option Evaluation

PPOA Title or PPOA ID Code(s): ______________________________

Criteria	Weight 'W'	Option No.: ____ Scale 'S'	'WxS'	Option No.: ____ Scale 'S'	'WxS'	Option No.: ____ Scale 'S'	'WxS'	Option No.: ____ Scale 'S'	'WxS'	Option No.: ____ Scale 'S'	'WxS'
Public Health, Safety, & Environment	10										
Employee Health & Safety	10										
Regulatory Compliance	8										
Economic	6										
Implementation Period	4										
Improved Operation / Product	2										
Other											
Subtotal											
Likelihood of Technical Success (Multiplier)		x		x		x		x		x	
Likelihood of Useful Results (Multiplier)		x		x		x		x		x	
Total											
Rank											

Many pollution prevention options will be identified in a successful assessment. At this point, it is necessary to identify those options that offer real potential to minimize waste and reduce costs. Worksheet 9 serves as a screening tool to prioritize or eliminate suggested options.

1. **Revision No.:** List the revision number for this worksheet.

2. **Revision Date:** List the most recent revision date for this worksheet.

3. **Page ____ of ____:** Indicate the number of this page and the total number of pages for this worksheet.

4. **PPOA Title or PPOA ID Code(s):** List the PPOA Title or PPOA ID Code(s) given on Worksheet 1.

Additional Instructions:

a. The values in the Weight column (designated by 'W') represent the facility's priority for the criteria.

b. In the Scale column for each option (designated by 'S'), rate each criteria by assigning a value from 0-10 (lowest to highest). Use the definitions which follow to help determine a value.

c. In the 'W x S' column for each option, enter the product of the weight and scale.

d. Sum the 'W x S' column for each option to obtain a subtotal.

e. Multiply the subtotal for each option by the Likelihood of Technical Success.

f. Multiply the value in step e. above for each option by the Likelihood of Useful Results.

g. Enter the product found in step f. in the Total column for each option.

h. Assign a priority rank for each option; #1 for the highest score, #2 for the next highest, and so on.

Worksheet 9 -- (Scale & Multiplier Definitions)

Scale Factor Definitions (0-10)

	Public Health, Safety, & Environment -- Health or safety risk to the general public or damage to the environment.
10	Reduce the risk of loss of life or long-term environmental damage. High concentrations of hazardous materials.
8	Reduce the risk of long-term disability or moderate environmental damage. Moderate concentrations of hazardous materials.
6	Reduce the risk of short-term disability or unplanned releases to the environment. Low concentrations of hazardous materials.
4	No effect.
0	Negative effect.

	Employee Health & Safety -- Health or safety risk to an employee, contractor, or visitor.
10	Reduce the risk of loss of life through an accident or long-term exposure.
8	Reduce the risk of permanent or long-term disability through an accident or long-term exposure.
6	Reduce the risk of short-term disability or lost-time through an accident or long-term exposure.
4	No effect.
0	Negative effect.

	Regulatory Compliance -- Risk of non-compliance to regulatory laws with respect to employees or managers.
10	Reduce the risk and avoid criminal penalties.
8	Reduce the risk and avoid civil penalties.
6	Reduce the risk.
4	No effect.
0	Negative impact.

	Economic -- Potential for cost savings and payback period.
10	Large savings and short payback.
8	Moderate savings and moderate payback.
6	Positive cost savings and extented payback.
4	No cost savings and no possibility of payback.
0	Negative cost savings.

	Implementation Period -- Potential for rapid implementation of pollution prevention options.
10	Immediate (e.g., within 1 month).
8	Short-term (e.g., within 1 year).
6	Intermediate (e.g., within 2 years).
4	Long-term (e.g., within 3 years).
0	Greater than 3 years.

	Improved Operation / Product -- Quality improvement to process or product.
10	Significant improvement.
8	Moderate improvement.
6	Positive improvement.
4	No improvement.
0	Negative effect.

Worksheet 9 -- (Scale & Multiplier Definitions)

Multiplier Definitions (0-1)

	Likelihood of Technical Success
1	High likelihood: No major technical breakthrough required. Well-designed plans to meet objectives and successful track record exists.
0.5	Medium likelihood: Technical advancements may be necessary. Key issues are identified but no specific contingency plans have been made.
0.1	Low likelihood: Major technical breakthroughs are required. Adequate plans for meeting objectives or key problems have not been identified.

	Likelihood of Useful Results
1	High likelihood: Project has demonstrated that it can meet production requirements. There is a high confidence that implementation will not create unacceptable risks. Benefits outweigh the costs.
0.5	Medium likelihood: Project has not yet demonstrated that it can meet production requirements. There are reservations that implementation can be achieved without creating unacceptable risks. Benefits do not clearly outweigh the costs.
0.1	Low likelihood: The option is not capable of demonstrating that it can meet production requirements. Serious reservations are present that implementation can be achieved without creating unacceptable risks. Costs significantly outweigh the benefits.

Worksheet 10
Level III

Revision No.:______
Revision Date:______
Page _____ of _____

Pollution Prevention Opportunity Assessment
Final Report Check Sheet

PPOA Title or PPOA ID Code(s): ______________________________

Requirement	***Completed***
Title Page	____
PPOA Title	
PPOA ID Code(s)	
Team members	
Issue date/revision date/revision no.	
Executive Summary	____
Process description	
Process assessment	
Option summary and analysis	
Conclusions	
Recommendations	
Introduction	____
Background of evaluation	
Process Description	____
Associated equipment	
Process flow diagram	
Process Assessment	____
Methodology	
Material Balance	
Unusual occurrences	
Option Summary and Analysis	____
Option description and rank	
Upstream/Downstream impacts	
Material usage	
Anticipated reduction	
Estimated costs	
Estimated benefits	
Feasibility	
Waste streams affected	
Conclusion	____
Concluding evaluation	
Option analysis decisions	
Concerns	
Options already implemented	
Lessons learned	
Recommendations	____
Future work	
New equipment	
Implementation strategies	
Worksheets	____
1-10	

Worksheet 10

A final report is required for each PPOA. The final report is a compilation of essential facts about the process, pollution prevention options, feasibility and impact of those options, and future implementation costs. The report documents the work performed and identifies funding requirements necessary to implement pollution prevention options. The length of the final report will depend on the complexity of the PPOA.

1. Revision No.: List the revision number for this worksheet.

2. Revision Date: List the most recent revision date for this worksheet.

3. Page____of____: Indicate the number of this page and the total number of pages for this worksheet.

4. PPOA Title or PPOA ID Code(s): List the PPOA Title or PPOA ID Code(s) given on Worksheet 1.

5. While writing the final report, check the blank next to each major **requirement** as all elements of that task are **completed**.

Title Page	Uniquely identify the PPOA, including team members and issue/revision date.
Executive Summary	This should be an overview of all of the elements of the final PPOA report. It should relate to the reader any information that is critical about this PPOA.
Introduction	Present background information and efforts taken to initiate the PPOA.
Process Description	Detail process flow and associated equipment. Include process flow diagram, if desired.
Process Assessment	Describe the approach used to complete the PPOA. Document any assumptions made. Include information on the material balance.
Option Summary & Analysis	Present the options generated, impacts if implemented, and their respective pollution prevention possibilities.
Conclusion	Provide closure to the report. The team's consensus on the benefits achieved from this PPOA or any concerns respective to the process should be included.
Recommendations	Describe any actions that will be taken to further advance the results of this PPOA.

Worksheet 1S
Level I

Date: ________
Page ______ of ______

Pollution Prevention Opportunity Assessment

Team & Process Description

Title:

PPOA ID Code:

Team Members (*Leader)	Job Classification	Phone
*		

Process Description:

Potential for Pollution Prevention or Recommendations:

Worksheet 1S

This worksheet provides the scope and identification of the pollution prevention opportunity assessment (PPOA) team. For the PPOA to be successful, employees involved with the activity being assessed should be members of the team. The assessment team needs a leader, members, and additional resources, as required.

The team leader should have technical knowledge of the area's operations and the personnel involved. The leader shall assemble the team to perform the assessment. Team members may include engineers, waste generators, waste management specialists, scientists, laboratory technicians, and other line personnel. Additional resources may be utilized to provide information not available within the team. The size of the team may be large for complicated operations, but should be kept to a minimum to maintain focus.

1. **Date:** List the initiation date for this PPOA.

2. **Title:** List the PPOA title selected by the team.

3. **PPOA ID Code:** List the PPOA ID Code selected by the team. This should be a unique identifier.

4. **Team Members, Job Classification, Phone:** To facilitate team meetings and for future reference, this information should be completed when the PPOA team is formed.

5. **Process Description:** This should detail important attributes of the operation. Equipment, summary of operations performed, controls, input materials, and operator training (qualification or certification) may be included.

6. **Potential for Pollution Prevention or Recommendations:** For this process, describe the potential for pollution prevention, source reduction, and/or waste minimization. (Is there any pollution prevention potential for the following changes: material substitution, procedures, process parameters, equipment, general practices, recycling, reuse, reclamation, etc.?) Are there any recommendations for this process?

Worksheet 2S

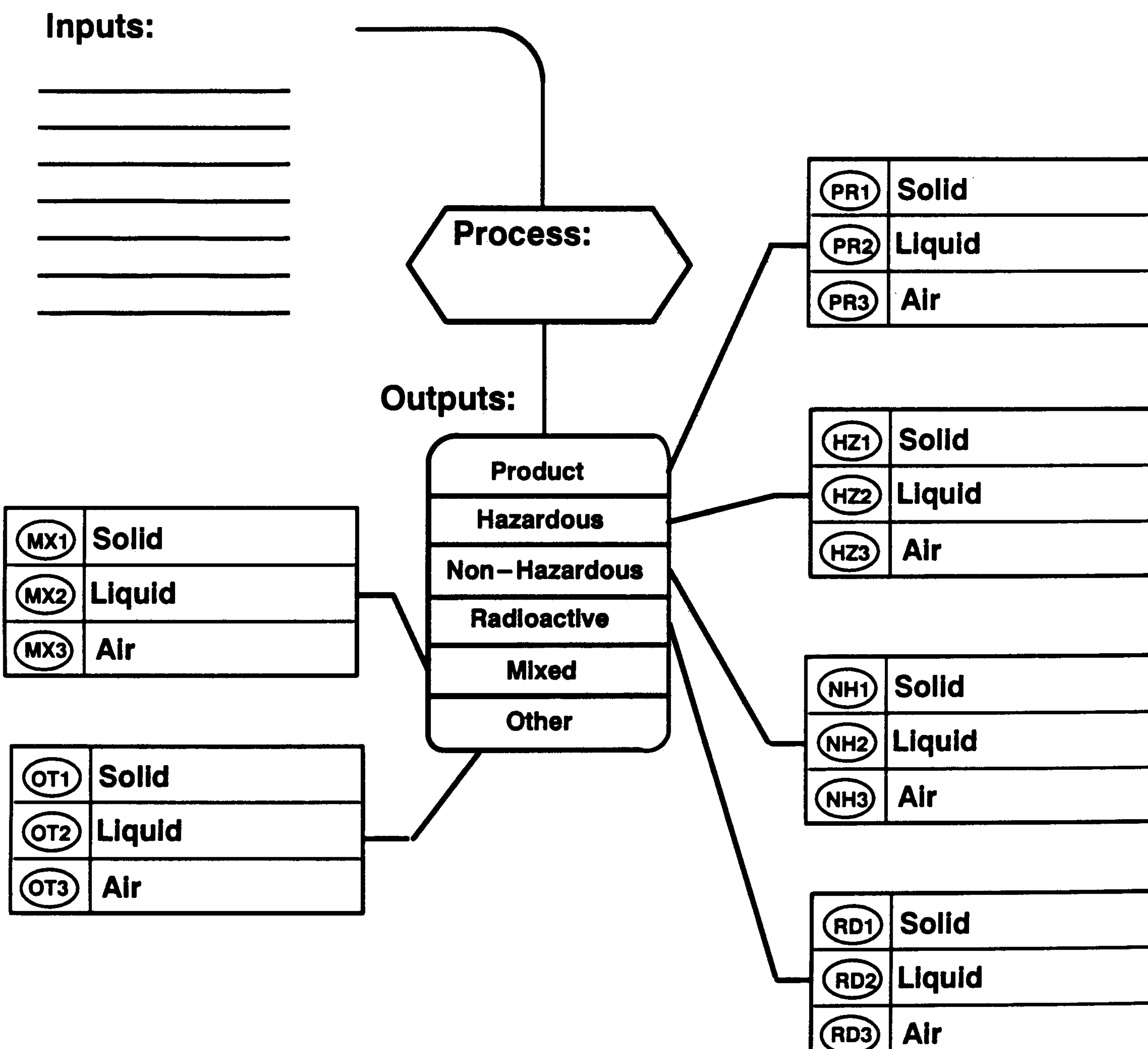
Level I

Date: ______

Pollution Prevention Opportunity Assessment

Process Flow Diagram

Title or Assessment ID Code: ______________________________



Worksheet 2S

This worksheet provides a method to document the process flow diagram for the assessment. The flow diagram should identify all Assessment Code(s) associated with the process, all input materials, and outputs (products/wastes). The flow diagram should track materials from the time they enter the process boundary until they leave. This diagram represents a very simplistic flow model; a more detailed diagram may be required to identify all waste streams, especially for complex, multi-step processes.

1. **Title or Assessment ID Code(s)**: List the PPOA Title or PPOA ID Code given on Worksheet 1S.

2. **Page ____of ____:** Indicate the page number for this worksheet and the number of pages for this worksheet.

3. **Inputs**: List the input materials on the lines provided. Fill in the Process Name box. Then highlight those outputs that are applicable to the process (e.g. Product, Hazardous, etc.). Then sub-categorize those outputs into solid, liquid, or air emission streams by highlighting the corresponding output stream. A **Stream ID Code** is provided for each sub-category of waste.

4. **Outputs:** The Stream ID Code provides a uniform coding scheme for the release information. A brief waste description may be recorded in the box to the right of the Stream ID Code. The code information is summarized in the table below:

Stream ID Codes

Designator	Code
Product	PR
Hazardous	HZ
Non-Hazardous	NH
Radioactive	RD
Mixed	MX
Other	OT

Solid Stream = 1, Liquid Stream = 2, Air Stream = 3

Worksheet 3S

Level I

Page ______ of ______

Pollution Prevention Opportunity Assessment

Material & Waste Stream Summary

Title: ______

PPOA ID Code: ______

Input Material	Annual Quantity Used	% Product	% Recycled	Total Releases % Air	% Liquid	% Solid

Does the process require further analysis based on the site's Priority Material/Waste Stream List? Yes ______ No ______

Level II ______ Level III ______

Worksheet 3S

This worksheet provides a brief summary of the input materials and output streams from the operation or activity being assessed. Its purpose is to provide the pollution prevention team an overview of the waste streams resulting from the PPOA.

1. **Title:** List the PPOA title given on Worksheet 1S.

2. **Assessment ID Code:** List the PPOA ID Code given on Worksheet 1S.

3. **Input Material:** List the material names which enter the operation.

4. **Annual Quantity Used:** Enter the annual quantity used for each material listed - include the unit of measure, e.g., lbs, curies, etc. For input material from another process, it may be helpful to also identify the release components of those materials.

5. **% Product:** For each input material, estimate the percent of the annual quantity used which goes to product.

6. **% Recycled:** For each input material, estimate the percent of the annual quantity used which is recycled.

7. **% Air:** For each input material, estimate the percent of the annual quantity used which is an air waste stream.

8. **% Liquid:** For each input material, estimate the percent of the annual quantity used which is a liquid waste stream.

9. **% Solid:** For each input material, estimate the percent of the annual quantity used which is a solid waste stream.

10. **Does the process require further analysis based on the site's Priority Material/Waste Stream List?** Using your site's Priority Material/Waste Stream List and the DOE Graded Approach Logic Diagram, determine if further assessment is necessary. If yes, indicate the level of assessment required.

Worksheet 4S
Level II

Page ______ of ______

Pollution Prevention Opportunity Assessment

Option Summary

Title or PPOA ID Code(s) ____________________

Option No. __: ____________________

Type (*)	Consider?	Feasibility	Estimated Cost	Estimated Savings	Anticipated Reduction Qty

Option No. __: ____________________

Type (*)	Consider?	Feasibility	Estimated Cost	Estimated Savings	Anticipated Reduction Qty

Option No. __: ____________________

Type (*)	Consider?	Feasibility	Estimated Cost	Estimated Savings	Anticipated Reduction Qty

(*) Type = Source Reduction, Recycling, Treatment, or Disposal

Worksheet 4S

This summary sheet serves as a method to record and evaluate the options that have been identified during brainstorming sessions or other option generating techniques.

1. **Title or PPOA ID Code(s)**: List the PPOA Title or PPOA ID Code given on Worksheet 1S.

2. **Option :** Options generated should be numbered consecutively. Briefly describe each option, affected materials, waste streams, upstream/downstream impacts if implemented, and anticipated reduction quantity if implemented.

3. **Type:** Indicate whether the option is source reduction, recycling, treatment, or disposal.

4. **Consider?:** If the option is worth further consideration, enter YES. If not, enter NO and briefly indicate in the Option Description why not.

5. **Feasibility**: Provide a brief description. (Excellent, good, fair, poor)

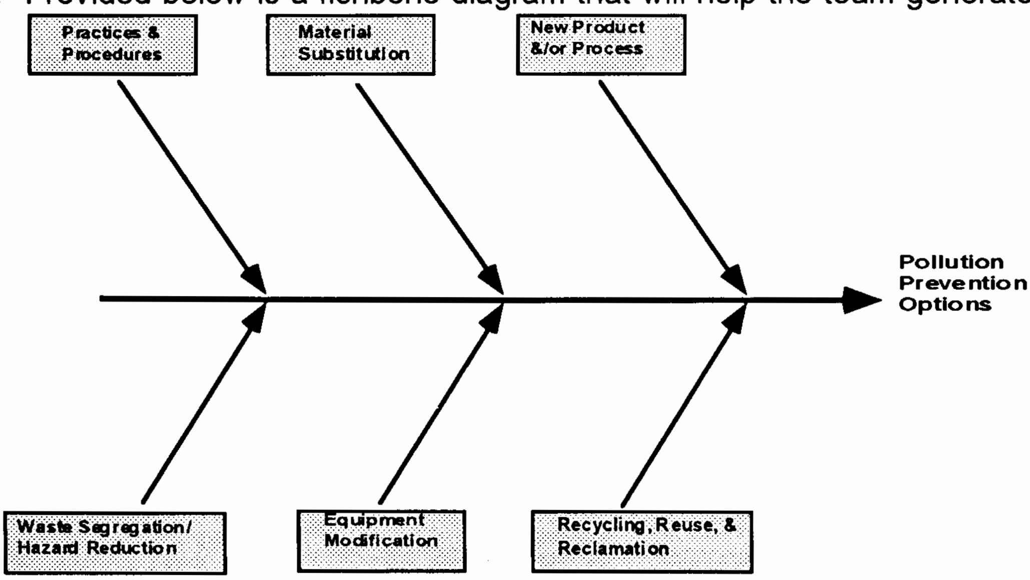
6. **Estimated Cost**: Estimate an implementation cost.

7. **Estimated Cost Savings**: Estimate the cost savings.

8. **Anticipated Reduction Qty.**: Estimate the weight or volume of the waste that will be reduced.

Note: Typically, it is difficult to estimate the anticipated waste reduction or cost avoidance in the initial phases of implementation because of many factors. However, for some options, especially in cases where the option provides complete elimination of a hazardous material or waste stream, these estimates can be accurately completed.

The process by which options are identified should occur in an environment that encourages creativity and independent thinking. Brainstorming sessions are effective ways for individuals to generate options. To make these sessions beneficial, research is often necessary. Provided below is a fishbone diagram that will help the team generate ideas.



Worksheet 5S

Level II

Date: __________

Page ______ **of** ______

Pollution Prevention Opportunity Assessment

Final Summary

Title:

PPOA ID Code(s):

Assessment:

Conclusions:

Recommendations:

Worksheet 5S

This sheet provides a brief summary of other pertinent information about the activity being assessed. Its purpose is to document how this assessment was performed, the conclusions reached by the team, and the recommendations for further actions.

1. **Date:** List the date this sheet was completed.

2. **Title:** List the title given on Worksheet 1S.

3. **PPOA ID Code(s):** List the ID Code(s) given on Worksheet 1S.

4. **Assessment:** Briefly describe the approach (methodology) used to complete this assessment and any assumptions made.

5. **Conclusions:** Briefly describe the waste streams or input material to be minimized, benefits achieved from this assessment, and any concerns (environmental or health risks) associated with the material or operation.

6. **Recommendations:** Briefly describe any actions that should or will be taken in respect to this assessment.

APPENDIX H

REFERENCES

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EPA/625/7-88/003
July 1988

Waste Minimization Opportunity Assessment Manual

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Notice

This report has been reviewed by the Hazardous Waste Engineering Research Laboratory, U.S. Environmental Protection Agency, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the U.S. Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

Users are encouraged to duplicate those portions of the manual as needed to implement a waste minimization program. Organizations interested in publishing and distributing the entire manual should contact the Alternative Technologies Division, Hazardous Waste Engineering Research Laboratory, U.S. Environmental Protection Agency, Cincinnati, Ohio 45268, to obtain a reproducible master.

Foreword

The term, "waste minimization" is heard increasingly at meetings and conferences of individuals working in the field of hazardous waste management. Waste minimization is an umbrella term that includes the first two categories of the EPA's preferred hazardous waste management strategy which is shown below:

1. Source Reduction: Reduce the amount of waste at the source, through changes in industrial processes.
2. Recycling: Reuse and recycle wastes for the original or some other purpose, such as materials recovery or energy production.
3. Incineration/Treatment: Destroy, detoxify, and neutralize wastes into less harmful substances.
4. Secure Land Disposal: Deposit wastes on land using volume reduction, encapsulation, leachate containment, monitoring, and controlled air and surface/subsurface waste releases.

In carrying out its program to encourage the adoption of waste minimization, the Hazardous Waste Engineering Research Laboratory has supported the development of a recommended procedure for identifying waste minimization applications. This manual describes that procedure and will be of interest to those responsible for reducing waste streams, and to those interested in learning about waste minimization in general.

Contents

List of Worksheets

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Harry M. Freeman of the U.S. Environmental Protection Agency, Office of Research and Development, Hazardous Waste Engineering Research Laboratory, was the project officer responsible for the preparation of this manual. Special acknowledgment is given to Myles Morse of the U.S. Environmental Protection Agency, Office of Solid Waste, for his assistance and comments. James Lounsbury and Roger Schecter of the EPA Office of Solid Waste are also acknowledged for their assistance in the preparation of this manual.

This manual was developed by the Hazardous and Toxic Materials Division of Jacobs Engineering Group as a subcontractor to Versar, Inc. Marvin Drabkin was the project manager for Versar. Participating in the preparation of this manual for Jacobs were Gregory A. Lorton, Carl H. Fromm, Michael P. Meltzer, Deborah A. Hanlon, Sally Lawrence, Michael S. Callahan, and Srinivas Budaraju.

Section 1
Introduction

Waste minimization (WM) has been successful for many organizations. By following the procedures outlined in this manual, a waste generator can:

- Save money by reducing waste treatment and disposal costs, raw material purchases, and other operating costs.
- Meet state and national waste minimization policy goals.
- Reduce potential environmental liabilities.
- Protect public health and worker health and safety.
- Protect the environment.

Waste minimization is a policy specifically mandated by the U. S. Congress in the 1984 Hazardous and Solid Wastes Amendments to the Resource Conservation and Recovery Act (RCRA). This mandate, coupled with other RCRA provisions that have led to unprecedented increases in the costs of waste management, have heightened general interest in waste minimization. A strong contributing factor has been a desire on the part of generators to reduce their environmental impairment liabilities under the provisions of the Comprehensive Environmental Response, Compensation, and Liabilities Act (CERCLA, or "Superfund"). Because of these increasing costs and liability exposure, waste minimization has become more and more attractive economically.

The following terms, used throughout this manual, are defined below:

Waste Minimization (WM). In the working definition currently used by EPA, waste minimization consists of *source reduction* and *recycling*. This concept of waste minimization is presented in Figure 1-1. Of the two approaches, source reduction is usually preferable to recycling from an environmental perspective. Source reduction and recycling each are comprised of a number of practices and approaches which are illustrated in Figure 1-2.

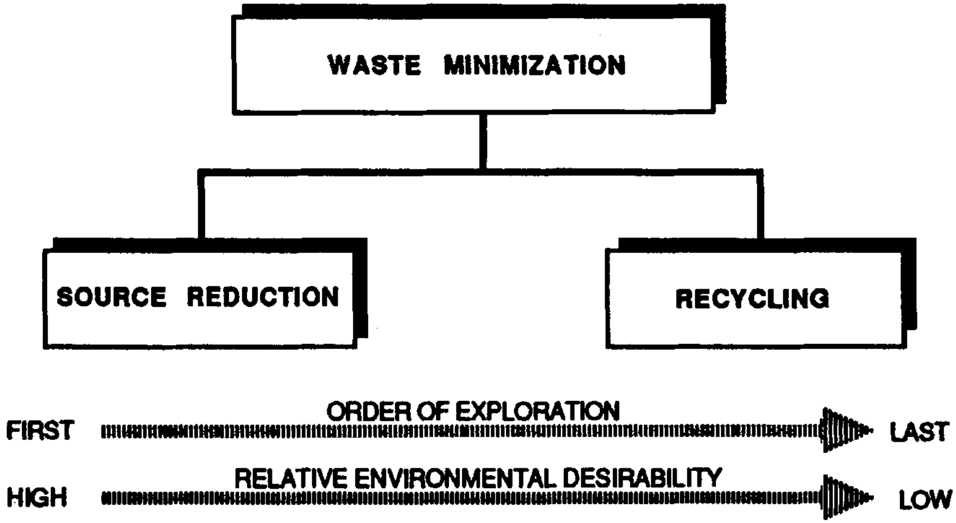
The present focus of WM activities is on hazardous wastes, as defined in RCRA. However, it is important that all pollutant emissions into air, water and land be considered as part of a waste minimization program. The transfer of pollutants from one medium to another is not waste minimization. For example, the removal of organics from wastewater using activated carbon, in and of itself, is not waste minimization, since the pollutants are merely transferred from one medium (wastewater) to another (carbon, as solid waste).

Waste minimization program (WMP). The RCRA regulations require that generators of hazardous waste "have a program in place to reduce the volume and toxicity of waste generated to the extent that is economically practical." A waste minimization program is an organized, comprehensive, and continual effort to systematically reduce waste generation. Generally, a program is established for the organization as a whole. Its components may include specific waste minimization projects and may use waste minimization assessments as a tool for determining where and how waste can be reduced. A waste minimization program should reflect the goals and policies for waste minimization set by the organization's management. Also, the program should be an ongoing effort and should strive to make waste minimization part of the company's operating philosophy. While the main goal of a waste minimization program is to reduce or eliminate waste, it may also bring about an improvement in a company's production efficiency.

EPA will publish separate guidance on the elements of effective waste minimization programs. This guidance will discuss the following elements likely to be found in an effective WM program:

- Top management support
- Explicit program scope and objectives
- Accurate waste accounting
- Accurate cost accounting
- Pervasive waste minimization philosophy
- Technology transfer

Waste minimization assessment (WMA). A waste minimization assessment is a systematic planned procedure with the objective of identifying ways to reduce or eliminate waste. The steps involved in conducting a waste minimization assessment are outlined in Figure 1-3. The assessment consists of a careful review of a plant's operations and waste streams, and the selection of specific areas to assess. After a specific waste stream or area is established as the WMA focus, a number of options with the potential to minimize waste are developed and screened. Third, the technical and economic feasibility of the selected options are evaluated. Finally, the most promising options are selected for implementation.



WASTE MINIMIZATION

The reduction, to the extent feasible, of hazardous waste that is generated or subsequently treated, stored or disposed of. It includes any source reduction or recycling activity undertaken by a generator that results in either (1) the reduction of total volume or quantity of hazardous waste or (2) the reduction of toxicity of the hazardous waste, or both, so long as such reduction is consistent with the goal of minimizing present and future threats to human health and the environment (EPA's Report to Congress, 1986, EPA/530-SW-86-033).

SOURCE REDUCTION

Any activity that reduces or eliminates the generation of hazardous waste at the source, usually within a process (op. cit.).

RECYCLING

A material is "recycled" if it is used, reused, or reclaimed (40 CFR 261.1 (c) (7)). A material is "used or reused" if it is either (1) employed as an ingredient (including its use as an intermediate) to make a product; however a material will not satisfy this condition if distinct components of the material are recovered as separate end products (as when metals are recovered from metal containing secondary materials) or (2) employed in a particular function as an effective substitute for a commercial product (40 CFR 261.1 (c) (5)). A material is "reclaimed" if it is processed to recover a useful product or if it is regenerated. Examples include the recovery of lead values from spent batteries and the regeneration of spent solvents (40 CFR 261.1 (c) (4)).

Figure 1-1. Waste Minimization Definitions

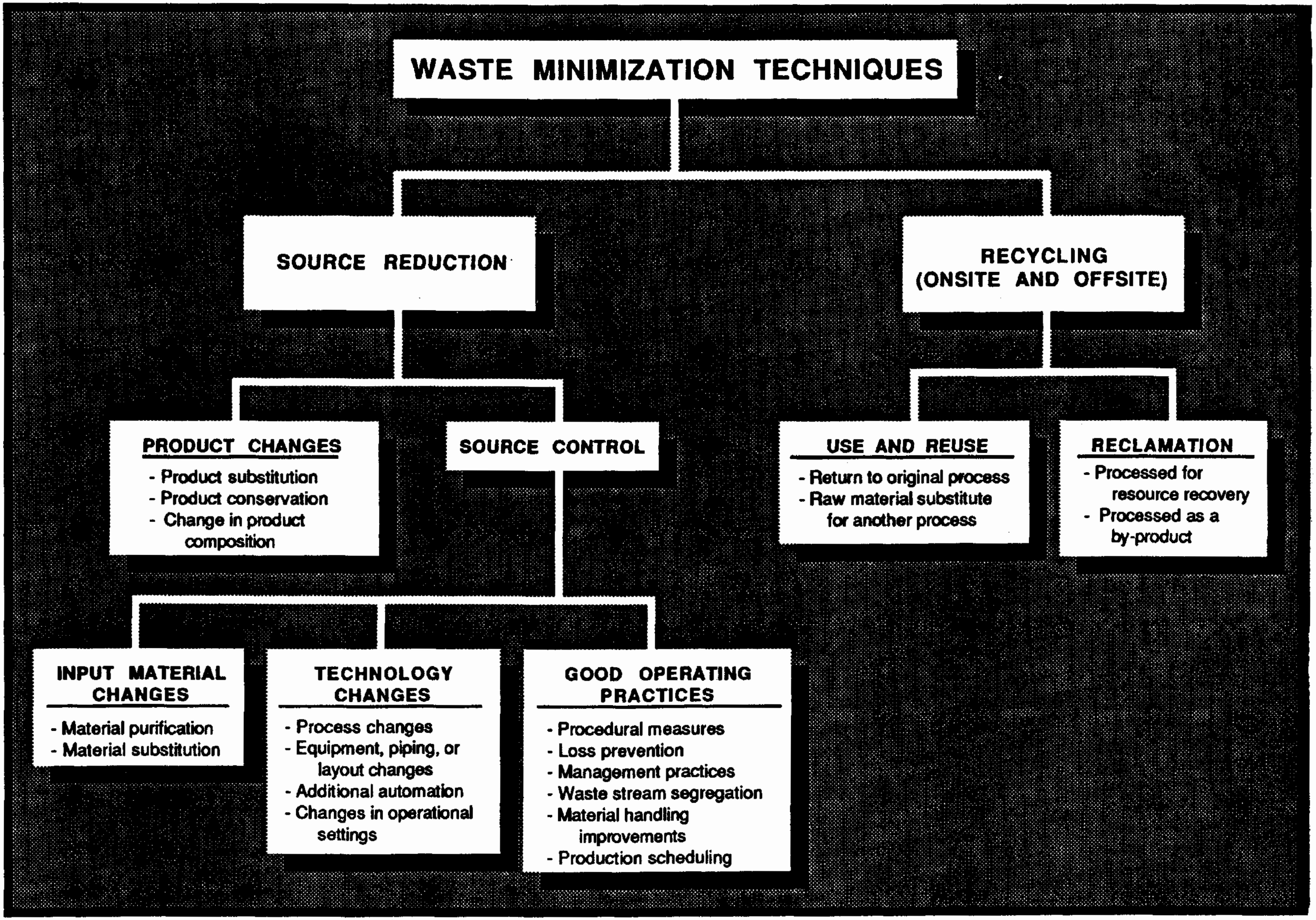
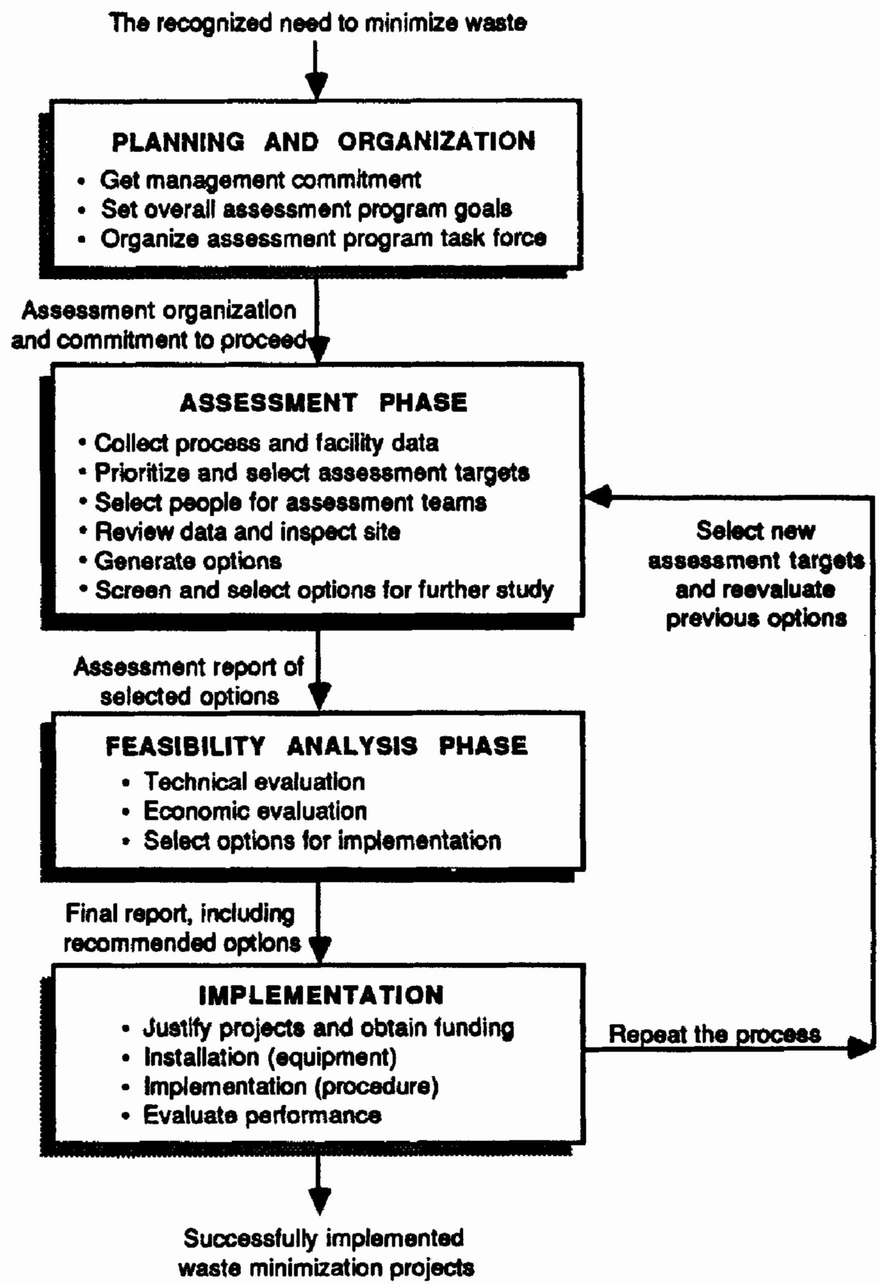


Figure 1-2. Waste Minimization Techniques

Figure 1-3. The Waste Minimization Assessment Procedure



Incentives for Waste Minimization

There are a number of compelling incentives for minimizing waste. Table 1-1 summarizes some of these incentives.

Table 1-1. Waste Minimization Incentives

Economics
- Landfill disposal cost increases.
- Costly alternative treatment technologies.
- Savings in raw material and manufacturing costs.

Regulations
- Certification of a WM program on the hazardous waste manifest.
- Biennial WM program reporting.
- Land disposal restrictions and bans.
- Increasing permitting requirements for waste handling and treatment.

Liability
- Potential reduction in generator liability for environmental problems at both onsite and offsite treatment, storage, and disposal facilities.
- Potential reduction in liability for worker safety.

Public Image and Environmental Concern
- Improved image in the community and from employees.
- Concern for improving the environment.

EPA intends to publish a manual entitled "Waste Minimization Benefits Handbook" which will discuss in detail the cost/benefit analyses of WM options.

About this manual

This manual has been prepared for those responsible for planning, managing, and implementing waste minimization activities at the plant and corporate levels. The manual concentrates on procedures that motivate people to search, screen, and put into practice measures involving administrative, material, or technology changes that result in decreased waste generation. It is also a source of concepts and ideas for developing and implementing a waste minimization program.

The manual is organized as follows:

- Section 2 outlines the planning and organizational aspects that provide a necessary foundation for a waste minimization assessment.

- Section 3 describes the assessment phase, including collecting information, selecting assessment targets, selecting assessment teams, and identifying potential WM options.

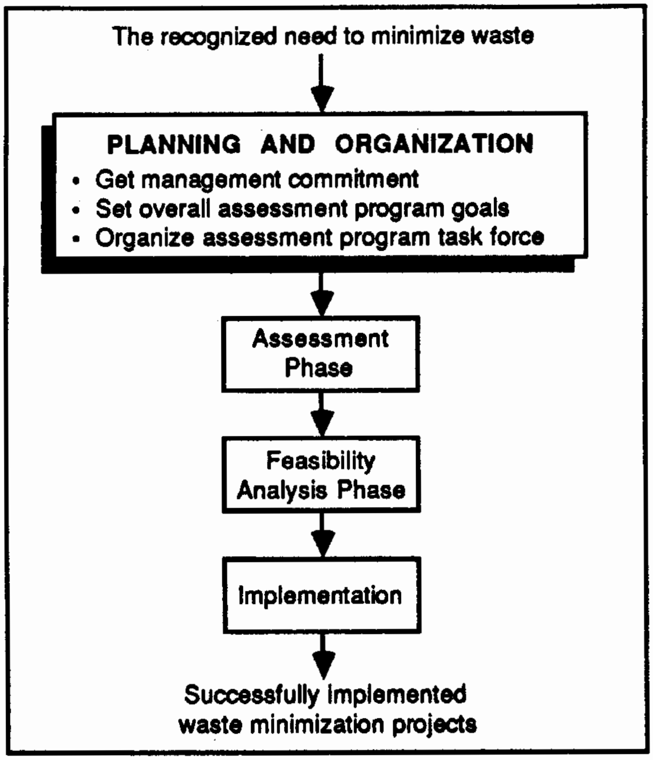
- Section 4 discusses the methods for evaluating options for technical and economic feasibility.

- Section 5 describes the implementation of attractive options: obtaining funding, installation and implementation, and measuring the effectiveness of implemented options.

A set of worksheets useful in carrying out assessments is included in Appendix A. Because individual generators' circumstances and needs vary widely, users of this manual are encouraged to modify the procedures and worksheets to fit their unique requirements. The manual is intended to serve as a point of departure, rather than as a set of rigid requirements. Accordingly, Appendix B presents a simplified set of worksheets that are designed to assist generators who are interested in performing only preliminary assessments. These worksheets also provide a useful framework for conducting assessments for small businesses and small quantity generators.

A sample assessment is presented in Appendix C. Appendix D describes waste streams from common industrial operations. Appendix E is a catalog and brief description of waste minimization techniques applicable in a number of common waste-intensive operations. Appendix F is a list of addresses and telephone numbers of state programs for technical assistance in waste minimization. Appendix G presents describes a method for screening and rating potential waste minimization options for further study. Finally, an example of an economic feasibility analysis of a large waste minimization project is presented in Appendix H.

Section 2
Planning and Organization



This section discusses factors that are important to the success of a waste minimization program. Because a comprehensive WM program affects many functional groups within a company, the program needs to bring these different groups together to reduce wastes. The formality of the program depends upon the size and complexity of the organization and its waste problems. The program structure must be flexible enough to accommodate unforeseen changes. The developmental activities of a WM program include:

- getting management commitment
- setting WM goals
- staffing the program task force

Getting Management Commitment

The management of a company will support a waste minimization program if it is convinced that the benefits of such a program will outweigh the costs. The potential benefits include economic advantages, compliance with regulations, reduction in liabilities associated with the generation of wastes, improved public image, and reduced environmental impact.

The objectives of a WM program are best conveyed to a company's employees through a formal policy statement or management directive. A company's upper management is responsible for establishing a formal commitment throughout all divisions of the organization. The person in charge of the company's environmental affairs is responsible to advise management of the importance of waste minimization and the need for this formal commitment. An example of a formal policy statement follows:

CORPORATE ENVIRONMENTAL POLICY

[A major chemical company]..."is committed to continue excellence, leadership, and stewardship in protecting the environment. Environmental protection is a primary management responsibility, as well as the responsibility of every employee.

In keeping with this policy, our objective as a company is to reduce waste and achieve minimal adverse impact on the air, water, and land through excellence in environmental control.

The Environmental Guidelines include the following points:

- Environmental protection is a line responsibility and an important measure of employee performance. In addition, every employee is responsible for environmental protection in the same manner he or she is for safety.

- Minimizing or eliminating the generation of waste has been and continues to be a prime consideration in research, process design, and plant operations; and is viewed by management like safety, yield, and loss prevention.

- Reuse and recycling of materials has been and will continue to be given first consideration prior to classification and disposal of waste."

Involve Employees

Although management commitment and direction are fundamental to the success of a waste minimization program, commitment throughout an organization is necessary in order to resolve conflicts and to remove barriers to the WM program. Employees often cause the generation of waste, and they can contribute to the overall success of the program. Bonuses, awards, plaques, and other forms of recognition are often used to provide motivation, and to boost employee cooperation and participation. In some companies, meeting the waste minimization goals is used as a measure for evaluating the job performance of managers and employees.

Cause Champions

Any WM program needs one or more people to champion the cause. These "cause champions" help overcome the inertia present when changes to an existing operation are proposed. They also lead the WM program, either formally or informally. An environmental engineer, production manager, or plant process engineer may be a good candidate for this role. Regardless of who takes the lead, this cause champion must be given enough authority to effectively carry out the program.

Organizing a WM Program: The Program Task Force

The WM program will affect a number of groups within a company. For this reason, a program task force should be assembled. This group should include members of any group or department in the company that has a significant interest in the outcome of the program. Table 2-4 at the end of this section and Worksheet 3 in Appendix A lists departments or groups of a typical manufacturing company that should be involved in the program.

The formality or informality of the WM program will depend on the nature of the company. The program in a large highly structured company will probably develop to be quite formal, in contrast to a small company, or a company in a dynamic industry, where the organizational structure changes frequently.

Table 2-1 lists the typical responsibilities of a WM program task force. It will draw on expertise within the company as required. The scope of the program will determine whether full-time participation is required by any of the team members.

Table 2-1. Responsibilities of the WM Program Task Force

- Get commitment and a statement of policy from management.
- Establish overall WM program goals.
- Establish a waste tracking system.
- Prioritize the waste streams or facility areas for assessment.
- Select assessment teams.
- Conduct (or supervise) assessments.
- Conduct (or monitor) technical/economic feasibility analyses of favorable options.
- Select and justify feasible options for implementation.
- Obtain funding and establish schedule for implementation.
- Monitor (and/or direct) implementation progress.
- Monitor performance of the option, once it is operating.

In a small company, several people at most will be all that are required to implement a WM program. Include the people with responsibility for production, facilities, maintenance, quality control, and waste treatment and disposal on the team. It may be that a single person, such as the plant manager, has all of these responsibilities at a small facility. However, even at a small facility, at least two people should be involved to get a variety of viewpoints and perspectives.

Some larger companies have developed a system in which assessment teams periodically visit different facilities within the company. The benefits result through sharing the ideas and experiences with other divisions. Similar results can be achieved with periodic in-house seminars, workshops, or meetings. A large chemical manufacturer held a corporate-wide symposium in 1986 dealing specifically with waste minimization. The company has also developed other programs to increase company-wide awareness of waste minimization, including an internally published newsletter and videotape.

Setting Goals

The first priority of the WM program task force is to establish goals that are consistent with the policy adopted by management. Waste minimization goals can be qualitative, for example, "a significant reduction of toxic substance emissions into the environment." However, it is better to establish measurable, quantifiable goals, since qualitative goals can be interpreted ambiguously. Quantifiable goals establish a clear guide as to the degree of sucess expected of the program. A major chemical company has adopted a corporate-wide goal of 5% waste reduction per year. In addition, each facility within the company has set its own waste minimization goals.

As part of its general policy on hazardous waste, a large defense contractor has established an ambitious corporate-wide goal of zero discharge of hazardous wastes from its facilities by the end of 1988. Each division within the corporation is given the responsibility and freedom to develop its own program (with intermediate goals) to meet this overall goal. This has resulted in an extensive investigation of procedures and technologies to accomplish source reduction, recycling and resource recovery, and onsite treatment.

Table 2-2 lists the qualities that goals should possess. It is important that the company's overall waste minimization goals be incorporated into the appropriate individual departmental goals.

The goals of the program should be reviewed periodically. As the focus of the WM program becomes more defined, the goals should be changed to reflect any changes. Waste minimization assessments are not intended to be a one-time project. Periodic reevaluation of goals is recommended due to changes, for example, in available technology, raw

Table 2-2. Attributes of Effective Goals

- ACCEPTABLE to those who will work to achieve them.
- FLEXIBLE and adaptable to changing requirements.
- MEASURABLE over time.
- MOTIVATIONAL.
- SUITABLE to the overall corporate goals and mission.
- UNDERSTANDABLE.
- ACHIEVABLE with a practical level of effort.

Source: Pearce and Robinson, Strategic Management (1985)

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material supplies, environmental regulations, and economic climate.

Overcoming Barriers

As it sets goals for waste minimization and then defines specific objectives that can be achieved, the program task force should recognize potential barriers. Although waste minimization projects can reduce operating costs and improve environmental compliance, they can lead to conflicts between different groups within the company. Table 2-3 lists examples of jurisdictional conflicts that can arise during the implementation of a waste minimization project.

In addition to jurisdictional conflicts related to these objective barriers, there are attitude-related barriers that can disrupt a WM program. A commonly held attitude is "If it ain't broke, don't fix it!" This attitude stems from the desire to maintain the status quo and avoid the unknown. It is also based on the fear that a new WM option may not work as advertised. Without the commitment to carefully conceive and implement the option, this attitude can become a self-fulfilling prophecy. Management must declare that "It is broke!"

Another attitude-related barrier is the feeling that "It just won't work!" This response is often given when a person does not fully understand the nature of the proposed option and its impact on operations. The danger here is that promising options may be dropped before they can be evaluated. One way to avoid this is to use idea-generating sessions (e.g., brainstorming). This encourages participants to propose a large number of options, which are individually evaluated on their merits.

An often-encountered barrier is the fear that the WM option will diminish product quality. This is particularly common in situations where unused feed materials are recovered from the waste and then recycled back to the process. The deterioration of product quality can be a valid concern if unacceptable concentrations of waste materials build up in the system. The best way to allay this concern is to set up a small-scale demonstration in the facility, or to observe the particular option in operation at another facility.

Table 2-3. Examples of Barriers to Waste Minimization

Production
- A new operating procedure will reduce waste but may also be a bottleneck that decreases the overall production rate.
- Production will be stopped while the new process equipment is installed.
- A new piece of equipment has not been demonstrated in a similar service. It may not work here.

Facilities/Maintenance
- Adequate space is not available for the installation of new equipment.
- Adequate utilities are not available for the new equipment.
- Engineering or construction manpower will not be available in time to meet the project schedule.
- Extensive maintenance may be required.

Quality Control
- More intensive QC may be needed.
- More rework may be required.

Client Relations/Marketing
- Changes in product characteristics may affect customer acceptance.

Inventory
- A program to reduce inventory (to avoid material deterioration and reprocessing) may lead to stockouts during high product demand.

Finance
- There is not enough money to fund the project.

Purchasing
- Existing stocks (or binding contracts) will delay the replacement of a hazardous material with a non-hazardous substitute.

Environmental
- Accepting another plant's waste as a feedstock may require a lengthy resolution of regulatory issues.

Waste Treatment
- Use of a new nonhazardous raw material will adversely impact the existing wastewater treatment facility.

Planning and Organization Summary

Table 2-4 provides a summary of the steps involved in planning and organizing a waste minimization program.

Assessment Worksheets

Appendix A includes a set of worksheets for use in planning and carrying out a waste minimization assessment, and implementing the selected options. Worksheet 1 summarizes the entire assessment procedure. Worksheets 2 and 3 are used to record the organization of the WM program task force and the individual assessment teams, respectively. Worksheet 3 includes a list of functions and departments that should be considered when organizing the assessment teams.

Table 2-4. Planning and Organization Activities Summary

SETTING UP THE PROGRAM

Get management commitment to:
- Establish waste minimization as a company goal.
- Establish a waste minimization program to meet this goal.
- Give authority to the program task force to implement this program.

Set overall goals for the program. These goals should be:
- ACCEPTABLE to those who will work to achieve them.
- FLEXIBLE to adapt to changing requirements.
- MEASURABLE over time.
- MOTIVATIONAL.
- SUITABLE to the overall corporate goals.
- UNDERSTANDABLE.
- ACHIEVABLE with a practical level of effort.

STAFFING THE PROGRAM TASK FORCE

Find a "cause champion", with the following attributes:
- Familiar with the facility, its production processes, and its waste management operations.
- Familiar with the people.
- Familiar with quality control requirements.
- Good rapport with management.
- Familiar with new production and waste management technology.
- Familiar with WM principles and techniques, and environmental regulations.
- Aggressive managerial style.

Get people who know the facility, processes, and procedures.

Get people from the affected departments or groups.
- Production.
- Facilities/Maintenance.
- Process Engineering.
- Quality Control.
- Environmental.
- Research and Development.
- Safety/Health.
- Marketing/Client Relations.
- Purchasing.
- Material Control/Inventory.
- Legal.
- Finance/Accounting.
- Information Systems.

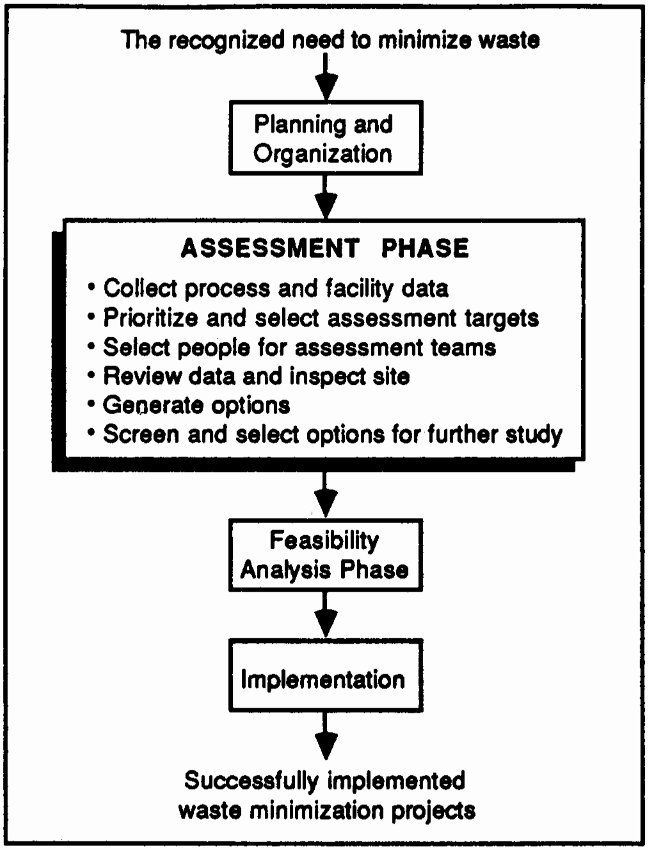
GETTING COMPANY-WIDE COMMITMENT

Incorporate the company's WM goals into departmental goals.

Solicit employee cooperation and participation.

Develop incentives and/or awards for managers and employees.

Section 3
Assessment Phase



The purpose of the assessment phase is to develop a comprehensive set of waste minimization options, and to identify the attractive options that deserve additional, more detailed analysis. In order to develop these WM options, a detailed understanding of the plant's wastes and operations is required. The assessment should begin by examining information about the processes, operations, and waste management practices at the facility.

Collecting and Compiling Data

The questions that this information gathering effort will attempt to answer include the following:

- What are the waste streams generated from the plant? And how much?
- Which processes or operations do these waste streams come from?
- Which wastes are classified as hazardous and which are not? What makes them hazardous?
- What are the input materials used that generate the waste streams of a particular process or plant area?
- How much of a particular input material enters each waste stream?
- How much of a raw material can be accounted for through fugitive losses?
- How efficient is the process?
- Are unnecessary wastes generated by mixing otherwise recyclable hazardous wastes with other process wastes?
- What types of housekeeping practices are used to limit the quantity of wastes generated?
- What types of process controls are used to improve process efficiency?

Table 3-1 lists information that can be useful in conducting the assessment. Reviewing this information will provide important background for understanding the plant's production and maintenance processes and will allow priorities to be determined. Worksheets 4 through 10 in Appendix A can be used to record the information about site characteristics, personnel, processes, input materials, products, and waste streams. Worksheets S2 through S6 in Appendix B are designed to record the same information, but in a more simplified approach.

Waste Stream Records

One of the first tasks of a waste minimization assessment is to identify and characterize the facility waste streams. Information about waste streams can come from a variety of sources. Some information on waste quantities is readily available from the completed hazardous waste manifests, which include the description and quantity of hazardous waste shipped to a TSDF. The total amount of hazardous waste shipped during a one-year period, for example, is a convenient means of measuring waste generation and waste reduction efforts. However, manifests often lack such information as chemical analysis of the waste, specific source of the waste, and the time period during which the waste was generated. Also, manifests do not cover wastewater effluents, air emissions, or nonhazardous solid wastes.

Other sources of information on waste str eams include biennial reports and NPDES (National Pollutant

Table 3-1. Facility Information for WM Assessments

Design Information
- Process flow diagrams
- Material and heat balances (both design balances and actual balances) for
  - production processes
  - pollution control processes
- Operating manuals and process descriptions
- Equipment lists
- Equipment specifications and data sheets
- Piping and instrument diagrams
- Plot and elevation plans
- Equipment layouts and work flow diagrams

Environmental Information
- Hazardous waste manifests
- Emission inventories
- Biennial hazardous waste reports
- Waste analyses
- Environmental audit reports
- Permits and/or permit applications

Raw Material/Production Information
- Product composition and batch sheets
- Material application diagrams
- Material safety data sheets
- Product and raw material inventory records
- Operator data logs
- Operating procedures
- Production schedules

Economic Information
- Waste treatment and disposal costs
- Product, utility, and raw material costs
- Operating and maintenance costs
- Departmental cost accounting reports

Other Information
- Company environmental policy statements
- Standard procedures
- Organization charts

Discharge Elimination System) monitoring reports. These NPDES monitoring reports will include the volume and constituents of wastewaters that are discharged. Additionally, toxic substance release inventories prepared under the "right to know" provisions of SARA Title III, Section 313 (Superfund Amendment and Reauthorization Act) may providevaluable information on emissions into all environmental media (land, water, and air).

Analytical test data available from previous waste evaluations and routine sampling programs can be helpful if the focus of the assessment is a particular chemical within a waste stream.

Flow Diagrams and Material Balances

Flow diagrams provide the basic means for identifying and organizing information that is useful for the assessment. Flow diagrams should be prepared to identify important process steps and to identify sources where wastes are generated. Flow diagrams are also the foundation upon which material balances are built.

Material balances are important for many WM projects, since they allow for quantifying losses or emissions that were previously unaccounted for Also, material balances assist in developing the following information:

- baseline for tracking progress of the WM efforts
- data to estimate the size and cost of additional equipment and other modifications
- data to evaluate economic performance

In its simplest form, the material balance is represented by the mass conservation principle:

$$\text{Mass in} = \text{Mass out} + \text{Mass accumulated}$$

The material balance should be made individually for all components that enter and leave the process. When chemical reactions take place in a system, there is an advantage to doing "elemental balances" for specific chemical elements in a system.

Material balances can assist in determining concentrations of waste constituents where analytical test data is limited. They are particularly useful where there are points in the production process where it is difficult (due to inaccessibility) or uneconomical to collect analytical data. A material balance can help determine if fugitive losses are occurring. For example, the evaporation of solvent from a parts cleaning tank can be estimated as the difference between solvent put into the tank and solvent removed from the tank.

To characterize waste streams by material balance can require considerable effort. However, by doing so, a more complete picture of the waste situation results. This helps to establish the focus of the WM activities and provides a baseline for measuring performance. Appendix D lists potential sources of waste from specific processes and operations.

Sources of Material Balance Information

By definition, the material balance includes both materials entering and leaving a process. Table 3-2 lists potential sources of material balance information.

Table 3-2. Sources of Material Balance Information

- Samples, analyses, and flow measurements of feed stocks, products, and waste streams
- Raw material purchase records
- Material inventories
- Emission inventories
- Equipment cleaning and validation procedures
- Batch make-up records
- Product specifications
- Design material balances
- Production records
- Operating logs
- Standard operating procedures and operating manuals
- Waste manifests

Material balances are easier, more meaningful, and more accurate when they are done for individual units, operations, or processes. For this reason, it is important to define the material balance envelope properly. The envelope should be drawn around the specifc area of concern, rather than a larger group of areas or the entire facility. An overall material balance for a facility can be constructed from individual unit material balances. This effort will highlight interrelationships between units and will help to point out areas for waste minimization by way of cooperation between different operating units or departments.

Pitfalls in Preparing Material Balances

There are several factors that must be considered when preparing material balances in order to avoid errors that could significantly overstate or understate waste streams. The precision of analytical data and flow measurements may not allow an accurate measure of the stream. In particular, in processes with very large inlet and outlet streams, the absolute error in measurement of these quantities may be greater in magnitude than the actual waste stream itself. In this case, a reliable estimate of the waste stream cannot be obtained by subtracting the quantity of hazardous material in the product from that in the feed.

The time span is important when constructing a material balance. Material balances constructed over a shorter time span require more accurate and more frequent stream monitoring in order to close the balance. Material balances performed over the duration of a complete production run are typically the easiest to construct and are reasonably accurate. Time duration also affects the use of raw material purchasing records and onsite inventories for calculating input material quantities. The quantities of materials *purchased* during a specific time period may not necessarily equal the quantity of materials *used* in production during the same time period, since purchased materials can accumulate in warehouses or stockyards.

Developing material balances around complex processes can be a complicated undertaking, especially if recycle streams are present. Such tasks are usually performed by chemical engineers, often with the assistance of computerized process simulators.

Material balances will often be needed to comply with Section 313 of SARA (Superfund Amendment and Reauthorization Act of 1986) in establishing emission inventories for specific toxic chemicals. EPA's Office of Toxic Substances (OTS) has prepared a guidance manual entitled <u>Estimating Releases and Waste Treatment Efficiencies for the Toxic Chemicals Inventory Form</u> (EPA 560/4-88-02). The OTS manual contains additional information for developing material balances for the listed toxic chemicals. The information presented in this manual applies to a WM assessment when the material balances are for individual operations being assessed rather than an overall facility, when the variations in flow over time is accounted for, and when the data is used from separate streams rather than from aggregate streams.

Tracking Wastes

Measuring waste mass flows and compositions is something that should be done periodically. By tracking wastes, seasonal variations in waste flows or single large waste streams can be distinguished from continual, constant flows. Indeed, changes in waste generation cannot be meaningfully measured unless the information is collected both before and after a waste minimization option is implemented. Fortunately, it is easier to do material balances the second time, and gets even easier as more are done because of the "learning curve" effect. In some larger companies, computerized database systems have been used to track wastes. Worksheets 9 and 10 in Appendix A (and Worksheet S6 in Appendix B) provide a means of recording pertinent waste stream characteristics.

Prioritizing Waste Streams and/or Operations to Assess

Ideally, all waste streams and plant operations should be assessed. However, prioritizing the waste streams and/or operations to assess is necessary when available funds and/or personnel are limited. The WM assessments should concentrate on the most important waste problems first, and then move on to the lower priority problems as the time, personnel, and budget permit.

Setting the priorities of waste streams or facility areas to assess requires a great deal of care and attention, since this step focuses the remainder of the assessment activity. Table 3-3 lists important criteria to consider when setting these priorities.

Table 3-3. Typical Considerations for Prioritizing Waste Streams to Assess

- Compliance with current and future regulations.
- Costs of waste management (treatment and disposal).
- Potential environmental and safety liability.
- Quantity of waste.
- Hazardous properties of the waste (including toxicity, flammability, corrosivity, and reactivity).
- Other safety hazards to employees.
- Potential for (or ease of) minimization.
- Potential for removing bottlenecks in production or waste treatment.
- Potential recovery of valuable by-products.
- Available budget for the waste minimization assessment program and projects.

Worksheet 10 in Appendix A (Worksheet S6 in Appendix B) provides a means for evaluating waste stream priorities for the remainder of the assessment.

Small businesses, or large businesses with only a few waste generating operations should assess their entire facility. It is also beneficial to look at an entire facility when there are a large number of similar operations. Similarly, the implementation of good operating practices that involve procedural or organizational measures, such as soliciting employee suggestions, awareness-building programs, better inventory and maintenance procedures, and internal cost accounting changes, should be implemented on a facility-wide basis. Since many of these options do not require large capital expenditures, they should be implemented as soon as practical.

Selecting the Assessment Teams

The WM program task force is concerned with the whole plant. However, the focus of each of the assessment teams is more specific, concentrating on a particular waste stream or a particular area of the plant. Each team should include people with direct responsibility and knowledge of the particular waste stream or area of the plant. Table 3-4 presents four examples of teams for plants of various sizes in different industries.

In addition to the internal staff, consider using outside people, especially in the assessment and implementation phases. They may be trade association representatives, consultants, or experts from a different facility of the same company. In large multi-division companies, a centralized staff of experts at the corporate headquarters may be available. One or more "outsiders" can bring in new ideas and provide an objective viewpoint. An outsider also is more likely to counteract bias brought about by "inbreeding", or

Table 3-4. Examples of WM Assessment Teams

1. Metal finishing department in a large defense contractor.
   - Metal finishing department manager
   - Process engineer responsible for metal finishing processes
   - Facilities engineer responsible for metal finishing department*
   - Wastewater treatment department supervisor
   - Staff environmental engineer

2. Small pesticide formulator.
   - Production manager*
   - Environmental manager
   - Maintenance supervisor
   - Pesticide industry consultant

3. Cyanide plating operation at a military facility.
   - Internal assessment team
     - Environmental coordinator*
     - Environmental engineer
     - Electroplating facility engineering supervisor
     - Metallurgist
     - Materials science group chemist
   - Outside assessment team
     - Chemical engineers (2)
     - Environmental engineering consultant
     - Plating chemistry consultant

4. Large offset printing facility.
   - Internal assessment team
     - Plant vice president
     - Film processing supervisor
     - Pressroom supervisor
   - Outside assessment team
     - Chemical engineers (2)*
     - Environmental scientist
     - Printing industry technical consultant

* - Team leader

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the "sacred cow" syndrome, such as when an old process area, rich in history, undergoes an assessment.

Outside consultants can bring a wide variety of experience and expertise to a waste minimization assessment. Consultants may be especially useful to smaller companies who may not have in-house expertise in the relevant waste minimization techniques and technologies.

Production operators and line employees must not be overlooked as a source of WM suggestions, since they possess firsthand knowledge and experience with the process. Their assistance is especially useful in assessing operational or procedural changes, or in equipment modifications that affect the way they do their work.

"Quality circles" have been instituted by many companies, particularly in manufacturing industries, to improve product quality and production efficiency. These quality circles consist of meetings of workers and supervisors, where improvements are proposed and evaluated. Quality circles are beneficial in that they involve the production people who are closely associated with the operations, and foster participation and commitment to improvement. Several large companies that have quality circles have used them as a means of soliciting successful suggestions for waste minimization.

Site Inspection

With a specific area or waste stream selected, and with the assessment team in place, the assessment continues with a visit to the site. In the case where the entire assessment team is employed at the plant being assessed, the team should have become very familiar with the specific area in the process of collecting the operating and design data. The members of the assessment team should familiarize themselves with the site as much as possible. Although the collected information is critical to gaining an understanding of the processes involved, seeing the site is important in order to witness the actual operation. For example, in many instances, a process unit is operated differently from the method originally described in the operating manual. Modifications may have been made to the equipment that were not recorded in the flow diagrams or equipment lists.

When people from outside of the plant participate in the assessment, it is recommended that a formal site inspection take place. Even when the team is made up entirely of plant employees, a site inspection by all team members is helpful after the site information has been collected and reviewed. The inspection helps to resolve questions or conflicting data uncovered during the review. The site inspection also provides additional information to supplement that obtained earlier.

When the assessment team includes members employed outside of the plant, the team should prepare a list of needed information and an inspection agenda. The list can be presented in the form of a checklist detailing objectives, questions and issues to be resolved, and/or further information requirements. The agenda and information list are given to the appropriate plant personnel in the areas to be assessed early enough before the visit to allow them to assemble the information in advance. Of course, it may be that the assessment team members themselves are in the best position to collect and compile much of the data. By carefully thinking out the agenda and needs list, important points are less likely to be overlooked during the inspection. Table 3-5 presents useful guidelines for the site inspection.

Table 3-5. Guidelines for the Site Inspection

- Prepare an agenda in advance that covers all points that still require clarification. Provide staff contacts in the area being assessed with the agenda several days before the inspection.
- Schedule the inspection to coincide with the particular operation that is of interest (e.g., make-up chemical addition, bath sampling, bath dumping, start-up, shutdown, etc.).
- Monitor the operation at different times during the shift, and if needed, during all three shifts, especially when waste generation is highly dependent on human involvement (e.g., in painting or parts cleaning operations).
- Interview the operators, shift supervisors, and foremen in the assessed area. Do not hesitate to question more than one person if an answer is not forthcoming. Assess the operators' and their supervisors' awareness of the waste generation aspects of the operation. Note their familiarity (or lack thereof) with the impacts their operation may have on other operations.
- Photograph the area of interest, if warranted. Photographs are valuable in the absence of plant layout drawings. Many details can be captured in photographs that otherwise could be forgotten or inaccurately recalled at a later date.
- Observe the "housekeeping" aspects of the operation. Check for signs of spills or leaks. Visit the maintenance shop and ask about any problems in keeping the equipment leak-free. Assess the overall cleanliness of the site. Pay attention to odors and fumes.
- Assess the organizational structure and level of coordination of environmental activities between various departments.
- Assess administrative controls, such as cost accounting procedures, material purchasing procedures, and waste collection procedures.

In performing the site inspection the assessment team should follow the process from the point where raw materials enter the area to the point where the products and the wastes leave the area. The team should identify the suspected sources of waste. This may include the production process; maintenance operations; storage areas for raw materials, finished product, and work-in-process. Recognize that the plant's waste treatment area itself may also offer opportunities to minimize waste. This inspection often results in forming preliminary conclusions about the causes of waste generation. Full confirmation of these conclusions may require additional data collection, analysis, and/or site visits.

Generating WM Options

Once the origins and causes of waste generation are understood, the assessment process enters the creative phase. The objective of this step is to generate a comprehensive set of WM options for further consideration. Following the collection of data and site inspections, the members of the team will have begun to identify possible ways to minimize waste in the assessed area. Identifying potential options relies both on the expertise and creativity of the team members. Much of the requisite knowledge may come from their education and on-the-job experience, however, the use of technical literature, contacts, and other sources is always helpful. Some sources of background information for waste minimization techniques are listed in Table 3-6.

Table 3-6. Sources of Background Information on WM Options

Trade associations
As part of their overall function to assist companies within their industry, trade associations generally provide assistance and information about environmental regulations and various available techniques for complying with these regulations. The information provided is especially valuable since it is industry-specific.

Plant engineers and operators
The employees that are intimately familiar with a facility's operations are often the best source of suggestions for potential WM options.

Published literature
Technical magazines, trade journals, government reports, and research briefs often contain information that can be used as waste minimization options.

State and local environmental agencies
A number of states and local agencies have, or are developing, programs that include technical assistance, information on industry-specific waste minimization techniques, and compiled bibliographies. Appendix E provides a list of addresses for state and federal programs for WM assistance.

Equipment vendors
Meetings with equipment vendors, as well as vendor literature, are particularly useful in identifying potential equipment-oriented options. Vendors are eager to assist companies in implementing projects. Remember, though, that the vendor's job is to sell equipment.

Consultants
Consultants can provide information about WM techniques. Section 2 discusses the use of consultants in WM programs. A consultant with waste minimization experience in your particular industry is most desirable.

Waste Minimization Options

The process for identifying options should follow a hierarchy in which source reduction options are explored first, followed by recycling options. This hierarchy of effort stems from the environmental desirability of source reduction as the preferred means of minimizing waste. Treatment options should be considered only after acceptable waste minimization techniques have been identified.

Recycling techniques allow hazardous materials to be put to a beneficial use. Source reduction techniques avoid the generation of hazardous wastes, thereby eliminating the problems associated with handling these wastes. Recycling techniques may be performed onsite or at an offsite facility designed to recycle the waste.

Source reduction techniques are characterized as good operating practices, technology changes, material changes, or product changes. Recycling techniques are characterized as use/reuse techniques and resource recovery techniques. These techniques are described below:

Source Reduction: Good Operating Practices

Good operating practices are procedural, administrative, or institutional measures that a company can use to minimize waste. Good operating practices apply to the human aspect of manufacturing operations. Many of these measures are used in industry largely as efficiency improvements and good management practices. Good operating practices can often be implemented with little cost and, therefore, have a high return on investment. These practices can be implemented in all areas of a plant, including production, maintenance operations, and in raw material and product storage. Good operating practices include the following:

- Waste minimization programs
- Management and personnel practices
- Material handling and inventory practices
- Loss prevention
- Waste segregation
- Cost accounting practices
- Production scheduling

Management and personnel practices include employee training, incentives and bonuses, and other programs that encourage employees to conscientiously strive to reduce waste. Material handling and inventory practices include programs to reduce loss of input materials due to mishandling, expired shelf life of time-sensitive materials, and proper storage conditions. Loss prevention minimizes wastes by avoiding leaks from equipment and spills. Waste segregation practices reduce the volume of hazardous wastes by preventing the mixing of hazardous and nonhazardous wastes. Cost accounting practices include programs to allocate waste treatment and disposal costs directly to the departments or groups that generate waste, rather than charging these costs to general company overhead accounts. In doing so, the departments or groups that generate the waste become more aware of the effects of their treatment and disposal practices, and have a financial incentive to minimize their waste. By judicious scheduling of batch production runs, the frequency of equipment cleaning and the resulting waste can be reduced.

<u>*Example: Good Operating Practices*</u>

A large consumer product company in California adopted a corporate policy to minimize the generation of hazardous waste. In order to implement the policy, the company mobilized quality circles made up of employees representing areas within the plant that generated hazardous wastes. The company experienced a 75% reduction in the amount of wastes generated by instituting proper maintenance procedures suggested by the quality circle teams. Since the team members were also line supervisors and operators, they made sure the procedures were followed.

Source Reduction: Technology Changes

Technology changes are oriented toward process and equipment modifications to reduce waste, primarily in a production setting. Technology changes can range from minor changes that can be implemented in a matter of days at low cost, to the replacement of processes involving large capital costs. These changes include the following:

- Changes in the production process
- Equipment, layout, or piping changes
- Use of automation
- Changes in process operating conditions, such as
  - Flow rates
  - Temperatures
  - Pressures
  - Residence times

<u>*Example: Technology Changes*</u>

A manufacturer of fabricated metal products cleaned nickel and titanium wire in an alkaline chemical bath prior to using the wire in their product. In 1986, the company began to experiment with a mechanical abrasive system. The wire was passed through the system which uses silk and carbide pads and pressure to brighten the metal. The system worked, but required passing the wire through the unit twice for complete cleaning. In 1987. The company bought a second abrasive unit and installed it in series with the first unit. This system allowed the company to completely eliminate the need for the chemical cleaning bath.

Source Reduction: Input Material Changes

Input material changes accomplish waste minimization by reducing or eliminating the hazardous materials that enter the production process. Also, changes in input materials can be made to avoid the generation of hazardous wastes within the production processes. Input material changes include:

- Material purification
- Material substitution

<u>*Example: Input Material Changes*</u>

An electronic manufacturing facility of a large diversified corporation originally cleaned printed ciruit boards with solvents. The company found that by switching from a solvent-based cleaning system to an aqueous-based system that the same operating conditions and workloads could be maintained. The aqueous-based system was found to clean six times more effectively. This resulted in a lower product reject rate, and eliminated a hazardous waste.

Source Reduction: Product Changes

Product changes are performed by the manufacturer of a product with the intent of reducing waste resulting from a product's use. Product changes include:

- Product substitution
- Product conservation
- Changes in product composition

<u>*Example: Product changes*</u>

In the paint manufacturing industry, water-based coatings are finding increasing applications where solvent-based paints were used before. These products do not contain toxic or flammable solvents that make solvent-based paints hazardous when they are disposed of. Also, cleaning the applicators with solvent is not necessary. The use of water-

based paints instead of solvent-based paints also greatly reduces volatile organic compound emissions to the atmosphere.

Recycling: Use and Reuse

Recycling via use and/or reuse involves the return of a waste material either to the originating process as a substitute for an input material, or to another process as an input material.

Example: Reuse

A printer of newpaper advertising in California purchased an ink recycling unit to produce black newspaper ink from its various waste inks. The unit blends the different colors of waste ink together with fresh black ink and black toner to create the black ink. This ink is then filtered to remove flakes of dried ink. This ink is used in place of fresh black ink, and eliminates the need for the company to ship waste ink offsite for disposal. The price of the recycling unit was paid off in 18 months based only on the savings in fresh black ink purchases. The payback improved to 9 months when the costs for disposing of ink as a hazardous waste are included.

Recycling: Reclamation

Reclamation is the recovery of a valuable material from a hazardous waste. Reclamation techniques differ from use and reuse techniques in that the recovered material is not used in the facility, rather it is sold to another company.

Example: Reclamation

A photoprocessing company uses an electrolytic deposition cell to recover silver out of the rinsewater from film processing equipment. The silver is then sold to a small recycler. By removing the silver from this wastewater, the wastewater can be discharged to the sewer without additional pretreatment by the company. This unit pays for itself in less than two years with the value of silver recovered.

The company also collects used film and sells it to the same recycler. The recycler burns the film and collects the silver from the the residual ash. By removing the silver from the ash, the ash becomes nonhazardous.

Appendix E lists many WM techniques and concepts applicable to common waste-generating operations (coating, equipment cleaning, parts cleaning, and materials handling). Additionally, a list of good operating practices is provided.

Methods of Generating Options

The process by which waste minimization options are identified should occur in an environment that encourages creativity and independent thinking by the members of the assessment team. While the individual team members will suggest many potential options on their own, the process can be enhanced by using some of the common group decision techniques. These techniques allow the assessment team to identify options that the individual members might not have come up with on their own. Brainstorming sessions with the team members are an effective way of developing WM options. Most management or organizational behavior textbooks describe group decision techniques, such as brainstorming or the nominal group technique.

Worksheet 11 in Appendix A is a form for listing options that are proposed during an option generation session. Worksheet 12 in Appendix A is used to briefly describe and document the options that are proposed. Worksheets S7 and S8 in Appendix B perform the same function in the simplified set of worksheets.

Screening and Selecting Options for Further Study

Many waste minimization options will be identified in a successful assessment. At this point, it is necessary to identify those options that offer real potential to minimize waste and reduce costs. Since detailed evaluation of technical and economic feasibility is usually costly, the proposed options should be screened to identify those that deserve further evaluation. The screening procedure serves to eliminate suggested options that appear marginal, impractical, or inferior without a detailed and more costly feasibility study.

The screening procedures can range from an informal review and a decision made by the program manager or a vote of the team members, to quantitative decision-making tools. The informal evaluation is an unstructured procedure by which the assessment team or WM program task force selects the options that appear to be the best. This method is especially useful in small facilities, with small management groups, or in situations where only a few options have been generated. This method consists of a discussion and examination of each option.

The weighted sum method is a means of quantifying the important factors that affect waste management at a particular facility, and how each option will perform with respect to these factors. This method is recommended when there are a large number of options to consider. Appendix G presents the weighted sum method in greater detail, along with an example. Worksheet 13 in Appendix A is designed to screen and rank options using this method.

The assessment procedure is flexible enough to allow common group decision-making techniques to be used here. For example, many large corporations currently use decision-making systems that can be used to screen and rank WM options.

No matter what method is used, the screening procedure should consider the following questions.

- What is the main benefit gained by implementing this option? (e.g., economics, compliance, liability, workplace safety, etc.)

- Does the necessary technology exist to develop the option?

- How much does it cost? Is it cost effective?

- Can the option be implemented within a reasonable amount of time without disrupting production?

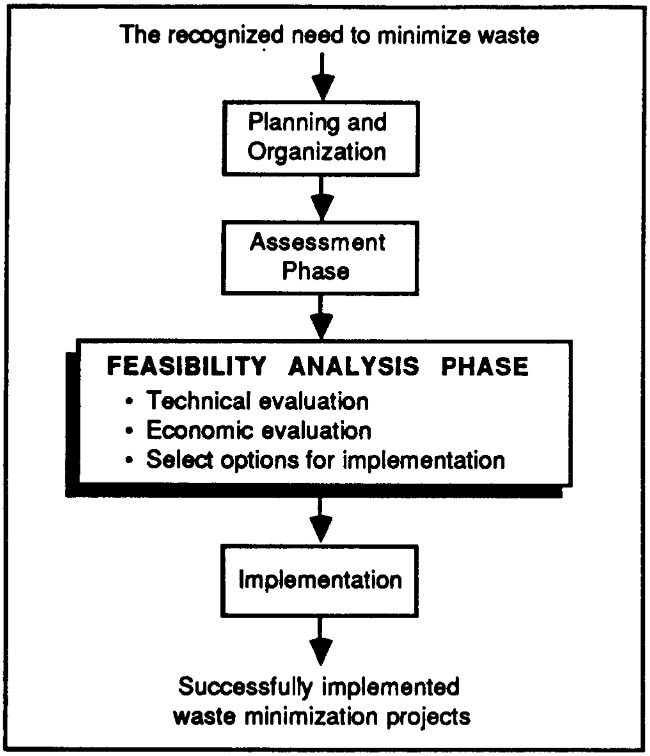
- Does the option have a good "track record"? If not, is there convincing evidence that the option will work as required?

- Does the option have a good chance of success? (A successfully initiated WM program will gain wider acceptance as the program progresses.)

- What other benefits will occur?

The results of the screening activity are used to promote the successful options for technical and economic feasibility analyses. The number of options chosen for the feasibility analyses depends on the time, budget, and resources available for such a study.

Some options (such as procedural changes) may involve no capital costs and can be implemented quickly with little or no further evaluation. The screening procedure should account for ease of implementation of an option. If such an option is clearly desirable and indicates a potential cost savings, it should be promoted for further study or outright implementation.



The final product of the assessment phase is a list of WM options for the assessed area. The assessment will have screened out the impractical or unattractive options. The next step is to determine if the remaining options are technically and economically feasible.

Technical Evaluation

The technical evaluation determines whether a proposed WM option will work in a specific application. The assessment team should use a "fast-track" approach in evaluating procedural changes that do not involve a significant capital expenditure. Process testing of materials can be done relatively quickly, if the options do not involve major equipment installation or modifications.

For equipment-related options or process changes, visits to see existing installations can be arranged through equipment vendors and industry contacts. The operator's comments are especially important and should be compared with the vendor's claims. Bench-scale or pilot-scale demonstration is often necessary. Often it is possible to obtain scale-up data using a rental test unit for bench-scale or pilot-scale experiments. Some vendors will install equipment on a trial basis, with acceptance and payment after a prescribed time, if the user is satisfied.

The technical evaluation of an option also must consider facility constraints and product requirements, such as those described in Table 4-1. Although an inability to meet these constraints may not present insurmountable problems, correcting them will likely add to the capital and/or operating costs.

Table 4-1. Typical Technical Evaluation Criteria

- Is the system safe for workers?
- Will product quality be maintained?
- Is space available?
- Is the new equipment, materials, or procedures compatible with production operating procedures, work flow, and production rates?
- Is additional labor required?
- Are utilitities available? Or must they be installed, thereby raising capital costs?
- How long will production be stopped in order to install the system?
- Is special expertise required to operate or maintain the new system?
- Does the vendor provide acceptable service?
- Does the system create other environmental problems?

All affected groups in the facility should contribute to and review the results of the technical evaluation. Prior consultation and review with the affected groups (e.g., production, maintenance, purchasing) is needed to ensure the viability and acceptance of an option. If the option calls for a change in production methods or input materials, the project's effects on the quality of the final product must be determined. If after the technical evaluation, the project appears infeasible or impractical, it should be dropped. Worksheet 14 in Appendix A is a checklist of important items to consider when evaluating the technical feasibility of a WM option.

Economic Evaluation

The economic evaluation is carried out using standard measures of profitability, such as payback period, return on investment, and net present value. Each organization has its own economic criteria for selecting projects for implementation. In performing the economic evaluation, various costs and savings must be considered. As in any projects, the cost elements of a WM project can be broken down into capital costs and operating costs. The economic analysis described in this section and in the associated worksheets represents a preliminary, rather than detailed, analysis.

For smaller facilities with only a few processes, the entire WM assessment procedure will tend to be much

Table 4-2. Capital Investment for a Typical Large WM Project

Direct Capital Costs
- Site Development
  - Demolition and alteration work
  - Site clearing and grading
  - Walkways, roads, and fencing
- Process Equipment
  - All equipment listed on flow sheets
  - Spare parts
  - Taxes, freight, insurance, and duties
- Materials
  - Piping and ducting
  - Insulation and painting
  - Electrical
  - Instrumentation and controls
  - Buildings and structures
- Connections to Existing Utilities and Services (water, HVAC, power, steam, refrigeration, fuels, plant air and inert gas, lighting, and fire control)
- New Utility and Service Facilities (same items as above)
- Other Non-Process Equipment
- Construction/Installation
  - Construction/Installation labor salaries and burden
  - Supervision, accounting, timekeeping, purchasing, safety, and expediting
  - Temporary facilities
  - Construction tools and equipment
  - Taxes and insurance
  - Building permits, field tests, licenses

Indirect Capital Costs
- In-house engineering, procurement, and other home office costs
- Outside engineering, design, and consulting Services
- Permitting costs
- Contractors' fees
- Start-up costs
- Training costs
- Contingency
- Interest accrued during construction
  - TOTAL FIXED CAPITAL COSTS

Working Capital
- Raw materials inventory
- Finished product inventory
- Materials and supplies
  - TOTAL WORKING CAPITAL

TOTAL CAPITAL INVESTMENT

Source: Adapted from Perry, Chemical Engineer's Handbook (1985); and Peters and Timmerhaus, Plant Design and Economics for Chemical Engineers (1980).

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less formal. In this situation, several obvious WM options, such as installation of flow controls and good operating practices may be implemented with little or no economic evaluation. In these instances, no complicated analyses are necessary to demonstrate the advantages of adopting the selected WM options.

A proper perspective must be maintained between the magnitude of savings that a potential option may offer, and the amount of manpower required to do the technical and economic feasibility analyses.

Capital Costs

Table 4-2 is a comprehensive list of capital cost items associated with a large plant upgrading project. These costs include not only the fixed capital costs for designing, purchasing, and installing equipment, but also costs for working capital, permitting, training, start-up, and financing charges.

With the increasing level of environmental regulations, initial permitting costs are becoming a significant portion of capital costs for many recycling options (as well as treatment, storage, and disposal options). Many source reduction techniques have the advantage of not requiring environmental permitting in order to be implemented.

Operating Costs and Savings

The basic economic goal of any waste minimization project is to reduce (or eliminate) waste disposal costs and to reduce input material costs. However, a variety of other operating costs (and savings) should also be considered. In making the economic evaluation, it is convenient to use incremental operating costs in comparing the existing system with the new system that incorporates the waste minimization option. ("Incremental operating costs" represent the difference between the estimated operating costs associated with the WM option, and the actual operating costs of the existing system, without the option.) Table 4-3 describes incremental operating costs and savings and incremental revenues typically associated with waste minimization projects.

Reducing or avoiding present and future operating costs associated with waste treatment, storage, and disposal are major elements of the WM project economic evaluation. Companies have tended to ignore these costs in the past because land disposal was relatively inexpensive. However, recent regulatory requirements imposed on generators and waste management facilities have caused the costs of waste management to increase to the point where it is becoming a significant factor in a company's overall cost structure. Table 4-4 presents typical external costs for offsite waste treatment and disposal. In addition to these external costs, there are significant internal costs, including the labor to store and ship out wastes, liability insurance costs, and onsite treatment costs.

Table 4-3. Operating Costs and Savings Associated with WM Projects

Reduced waste management costs.
This includes reductions in costs for:
- Offsite treatment, storage, and disposal fees
- State fees and taxes on hazardous waste generators
- Transportation costs
- Onsite treatment, storage, and handling costs
- Permitting, reporting, and recordkeeping costs

Input material cost savings.
An option that reduces waste usually decreases the demand for input materials.

Insurance and liability savings.
A WM option may be significant enough to reduce a company's insurance payments. It may also lower a company's potential liability associated with remedial clean-up of TSDFs and workplace safety. (The magnitude of liability savings is difficult to determine).

Changes in costs associated with quality.
A WM option may have a positive or negative effect on product quality. This could result in higher (or lower) costs for rework, scrap, or quality control functions.

Changes in utilities costs.
Utilities costs may increase or decrease. This includes steam, electricity, process and cooling water, plant air, refrigeration, or inert gas.

Changes in operating and maintenance labor, burden, and benefits.
An option may either increase or decrease labor requirements. This may be reflected in changes in overtime hours or in changes in the number of employees. When direct labor costs change, then the burden and benefit costs will also change. In large projects, supervision costs will also change.

Changes in operating and maintenance supplies.
An option may result increase or decrease the use of O&M supplies.

Changes in overhead costs.
Large WM projects may affect a facility's overhead costs.

Changes in revenues from increased (or decreased) production.
An option may result in an increase in the productivity of a unit. This will result in a change in revenues. (Note that operating costs may also change accordingly.)

Increased revenues from by-products.
A WM option may produce a by-product that can be sold to a recycler or sold to another company as a raw material. This will increase the company's revenues.

Table 4-4. Typical Costs of Offsite Industrial Waste Management*

Disposal	
Drummed hazardous waste**	
Solids	$75 to $110 per drum
Liquids	$65 to $120 per drum
Bulk waste	
Solids	$120 per cubic yard
Liquids	$0.60 to $2.30 per gallon
Lab packs	$110 per drum
Analysis (at disposal site)	$200 to $300
Transportation	$65 to $85 per hour @ 45 miles per hour (round trip)

* - Does not include internal costs, such as taxes and fees, and labor for manifest preparation, storage, handling, and recordkeeping.

**- Based on 55 gallon drums. These prices are for larger quantities of drummed wastes. Disposal of a small number of drums can be up to four times higher per drum.

For the purpose of evaluating a project to reduce waste quantities, some types of costs are larger and more easily quantified. These include:

- disposal fees
- transportation costs
- predisposal treatment costs
- raw materials costs
- operating and maintenance costs.

It is suggested that savings in these costs be taken into consideration first, because they have a greater effect on project economics and involve less effort to estimate reliably. The remaining elements are usually secondary in their direct impact and should be included on an as-needed basis in fine-tuning the analysis.

Profitability Analysis

A project's profitability is measured using the estimated net cash flows (cash incomes minus cash outlays) for each year of the project's life. A profitability analysis example in Appendix H includes two cash flow tables (Figure H-3 and H-4).

If the project has no significant capital costs, the project's profitability can be judged by whether an operating cost savings occurs or not. If such a project reduces overall operating costs, it should be implemented as soon as practical.

For projects with significant capital costs, a more detailed profitability analysis is necessary. The three standard profitability measures are:

- Payback period
- Internal rate of return (IRR)
- Net present value

The payback period for a project is the amount of time it takes to recover the initial cash outlay on the project. The formula for calculating the payback period on a pretax basis is the following:

$$\text{Payback period (in years)} = \frac{\text{Capital investment}}{\text{Annual operating cost savings}}$$

For example, suppose a waste generator installs a piece of equipment at a total cost of $120,000. If the piece of equipment is expected to save $48,000 per year, then the payback period is 2.5 years.

Payback periods are typically measured in years. However, a particularly attractive project may have a payback period measured in months. Payback periods in the range of three to four years are usually considered acceptable for low-risk investments. This method is recommended for quick assessments of profitability. If large capital expenditures are involved, it is usually followed by more detailed analysis.

The internal rate of return (IRR) and the net present value (NPV) are both discounted cash flow techniques for determining profitability. Many companies use these methods for ranking capital projects that are competing for funds. Capital funding for a project may well hinge on the ability of the project to generate positive cash flows beyond the payback period to realize acceptable return on investment. Both the NPV and IRR recognize the time value of money by discounting the projected future net cash flows to the present. For investments with a low level of risk, an aftertax IRR of 12 to 15 percent is typically acceptable.

Most of the popular spreadsheet programs for personal computers will automatically calculate IRR and NPV for a series of cash flows. Refer to any financial management, cost accounting, or engineering economics text for more information on determining the IRR or NPV. Appendix H presents a profitability analysis example for a WM project using IRR and NPV.

Adjustments for Risks and Liability

As mentioned earlier, waste minimization projects may reduce the magnitude of environmental and safety risks for a company. Although these risks can be identified, it is difficult to predict if problems occur, the nature of the problems, and their resulting magnitude. One way of accounting for the reduction of these risks is to ease the financial performance requirements of the project. For example, the acceptable payback may be lengthened from four to five years, or the required internal rate of return may be lowered from 15 percent to 12 percent. Such adjustments reflect recognition of elements that affect the risk exposure of the company, but cannot be included directly in the analyses. These adjustments are judgmental and necessarily reflect the individual viewpoints of the people evaluating the project for capital funding. Therefore, it is important that the financial analysts and the decision makers in the company be aware of the risk reduction and other benefits of the WM options. As a policy to encourage waste minimization, some companies have set lower hurdle rates for WM projects.

While the profitability is important in deciding whether or not to implement an option, environmental regulations may be even more important. A company operating in violation of environmental regulations can face fines, lawsuits, and criminal penalties for the company's managers. Ultimately, the facility may even be forced to shut down. In this case the total cash flow of a company can hinge upon implementing the environmental project.

Worksheets for Economic Evaluation

Worksheets 15 through 17 in Appendix A are used to determine the economic evaluation of a WM option. Worksheet 15 is a checklist of capital and operating cost items. Worksheet 16 is used to find a simple payback period for an option that requires capital investment. Worksheet 17 is used to find the net present value and internal rate of return for an option that requires capital investment. Worksheet S9 in Appendix B is used to record estimated capital and operating costs, and to determine the payback period in the simplified assessment procedure.

Final Report

The product of a waste minimization assessment is a report that presents the results of the assessment and the technical and economic feasibility analyses. The report also containes recommendations to implement the feasible options.

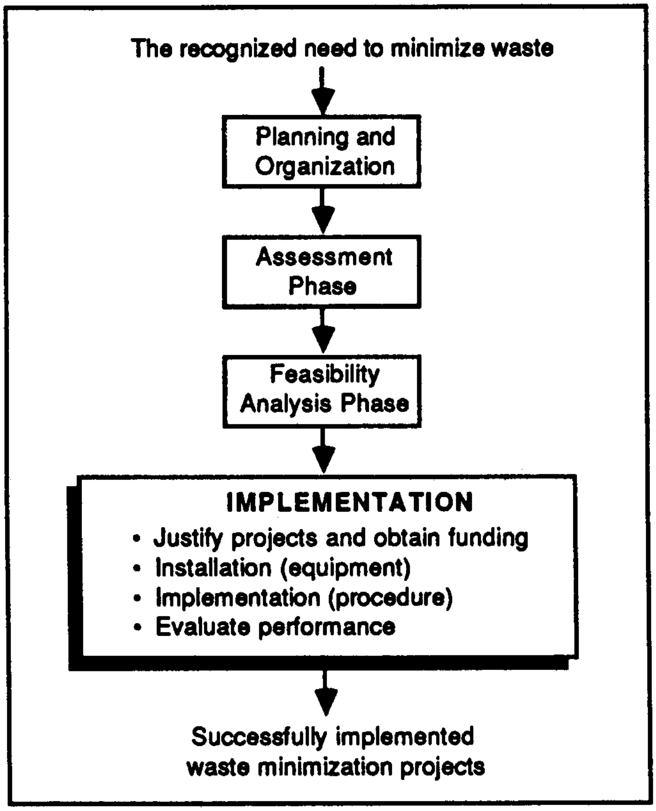
A good final report can be an important tool for getting a project implemented. It is particularly valuable in obtaining funding for the project. In presenting the feasibility analyses, it is often useful to evaluate the project under different scenarios. For example, comparing a projects's profitability under optimistic and pessimistic assumptions (such as increasing waste disposal costs) can be beneficial. Sensitivity analyses that indicate the effect of key variables on profitability are also useful.

The report should include not only how much the project will cost and its expected performance, but also how it will be done. It is important to discuss:

- whether the technology is established, with mention of succesful applications;
- the required resources and how they will be obtained;
- estimated construction period;
- estimated production downtime;
- how the performance of the project can be evaluated after it is implemented.

Before the report is finalized, it is important to review the results with the affected departments and to solicit their support. By having department representatives assist in preparing and reviewing the report, the chances are increased that the projects will be implemented. In summarizing the results, a qualitative evaluation of intangible costs and benefits to the company should be included. Reduced liabilities and improved image in the eyes of the employees and the community should be discussed.

Section 5
Implementing Waste Minimization Options



The WM assessment report provides the basis for obtaining company funding of WM projects. Because projects are not always sold on their technical merits alone, a clear description of both tangible and intangible benefits can help edge a proposed project past competing projects for funding.

The champions of the WM assessment program should be flexible enough to develop alternatives or modifications. They should also be committed to the point of doing background and support work, and should anticipated potential problems in implementing the options. Above all, they should keep in mind that an idea will not sell if the sponsors are not sold on it themselves.

Obtaining Funding

Waste reduction projects generally involve improvements in process efficiency and/or reductions in operating costs of waste management. However, an organization's capital resources may be prioritized toward enhancing future revenues (for example, moving into new lines of business, expanding plant capacity, or acquiring other companies), rather than toward cutting current costs. If this is the case, then a sound waste reduction project could be postponed until the next capital budgeting period. It is then up to the project sponsor to ensure that the project is reconsidered at that time.

Knowing the level within the organization that has approval authority for capital projects will help in enlisting the appropriate support. In large corporations, smaller projects are typically approved at the plant manager level, medium-size projects at the divisional vice president level, and larger projects at the executive committee level.

An evaluation team made up of financial and technical personnel can ensure that a sponsor's enthusiasm is balanced with objectivity. It can also serve to quell opposing "can't be done" or "if it ain't broke, don't fix it" attitudes that might be encountered within the organization. The team should review the project in the context of:

- past experience in this area of operation
- what the market and the competition are doing
- how the implementation program fits into the company's overall business strategy
- advantages of the proposal in relation to competing requests for capital funding

Even when a project promises a high interal rate of return, some companies will have difficulty raising funds internally for capital investment. In this case, the company should look to outside financing. The company generally has two major sources to consider: private sector financing and government-assisted funding.

Private sector financing includes bank loans and other conventional sources of financing. Government financing is available in some cases. It may be worthwhile to contact your state's Department of Commerce or the federal Small Business Administration for information regarding loans for pollution control or hazardous waste disposal projects. Some states can provide technical and financial assistance. Appendix F includes a list of states providing this assistance and addresses to get information.

Installation

Waste minimization options that involve operational, procedural, or materials changes (without additions or modifications to equipment) should be implemented as soon as the potential cost savings have been determined. For projects involving equipment modifications or new equipment, the installation of a waste minimization project is essentially no different from any other capital improvement project. The phases of the project include planning, design, procurement, and construction.

Worksheet 18 is a form for documenting the progress of a WM project through the implementation phase.

Demonstration and Follow-up

After the waste minimization option has been implemented, it remains to be seen how effective the option actually turns out to be. Options that don't measure up to their original performance expectations may requre rework or modifications. It is important to get warranties from vendors prior to installation of the equipment.

The documentation provided through a follow-up evaluation represents an important source of information for future uses of the option in other facilities. Worksheet 19 is a form for evaluating the performance of an implemented WM option. The experience gained in implementing an option at one facility can be used to reduce the problems and costs of implementing options at subsequent facilities.

Measuring Waste Reduction

One measure of effectiveness for a WM project is the project's effect on the organization's cash flow. The project should pay for itself through reduced waste management costs and reduced raw materials costs. However, it is also important to measure the actual reduction of waste accomplished by the WM project.

The easiest way to measure waste reduction is by recording the quantities of waste generated before and after a WM project has been implemented. The difference, dividied by the original waste generation rate, represents the percentage reduction in waste quantity. However, this simple measurement ignores other factors that also affect the quantity of waste generated.

In general, waste generation is directly dependent on the production rate. Therefore, the ratio of waste generation rate to production rate is a convenient way of measuring waste reduction.

Expressing waste reduction in terms of the ratio of waste to production rates is not free of problems, however. One of these problems is the danger of using the ratio of infrequent large quantities to the production rate. This problem is illustrated by a situation where a plant undergoes a major overhaul involving equipment cleaning, paint stripping, and repainting. Such overhauls are fairly infrequent and are typically performed every three to five years. The decision to include this intermittent stream in the calculation of the waste reduction index, based on the ratio of waste rate to product rate, would lead to an increase in this index. This decision cannot be justified, however, since the infrequent generation of painting wastes is not a function of production rate. In a situation like this, the waste reduction progress should be measured in terms of the ratio of waste quantity or materials use to the square footage of the area painted. In general, a distinction should be made between production- related wastes and maintenance-related wastes and clean-up wastes.

Also, a few waste streams may be inversely proportional to production rate. For example, a waste resulting from outdated input materials is likely to increase if the production rate decreases. This is because the age-dated materials in inventory are more likely to expire when their use in production decreases.

For these reasons, care must be taken when expressing the extent of waste reduction. This requires that the means by which wastes are generated be well understood.

In measuring waste reduction, the total quantity of an individual waste stream should be measured, as well as the individual waste components or characteristics. Many companies have reported substantial reduction in the quanitites of waste disposed. Often, much of the reduction can be traced to good housekeeping and steps taken to concentrate a dilute aqueous waste. Although concentration, as such, does not fall within the definition of waste minimization, there are practical benefits that result from concentrating wastewater streams, including decreased disposal costs. Concentration may render a waste stream easier to recycle, and is also desirable if a facility's current wastewater treatment system is overloaded.

Obtaining good quality data for waste stream quanities, flows, and composition can be costly and time consuming. For this reason, it may be practical, in some instances, to express waste reduction indirectly in terms of the ratio of input materials consumption to production rate. These data are easier to obtain, although the measure is not direct.

Measuring waste minimization by using a ratio of waste quantity to material throughput or product output is generally more meaningful for specific units or operations, rather than for an entire facility. Therefore, it is important to preserve the focus of the WM project when measuring and reporting progress. For those operations not involving chemical reactions, it may be helpful to measure WM progress by using the ratio of input material quantity to material throughput or production rate.

Waste Minimization Assessments for New Production Processes

This manual concentrates on waste minimization assessments conducted in existing facilities. However, it is important that waste minimization principles be applied to new projects. In general, it is easier to avoid waste generation during the research and development or design phase than to go back and modify the process after it has already been installed.

The planning and design team for a new product, production process, or operation should address waste generation aspects early on. The assessment procedure in this manual can be modified to provide a WM review of a product or process in the planning or design phase. The earlier the assessment is performed, the less likely it is that the project will require expensive changes. All new projects should be reviewed by the waste minimization program task force.

A better approach than a pre-project assessment is to include one or more members of the WM program task force on any new project that will generate waste. In this way, the new project will benefit from the "built-in" presence of a WM champion and his or her influence to design the process to minimize waste At a California facility of a major defense contractor, all new projects and modifications to existing facilities and equipment are reviewed by the WM program team. All projects that have no environmental impact are quickly screened and approved. Those projects that do have an environmental impact are assigned to a team member who participates in the project kick-off and review meetings from inception to implementation.

Ongoing Waste Minimization Program

The WM program is a continuing, rather than a one-time effort. Once the highest priority waste streams and facility areas have been assessed and those projects have been implemented, the assessment program should look to areas and waste streams with lower priorities. The ultimate goal of the WM program should be to reduce the generation of waste to the maximum extent achievable. Companies that have eliminated the generation of hazardous waste should continue to look at reducing industrial wastewater discharges, air emissions, and solid wastes.

The frequency with which assessments are done will depend on the program's budget, the company's budgeting cycle (annual cycle in most companies), and special circumstances. These special circumstances might be:

- a change in raw material or product requirements
- higher waste management costs
- new regulations
- new technology
- a major event with undesirable environmental consequences (such as a major spill)

Aside from the special circumstances, a new series of assessments should be conducted each fiscal year.

To be truly effective, a philosophy of waste minimization must be developed in the organization. This means that waste minimization must be an integral part of the company's operations. The most successful waste minimization programs to date have all developed this philosophy within their companies.

Appendix A
Waste Minimization Assessment Worksheets

The worksheets that follow are designed to facilitate the WM assessment procedure. Table A-1 lists the worksheets, according to the particular phase of the program, and a brief description of the purpose of the worksheets. Appendix B presents a series of simplified worksheets for small businesses or for preliminary assessments.

Table A-1. List of Waste Minimization Assessment Worksheets

Phase	Number and Title	Purpose/Remarks
	1. Assessment Overview	Summarizes the overall assessment procedure.
Planning and Organization (Section 2)		
	2. Program Organization	Records key members in the WMA program task force and the WM assessment teams. Also records the relevant organization.
	3. Assessment Team Make-up	Lists names of assessment team members as well as duties. Includes a list of potential departments to consider when selecting the teams.
Assessment Phase (Section 3)		
	4. Site Description	Lists background information about the facility, including location, products, and operations.
	5. Personnel	Records information about the personnel who work in the area to be assessed.
	6. Process Information	This is a checklist of useful process information to look for before starting the assessment.
	7. Input Materials Summary	Records input material information for a specific production or process area. This includes name, supplier, hazardous component or properties, cost, delivery and shelf-life information, and possible substitutes.
	8. Products Summary	Identifies hazardous components, production rate, revenues, and other information about products.
	9. Individual Waste Stream Characterization	Records source, hazard, generation rate, disposal cost, and method of treatment or disposal for each waste stream.
	10. Waste Stream Summary	Summarizes all of the information collected for each waste stream. This sheet is also used to prioritize waste streams to assess.

(continued)

Table A-1. List of Waste Minimization Assessment Worksheets (continued)

Phase	Number and Title	Purpose/Remarks
Assessment Phase (continued) (Section 3)		
	11. Option Generation	Records options proposed during brainstorming or nominal group technique sessions. Includes the rationale for proposing each option.
	12. Option Description	Describes and summarizes information about a proposed option. Also notes approval of promising options.
	13. Options Evaluation by Weighted Sum Method	Used for screening options using the weighted sum method.
Feasibility Analysis Phase (Section 4)		
	14. Technical Feasibility	Detailed checklist for performing a technical evaluation of a WM option. This worksheet is divided into sections for equipment-related options, personnel/procedural-related options, and materials-related options.
	15. Cost Information	Detailed list of capital and operating cost information for use in the economic evaluation of an option.
	16. Profitability Worksheet #1 Payback Period	Based on the capital and operating cost information developed from Worksheet 15, this worksheet is used to calculate the payback period.
	17. Profitability Worksheet #2 Cash Flow for NPV and IRR	This worksheet is used to develop cash flows for calculating NPV or IRR.
Implementation (Section 5)		
	18. Project Summary	Summarizes important tasks to be performed during the implementation of an option. This includes deliverable, responsible person, budget, and schedule.
	19. Option Performance	Records material balance information for evaluating the performance of an implemented option.

Firm ____	Waste Minimization Assessment Worksheets	Prepared By ____
Site ____		Checked By ____
Date ____	Proj. No. ____	Sheet 1 of 1 Page ___ of ___

WORKSHEET 1

ASSESSMENT OVERVIEW

EPA

Begin the Waste Minimization Assessment Program

↓

Worksheets used

PLANNING AND ORGANIZATION

	Worksheets used
• Get management commitment	
• Set overall assessment program goals	
• Organize assessment program task force	2

↓ Assessment organization and commitment to proceed

ASSESSMENT PHASE

Select new assessment targets and reevaluate previous options (→ back to Assessment Phase)

	Worksheets used
• Compile process and facility data	4,6,7,8,9,10
• Prioritize and select assessment targets	10
• Select people for assessment teams	3
• Review data and inspect site	
• Generate options	11,12
• Screen and select options for further study	13

↓ Assessment report of selected options

FEASIBILITY ANALYSIS PHASE

	Worksheets used
• Technical evaluation	14
• Economic evaluation	15,16,17
• Select options for implementation	

↓ Final report, including recommended options

IMPLEMENTATION

Repeat the process (← back to Assessment Phase)

	Worksheets used
• Justify projects and obtain funding	
• Installation (equipment)	18
• Implementation (procedure)	18
• Evaluate performance	19

↓

Successfully operating waste minimization projects

Firm ______	Waste Minimization Assessment	Prepared By ______
Site ______		Checked By ______
Date ______	Proj. No. ______	Sheet 1 of 1 Page __ of __

WORKSHEET 2

PROGRAM ORGANIZATION

EPA

FUNCTION	NAME	LOCATION	TELEPHONE #
Program Manager			
Site Coordinator			
Assessment Team Leader			

Organization Chart

(sketch)

Firm ______	Waste Minimization Assessment	Prepared By ______
Site ______		Checked By ______
Date ______	Proj. No. ______	Sheet 1 of 1 Page ___ of ___

WORKSHEET 3

ASSESSMENT TEAM MAKE-UP

EPA

Function/Department	Name	Location/ Telephone #	Manhours Required	Duties		
				Lead	Support	Review
Assessment Team						
Leader						
Site Coordinator						
Operations						
Engineering						
Maintenance						
Scheduling						
Materials Control						
Procurement						
Shipping/Receiving						
Facilities						
Quality Control						
Environmental						
Accounting						
Personnel						
R & D						
Legal						
Management						
Contractor/Consultant						
Safety						

Firm ____	Waste Minimization Assessment	Prepared By ____
Site ____		Checked By ____
Date ____	Proj. No. ____	Sheet 1 of 1 Page ___ of ___

WORKSHEET 4

SITE DESCRIPTION

EPA

Firm:

Plant:

Department:

Area:

Street Address:

City:

State/ZIP Code:

Telephone: (   )

Major Products:

SIC Codes:

EPA Generator Number :

Major Unit or:

Product or:

Operations:

Facilities/Equipment Age:

Firm ______	**Waste Minimization Assessment**	Prepared By ______
Site ______		Checked By ______
Date ______	Proj. No. ______	Sheet 1 of 1 Page ___ of ___

WORKSHEET 5

PERSONNEL

EPA

Attribute	Overall	Department/Area			
Total Staff					
Direct Supv. Staff					
Management					
Average Age, yrs.					
Annual Turnover Rate %					
Seniority, yrs.					
Yrs. of Formal Education					
Training, hrs./yr.					
Additional Remarks					

Firm ______	**Waste Minimization Assessment**	Prepared By ______
Site ______		Checked By ______
Date ______	Proj. No. ______	Sheet 1 of 1 Page ___ of ___

WORKSHEET 6

PROCESS INFORMATION

EPA

Process Unit/Operation: ______

Operation Type:
- ☐ Continuous
- ☐ Discrete
- ☐ Batch or Semi-Batch
- ☐ Other ______

Document	Status					
	Complete? (Y/N)	Current? (Y/N)	Last Revision	Used in this Report (Y/N)	Document Number	Location
Process Flow Diagram						
Material/Energy Balance						
Design						
Operating						
Flow/Amount Measurements						
Stream						
Analyses/Assays						
Stream						
Process Description						
Operating Manuals						
Equipment List						
Equipment Specifications						
Piping & Instrument Diagrams						
Plot and Elevation Plan(s)						
Work Flow Diagrams						
Hazardous Waste Manifests						
Emission Inventories						
Annual/Biennial Reports						
Environmental Audit Reports						
Permit/Permit Applications						
Batch Sheet(s)						
Materials Application Diagrams						
Product Composition Sheets						
Material Safety Data Sheets						
Inventory Records						
Operator Logs						
Production Schedules						

Firm ____________	Waste Minimization Assessment	Prepared By ____________
Site ____________		Checked By ____________
Date ____________	Proj. No. ____________	Sheet 1 of 1 Page __ of __

WORKSHEET 7

INPUT MATERIALS SUMMARY

EPA

Attribute	Description[1]		
	Stream No.____	Stream No.____	Stream No.____
Name/ID			
Source/Supplier			
Component/Attribute of Concern			
Annual Consumption Rate			
Overall			
Component(s) of Concern			
Purchase Price, $ per ______			
Overall Annual Cost			
Delivery Mode[2]			
Shipping Container Size & Type[3]			
Storage Mode[4]			
Transfer Mode[5]			
Empty Container Disposal/Management[6]			
Shelf Life			
Supplier Would			
- accept expired material (Y/N)			
- accept shipping containers (Y/N)			
- revise expiration date (Y/N)			
Acceptable Substitute(s), if any			
Alternate Supplier(s)			

1 stream numbers, if applicable, should correspond to those used on process flow diagrams.
2 e.g., pipeline, tank car, 100 bbl. tank truck, truck, etc.
3 e.g., 55 gal. drum, 100 lb. paper bag, tank, etc.
4 e.g., outdoor, warehouse, underground, aboveground, etc.
5 e.g., pump, forklift, pneumatic transport, conveyor, etc.
6 e.g., crush and landfill, clean and recycle, return to supplier, etc.

Firm ____	Waste Minimization Assessment	Prepared By ____
Site ____		Checked By ____
Date ____	Proj. No. ____	Sheet 1 of 1 Page ___ of ___

WORKSHEET 8

PRODUCTS SUMMARY

EPA

Attribute	Description[1]		
	Stream No.____	Stream No.____	Stream No.____
Name/ID			
Component/Attribute of Concern			
Annual Production Rate			
Overall			
Component(s) of Concern			
Annual Revenues, $ ______			
Shipping Mode			
Shipping Container Size & Type			
Onsite Storage Mode			
Containers Returnable (Y/N)			
Shelf Life			
Rework Possible (Y/N)			
Customer Would			
- relax specification (Y/N)			
- accept larger containers (Y/N)			

1 stream numbers, if applicable, should correspond to those used on process flow diagrams.

Firm ______	Waste Minimization Assessment	Prepared By ______
Site ______		Checked By ______
Date ______	Proj. No. ______	Sheet 2 of 4 Page __ of __

WORKSHEET 9a

INDIVIDUAL WASTE STREAM CHARACTERIZATION

EPA

1. **Waste Stream Name/ID:** ______ **Stream Number** ______
   Process Unit/Operation ______

2. **Waste Characteristics** (attach additional sheets with composition data, as necessary.)

   ☐ gas ☐ liquid ☐ solid ☐ mixed phase

   Density, lb/cuft ______ High Heating Value, Btu/lb ______
   Viscosity/Consistency ______
   pH ______ ,Flash Point ______ ; % Water ______

3. **Waste Leaves Process as:**
   ☐ air emission ☐ waste water ☐ solid waste ☐ hazardous waste

4. **Occurrence**
   ☐ continuous ______
   ☐ discrete ______
   discharge triggered by ☐ chemical analysis ______
   ☐ other (describe) ______
   Type: ☐ periodic ______ length of period: ______
   ☐ sporadic (irregular occurrence)
   ☐ non-recurrent

5. **Generation Rate**
   Annual ______ lbs per year
   Maximum ______ lbs per ______
   Average ______ lbs per ______
   Frequency ______ batches per ______
   Batch Size ______ average ______ range

Firm ______	Waste Minimization Assessment	Prepared By ______
Site ______	Proc. Unit/Oper. ______	Checked By ______
Date ______	Proj. No. ______	Sheet 2 of 4 Page ___ of ___

WORKSHEET
9b

INDIVIDUAL WASTE STREAM CHARACTERIZATION

(continued)

EPA

6. Waste Origins/Sources

Fill out this worksheet to identify the origin of the waste. If the waste is a mixture of waste streams, fill out a sheet for each of the individual waste streams.

Is the waste mixed with other wastes? ☐ Yes ☐ No

Describe how the waste is generated.

Example: Formation and removal of an undesirable compound, removal of an unconverted input material, depletion of a key component (e.g., drag-out), equipment cleaning waste, obsolete input material, spoiled batch and production run, spill or leak cleanup, evaporative loss, breathing or venting losses, etc.

Firm ______	**Waste Minimization Assessment**	Prepared By ______
Site ______	Proc. Unit/Oper. ______	Checked By ______
Date ______	Proj. No. ______	Sheet 3 of 4 Page ___ of ___

WORKSHEET
9c

INDIVIDUAL WASTE STREAM CHARACTERIZATION

(continued)

EPA

Waste Stream ______

7. Management Method

Leaves site in

- ☐ bulk ______
- ☐ roll off bins ______
- ☐ 55 gal drums ______
- ☐ other (describe) ______

Disposal Frequency ______

Applicable Regulations[1] ______

Regulatory Classification[2] ______

Managed

- ☐ onsite ☐ offsite
- ☐ commercial TSDF ______
- ☐ own TSDF ______
- ☐ other (describe) ______

Recycling

- ☐ direct use/re-use ______
- ☐ energy recovery ______
- ☐ redistilled ______
- ☐ other (describe) ______

reclaimed material returned to site?

☐ Yes ☐ No ☐ used by others

residue yield ______

residue disposal/repository ______

Note[1] list federal, state & local regulations, (e.g., RCRA, TSCA, etc.)

Note[2] list pertinent regulatory classification (e.g., RCRA - Listed K011 waste, etc.)

Firm ______	Waste Minimization Assessment	Prepared By ______
Site ______	Proc. Unit/Oper. ______	Checked By ______
Date ______	Proj. No. ______	Sheet 4 of 4 Page __ of __

WORKSHEET 9d

INDIVIDUAL WASTE STREAM CHARACTERIZATION

(continued)

EPA

Waste Stream ______

7. **Management Method (continued)**

Treatment

- ☐ biological ______
- ☐ oxidation/reduction ______
- ☐ incineration ______
- ☐ pH adjustment ______
- ☐ precipitation ______
- ☐ solidification ______
- ☐ other (describe) ______

______

residue disposal/repository ______

______

Final Disposition

- ☐ landfill ______
- ☐ pond ______
- ☐ lagoon ______
- ☐ deep well ______
- ☐ ocean ______
- ☐ other (describe) ______

______

Costs as of ______ (quarter and year)

Cost Element:	Unit Price $ per ____	Reference/Source:
Onsite Storage & Handling		
Pretreatment		
Container		
Transportation Fee		
Disposal Fee		
Local Taxes		
State Tax		
Federal Tax		
Total Disposal Cost		

Firm ________	Waste Minimization Assessment	Prepared By ________
Site ________	Proc. Unit/Oper. ________	Checked By ________
Date ________	Proj. No. ________	Sheet 1 of 1 Page ___ of ___

WORKSHEET 10

WASTE STREAM SUMMARY

EPA

Attribute		Description[1]					
		Stream No. ____		Stream No. ____		Stream No. ____	
Waste ID/Name:							
Source/Origin							
Component/or Property of Concern							
Annual Generation Rate (units ________)							
Overall							
Component(s) of Concern							
Cost of Disposal							
Unit Cost ($ per: ________)							
Overall (per year)							
Method of Management[2]							
Priority Rating Criteria[3]	Relative Wt. (W)	Rating (R)	R x W	Rating (R)	R x W	Rating (R)	R x W
Regulatory Compliance							
Treatment/Disposal Cost							
Potential Liability							
Waste Quantity Generated							
Waste Hazard							
Safety Hazard							
Minimization Potential							
Potential to Remove Bottleneck							
Potential By-product Recovery							
Sum of Priority Rating Scores		Σ(R x W)		Σ(R x W)		Σ(R x W)	
Priority Rank							

Notes:
1. Stream numbers, if applicable, should correspond to those used on process flow diagrams.
2. For example, sanitary landfill, hazardous waste landfill, onsite recycle, incineration, combustion with heat recovery, distillation, dewatering, etc.
3. Rate each stream in each category on a scale from 0 (none) to 10 (high).

Firm ______	**Waste Minimization Assessment**	Prepared By ______
Site ______	Proc. Unit/Oper. ______	Checked By ______
Date ______	Proj. No. ______	Sheet 1 of 1 Page ___ of ___

WORKSHEET 11

OPTION GENERATION

EPA

Meeting format (e.g., brainstorming, nominal group technique) ______

Meeting Coordinator ______

Meeting Participants ______

List Suggested Options	Rationale/Remarks on Option

Firm ____	Waste Minimization Assessment	Prepared By ____
Site ____	Proc. Unit/Oper. ____	Checked By ____
Date ____	Proj. No. ____	Sheet 1 of 1 Page ___ of ___

WORKSHEET 12

OPTION DESCRIPTION

EPA

Option Name: ____

Briefly describe the option ____

Waste Stream(s) Affected: ____

Input Material(s) Affected: ____

Product(s) Affected: ____

Indicate Type:

☐ **Source Reduction**

- ___ **Equipment-Related Change**
- ___ **Personnel/Procedure-Related Change**
- ___ **Materials-Related Change**

☐ **Recycling/Reuse**

___	**Onsite**	___	**Material reused for original purpose**
___	**Offsite**	___	**Material used for a lower-quality purpose**
		___	**Material sold**
		___	**Material burned for heat recovery**

Originally proposed by: ____ **Date:** ____

Reviewed by: ____ **Date:** ____

Approved for study? ____ **yes** ____ **no, by:** ____

Reason for Acceptance or Rejection ____

Firm ______	Waste Minimization Assessment	Prepared By ______
Site ______	Proc. Unit/Oper. ______	Checked By ______
Date ______	Proj. No. ______	Sheet 1 of 1 Page 1 of 1

WORKSHEET 13

OPTIONS EVALUATION BY WEIGHTED SUM METHOD

EPA

Criteria	Weight (W)	Options Rating (R)									
		#1 Option ______		#2 Option ______		#3 Option ______		#4 Option ______		#5 Option ______	
		R	R x W	R	R x W	R	R x W	R	R x W	R	R x W
Reduction in waste's hazard											
Reduction of treatment/disposal costs											
Reduction of safety hazards											
Reduction of input material costs											
Extent of current use in industry											
Effect on product quality (no effect = 10)											
Low capital cost											
Low O & M cost											
Short implementation period											
Ease of implementation											
Final Evaluation	Sum of Weighted Ratings Σ (W x R)										
Final Evaluation	Option Ranking										
Feasibility Analysis Scheduled for (Date)											

Firm ______	**Waste Minimization Assessment**	Prepared By ______
Site ______	Proc. Unit/Oper. ______	Checked By ______
Date ______	Proj. No. ______	Sheet 1 of 6 Page ___ of ___

WORKSHEET **14a**

TECHNICAL FEASIBILITY

EPA

WM Option Description ______

1. Nature of WM Option

- ☐ **Equipment-Related**
- ☐ **Personnel/Procedure-Related**
- ☐ **Materials-Related**

2. If the option appears technically feasible, state your rationale for this. ______

______

______

Is further analysis required? ☐ Yes ☐ No. If yes, continue with this worksheet. If not, skip to worksheet 15.

3. Equipment - Related Option

	YES	NO	
Equipment available commercially?	☐	☐	______
Demonstrated commercially?	☐	☐	______
In similar application?	☐	☐	______
Successfully?	☐	☐	______

Describe closest industrial analog ______

______

______

Describe status of development ______

______

______

Prospective Vendor	Working Installation(s)	Contact Person(s)	Date Contacted 1.

1. **Also attach filled out phone conversation notes, installation visit report, etc.**

Firm ____	Waste Minimization Assessment	Prepared By ____
Site ____	Proc. Unit/Oper. ____	Checked By ____
Date ____	Proj. No. ____	Sheet 2 of 6 Page ___ of ___

WORKSHEET **14b**

TECHNICAL FEASIBILITY

(continued)

EPA

WM Option Description ____

3. Equipment-Related Option (continued)

Performance information required (describe parameters): ____

____

____

____

____

Scaleup information required (describe): ____

____

____

____

____

Testing Required: ☐ yes ☐ no

Scale: ☐ bench ☐ pilot ☐ ____

Test unit available? ☐ yes ☐ no ____

Test Parameters (list) ____

____

____

____

Number of test runs: ____

Amount of material(s) required: ____

Testing to be conducted: ☐ in-plant

☐ ____

Facility/Product Constraints:

Space Requirements ____

Possible locations within facility ____

____

____

Firm ____	Waste Minimization Assessment	Prepared By ____
Site ____	Proc. Unit/Oper. ____	Checked By ____
Date ____	Proj. No. ____	Sheet 3 of 6 Page ___ of ___

WORKSHEET
14c

TECHNICAL FEASIBILITY

(continued)

EPA

WM Option Description ____

2. Equipment-Related Option (continued)

Utility Requirements:

Electric Power — Volts (AC or DC) ____ kW ____

Process Water — Flow ____ Pressure ____

Quality (tap, demin, etc.) ____

Cooling Water — Flow ____ Pressure ____

Temp. In ____ Temp. Out ____

Coolant/Heat Transfer Fluid ____

Temp. In ____ Temp. Out ____

Duty ____

Steam — Pressure ____ Temp. ____

Duty ____ Flow ____

Fuel — Type ____ Flow ____

Duty ____

Plant Air ____ Flow ____

Inert Gas ____ Flow ____

Estimated delivery time (after award of contract) ____

Estimated installation time ____

Installation dates ____

Estimated production downtime ____

Will production be otherwise affected? Explain the effect and impact on production. ____

Will product quality be affected? Explain the effect on quality. ____

Firm ______	Waste Minimization Assessment	Prepared By ______
Site ______	Proc. Unit/Oper. ______	Checked By ______
Date ______	Proj. No. ______	Sheet 4 of 6 Page ___ of ___

WORKSHEET 14d

TECHNICAL FEASIBILITY

(continued)

EPA

WM Option Description ______

3. Equipment-Related Option (continued)

Will modifications to work flow or production procedures be required? Explain. ______

Operator and maintenance training requirements

Number of people to be trained ______

☐ Onsite

☐ Offsite

Duration of training

Describe catalyst, chemicals, replacement parts, or other supplies required.

Item	Rate or Frequency of Replacement	Supplier, Address

Does the option meet government and company safety and health requirements?

☐ Yes ☐ No Explain ______

How is service handled (maintenance and technical assistance)? Explain ______

What warranties are offered? ______

Firm ______	Waste Minimization Assessment	Prepared By ______
Site ______	Proc. Unit/Oper. ______	Checked By ______
Date ______	Proj. No. ______	Sheet 5 of 6 Page ___ of ___

WORKSHEET 14e

TECHNICAL FEASIBILITY

(continued)

WM Option Description ______

3. Equipment-Related Option (continued)

Describe any additional storage or material handling requirements. ______

Describe any additional laboratory or analytical requirements. ______

4. Personnel/Procedure-Related Changes

Affected Departments/Areas ______

Training Requirements ______

Operating Instruction Changes. Describe responsible departments. ______

5. Materials-Related Changes (Note: If substantial changes in equipment are required, then handle the option as an equipment-related one.)

	Yes	No
Has the new material been demonstrated commercially?	☐	☐
In a similar application?	☐	☐
Successfully?	☐	☐

Describe closest application. ______

Firm ______	Waste Minimization Assessment	Prepared By ______
Site ______	Proc. Unit/Oper. ______	Checked By ______
Date ______	Proj. No. ______	Sheet 6 of 6 Page ___ of ___

WORKSHEET 14f

TECHNICAL FEASIBILITY
(continued)

EPA

WM Option Description ______

4. Materials-Related Changes (continued)

Affected Departments/Areas ______

______

______

______

Will production be affected? Explain the effect and impact on production.

______

______

______

Will product quality be affected? Explain the effect and the impact on product quality.

______

______

______

______

Will additional storage, handling or other ancillary equipment be required? Explain.

______

______

______

Describe any training or procedure changes that are required.

______

______

______

Decribe any material testing program that will be required.

______

______

______

Firm ____	**Waste Minimization Assessment**	Prepared By ____
Site ____	Proc. Unit/Oper. ____	Checked By ____
Date ____	Proj. No. ____	Sheet 1 of 6 Page ___ of ___

WORKSHEET 15a

COST INFORMATION

EPA

WM Option Description ____

CAPITAL COSTS - Include all costs as appropriate. **TOTALS**

☐ **Purchased Process Equipment**

- **Price (fob factory)** ____
- **Taxes, freight, insurance** ____
- **Delivered equipment cost** ____
- **Price for Initial Spare Parts Inventory** ____ ____

☐ **Estimated Materials Cost**

- **Piping** ____
- **Electrical** ____
- **Instruments** ____
- **Structural** ____
- **Insulation/Piping** ____ ____

☐ **Estimated Costs for Utility Connections and New Utility Systems**

- **Electricity** ____
- **Steam** ____
- **Cooling Water** ____
- **Process Water** ____
- **Refrigeration** ____
- **Fuel (Gas or Oil)** ____
- **Plant Air** ____
- **Inert Gas** ____ ____

☐ **Estimated Costs for Additional Equipment**

- **Storage & Material Handling** ____
- **Laboratory/Analytical** ____
- **Other** ____ ____

☐ **Site Preparation** ____

(Demolition, site clearing, etc.) ____

☐ **Estimated Installation Costs**

- **Vendor** ____
- **Contractor** ____
- **In-house Staff** ____ ____

WORKSHEET 15b

COST INFORMATION

(continued)

EPA

CAPITAL COSTS (Cont.) **TOTALS**

☐ **Engineering and Procurement Costs (In-house & outside)**

Planning	______	
Engineering	______	
Procurement	______	
Consultants	______	______

☐ **Start-up Costs**

Vendor	______	
Contractor	______	
In-house	______	______

☐ **Training Costs** ______ ______

☐ **Permitting Costs**

Fees	______	
In-house Staff Costs	______	______

☐ **Initial Charge of Catalysts and Chemicals**

Item #1	______	
Item #2	______	______

☐ **Working Capital** [Raw Materials, Product, Inventory, Materials and Supplies (not elsewhere specified)].

Item #1	______	
Item #2	______	
Item #3	______	
Item #4	______	______

☐ **Estimated Salvage Value (if any)** ______

Firm ______	Waste Minimization Assessment	Prepared By ______
Site ______	Proc. Unit/Oper. ______	Checked By ______
Date ______	Proj. No. ______	Sheet 3 of 6 Page ___ of ___

WORKSHEET 15c

COST INFORMATION

(continued)

EPA

CAPITAL COST SUMMARY

Cost Item	Cost
Purchased Process Equipment	
Materials	
Utility Connections	
Additional Equipment	
Site Preparation	
Installation	
Engineering and Procurement	
Start-up Cost	
Training Costs	
Permitting Costs	
Initial Charge of Catalysts and Chemicals	
Fixed Capital Investment	
Working Capital	
Total Capital Investment	
Salvage Value	

Firm ______	Waste Minimization Assessment	Prepared By ______
Site ______	Proc. Unit/Oper. ______	Checked By ______
Date ______	Proj. No. ______	Sheet 4 of 6 Page ___ of ___

WORKSHEET 15d

COST INFORMATION

(continued)

EPA

☐ **Estimated Decrease (or Increase) in Utilities**

Utility	Unit Cost $ per unit	Decrease (or Increase) in Quantity Unit per time	Total Decrease (or Increase) $ per time
Electricity			
Steam			
Cooling Process			
Process Water			
Refrigeration			
Fuel (Gas or Oil)			
Plant Air			
Inert Air			

INCREMENTAL OPERATING COSTS - Include all relevant operating savings. Estimate these costs on an incremental basis (i.e., as decreases or increases over existing costs).

☐ **BASIS FOR COSTS** Annual ______ Quarterly ______ Monthly ______ Daily ______ Other ______

☐ **Estimated Disposal Cost Saving**

Decrease in TSDF Fees ______

Decrease in State Fees and Taxes ______

Decrease in Transportation Costs ______

Decrease in Onsite Treatment and Handling ______

Decrease in Permitting, Reporting and Recordkeeping ______

Total Decrease in Disposal Costs ______

☐ **Estimated Decrease in Raw Materials Consumption**

Materials	Unit Cost $ per unit	Reduction in Quantity Units per time	Decrease in Cost $ per time

Firm ______	**Waste Minimization Assessment**	Prepared By ______
Site ______	Proc. Unit/Oper. ______	Checked By ______
Date ______	Proj. No. ______	Sheet 5 of 6 Page ___ of ___

WORKSHEET **15e**

COST INFORMATION

(continued)

EPA

☐ **Estimated Decrease (or Increase) in Ancillary Catalysts and Chemicals**

Catalyst/Chemical	Unit Cost $ per unit	Decrease (or Increase) in Quantity Unit per time	Total Decrease (or Increase) $ per time

☐ **Estimated Decrease (or Increase) in Operating Costs and Maintenance Labor Costs (include cost of supervision, benefits and burden).**

______

______

______

☐ **Estimated Decrease (or Increase) in Operating and Maintenance Supplies and Costs.**

______

______

______

☐ **Estimated Decrease (or Increase) in Insurance and Liability Costs (explain).** ______

______

______

☐ **Estimated Decrease (or Increase) in Other Operating Costs (explain).**

______

______

INCREMENTAL REVENUES

☐ **Estimated Incremental Revenues from an Increase (or Decrease) in Production or Marketable By-products (explain).**

______

______

Firm ______	**Waste Minimization Assessment**	Prepared By ______
Site ______	Proc. Unit/Oper. ______	Checked By ______
Date ______	Proj. No. ______	Sheet 6 of 6 Page ___ of ___

WORKSHEET **15 f**

COST INFORMATION

(continued)

EPA

INCREMENTAL OPERATING COST AND REVENUE SUMMARY (ANNUAL BASIS)

Decreases in Operating Cost or Increases in Revenue are Positive.
Increases in Operating Cost or Decrease in Revenue are Negative.

Operating Cost/Revenue Item	$ per year
Decrease in Disposal Cost	
Decrease in Raw Materials Cost	
Decrease (or Increase) in Utilities Cost	
Decrease (or Increase) in Catalysts and Chemicals	
Decrease (or Increase) in O & M Labor Costs	
Decrease (or Increase) in O & M Supplies Costs	
Decrease (or Increase) in Insurance/Liabilities Costs	
Decrease (or Increase) in Other Operating Costs	
Incremental Revenues from Increased (Decreased) Production	
Incremental Revenues from Marketable By-products	
Net Operating Cost Savings	

Firm ______	**Waste Minimization Assessment**	Prepared By ______
Site ______	Proc. Unit/Oper. ______	Checked By ______
Date ______	Proj. No. ______	Sheet 1 of 1 Page ___ of ___

WORKSHEET **16**

PROFITABILITY WORKSHEET # 1 PAYBACK PERIOD

EPA

Total Capital Investment ($) (from Worksheet 15c) ______________________

Annual Net Operating Cost Savings ($ per year) (from Worksheet 15f) ______________________

$$\textbf{Payback Period (in years)} = \frac{\textbf{Total Capital Investment}}{\textbf{Annual Net Operating Cost Savings}} = \_\_\_\_\_\_\_\_\_\_$$

Firm ______	Waste Minimization Assessment	Prepared By ______
Site ______	Proc. Unit/Oper. ______	Checked By ______
Date ______	Proj. No. ______	Sheet 1 of 1 Page ___ of ___

WORKSHEET 17

PROFITABILITY WORKSHEET #2
CASH FLOW FOR NPV, IRR

EPA

Cash incomes (such as net operating cost savings and salvage value) are shown as positive. Cash outlays (such as capital investments and increased operating costs) are shown as negative.

Line		Constr. Year 0	Operating[1] Year 1	2	3	4	5	6	7	8
A	Fixed Capital Investment									
B	+ Working Capital									
C	Total Capital Investment									
D	Salvage Value[2]									
E	Net Operating Costs Savings									
F	- Interest on Loans									
G	- Depreciation									
H	Taxable Income									
I	- Income Tax[3]									
J	Aftertax Profit[3]									
K	+ Depreciation									
L	- Repayment of Loan Principal									
M	- Capital Investment (line C)									
N	+ Salvage Value (line D)									
O	Cash Flow									
P	Present Value of Cash Flow[4]									
Q	Net Present Value (NPV)[5]									
	Present Worth[6] (5% discount)	1.0000	0.9524	0.9070	0.8638	0.8227	0.7835	0.7462	0.7107	0.6768
	(10% discount)	1.0000	0.9091	0.8264	0.7513	0.6830	0.6209	0.5645	0.5132	0.4665
	(15% discount)	1.0000	0.8696	0.7561	0.6575	0.5718	0.4972	0.4323	0.3759	0.3269
	(20% discount)	1.0000	0.8333	0.6944	0.5787	0.4823	0.4019	0.3349	0.2791	0.2326
	(25% discount)	1.0000	0.8000	0.6400	0.5120	0.4096	0.3277	0.2621	0.2097	0.1678

1 Adjust table as necessary if the anticipated project life is less than or more than 8 years.
2 Salvage value includes scrap value of equipment plus sale of working capital minus demolition costs.
3. The worksheet is used for calculating an aftertax cash flow. For pretax cash flow, use an income tax rate of 0%.
4 The present value of the cash flow is equal to the cash flow multiplied by the present worth factor.
5 The net present value is the sum of the present value of the cash flow for that year and all of the preceeding years.
6 The formula for the present worth factor is $\frac{1}{(1+r)^n}$ where *n* is years and *r* is the discount rate.
7 The internal rate of return (IRR) is the discount rate (r) that results in a net present value of zero over the life of the project.

Firm ______	Waste Minimization Assessment	Prepared By ______
Site ______	Proc. Unit/Oper. ______	Checked By ______
Date ______	Proj. No. ______	Sheet 1 of 1 Page ___ of ___

WORKSHEET 18

PROJECT SUMMARY

EPA

Goals/Objectives ______

Task	Deliverable	Task Leader	Manhours	Budget	Duration			Reference
					Wks	Start	Finish	
1.								
2.								
3.								
4.								
5.								
6.								
7.								
8.								
9.								
10.								
11.								
12.								
13.								
14.								
15.								
16.								
17.								
18.								
19.								
20.								
21.								
22.								
23.								
		TOTALS						

Approval By ______ Date ______

Authorization By ______ Date ______

Project Started (Date) ______

Firm ______	Waste Minimization Assessment	Prepared By ______
Site ______	Proc. Unit/Oper. ______	Checked By ______
Date ______	Proj. No. ______	Sheet 1 of 1 Page ___ of ___

WORKSHEET 19

OPTION PERFORMANCE

EPA

WM Option Description ______

☐ **Baseline** (without option) ☐ **Projected** ☐ **Actual**

(a) **Period Duration** ______ **From** ______ **To** ______

(b) **Production per Period** ______ **Units (** ______ **)**

(c) **Input Materials Consumption per Period**

Material	Pounds	Pounds/Unit Product

(d) **Waste Generation per Period**

Waste Stream	Pounds	Pounds/Unit Product

(e) **Substance(s) of Concern - Generation Rate per Period**

Waste Stream	Substance	Pounds	Pounds/Unit Product

Appendix B
Simplified Waste Minimization Assessment Worksheets

The worksheets that follow are designed to facilitate a simplified WM assessment procedure. Table B-1lists the worksheets, according to the particular phase of the program, and a brief description of the purpose of the worksheets. The worksheets here are presented as supporting only a preliminary effort at minimizing waste, or in a situation where a more formal rigorous assessment is not warranted.

Table B-1. List of Simplified WM Assessment Worksheets

Phase	Number and Title	Purpose/Remarks
	S1. Assessment Overview	Summarizes the overall assessment procedure.
Assessment Phase (Section 3)		
	S2. Site Description	Lists background information about the facility, including location, products, and operations.
	S3. Process Information	This is a checklist of useful process information to look for before starting the assessment.
	S4. Input Materials Summary	Records input material information for a specific production or process area. This includes name, supplier, hazardous component or properties, cost, delivery and shelf-life information, and possible substitutes.
	S5. Products Summary	Identifies hazardous components, production rate, revenues, and other information about products.
	S6. Waste Stream Summary	Summarizes all of the information collected for each waste stream. This sheet is also used to prioritize waste streams to assess.
	S7. Option Generation	Records options proposed during brainstorming or nominal group technique sessions. Includes the rationale for proposing each option.
	S8. Option Description	Describes and summarizes information about a proposed option. Also notes approval of promising options.
Feasibility Analysis Phase (Section 4)		
	S9. Profitability	This worksheet is used to identify capital and operating costs and to calculate the payback period.

Firm ____________	**Waste Minimization Assessment Simplified Worksheets**	Prepared By ____________
Site ____________		Checked By ____________
Date ____________	Proj. No. ____________	Sheet 1 of 1 Page ___ of ___

WORKSHEET S1

ASSESSMENT OVERVIEW

EPA

Begin the Waste Minimization Assessment Program

↓

Worksheets used

PLANNING AND ORGANIZATION

- Get management commitment
- Set overall assessment program goals
- Organize assessment program task force

↓ Assessment organization and commitment to proceed

ASSESSMENT PHASE

(Select new assessment targets and reevaluate previous options →)

	Worksheets used
• Compile process and facility data	S5
• Prioritize and select assessment targets	S2,S3,S4
• Select people for assessment teams	S6
• Review data and inspect site	S7,S8
• Generate options	S8
• Screen and select options for further study	S8

↓ Assessment report of selected options

FEASIBILITY ANALYSIS PHASE

	Worksheets used
• Technical evaluation	
• Economic evaluation	S9
• Select options for implementation	

↓ Final report, including recommended options

IMPLEMENTATION

- Justify projects and obtain funding
- Installation (equipment)
- Implementation (procedure)
- Evaluate performance

(← Repeat the process)

↓

Successfully operating waste minimization projects

Firm ______	Waste Minimization Assessment Simplified Worksheets	Prepared By ______
Site ______		Checked By ______
Date ______	Proj. No. ______	Sheet 1 of 1 Page ___ of ___

WORKSHEET S2

SITE DESCRIPTION

EPA

Firm:

Plant:

Department:

Area:

Street Address:

City:

State/ZIP Code:

Telephone: (   )

Major Products:

SIC Codes:

EPA Generator Number :

Major Unit or:

Product or:

Operations:

Facilities/Equipment Age:

Firm ______	**Waste Minimization Assessment Simplified Worksheets**	Prepared By ______
Site ______		Checked By ______
Date ______	Proj. No. ______	Sheet 1 of 1 Page __ of __

WORKSHEET
S3

PROCESS INFORMATION

EPA

Process Unit/Operation: ______

Operation Type: ☐ Continuous ☐ Discrete ☐ Batch or Semi-Batch ☐ Other ______

Document	Status					
	Complete? (Y/N)	Current? (Y/N)	Last Revision	Used in this Report (Y/N)	Document Number	Location
Process Flow Diagram						
Material/Energy Balance						
Design						
Operating						
Flow/Amount Measurements						
Stream						
Analyses/Assays						
Stream						
Process Description						
Operating Manuals						
Equipment List						
Equipment Specifications						
Piping & Instrument Diagrams						
Plot and Elevation Plan(s)						
Work Flow Diagrams						
Hazardous Waste Manifests						
Emission Inventories						
Annual/Biennial Reports						
Environmental Audit Reports						
Permit/Permit Applications						
Batch Sheet(s)						
Materials Application Diagrams						
Product Composition Sheets						
Material Safety Data Sheets						
Inventory Records						
Operator Logs						
Production Schedules						

Firm ____________	Waste Minimization Assessment Simplified Worksheets	Prepared By ____________
Site ____________		Checked By ____________
Date ____________	Proj. No. ____________	Sheet 1 of 1 Page ___ of ___

WORKSHEET **S4**

INPUT MATERIALS SUMMARY

EPA

Attribute	Description		
	Stream No.____	Stream No.____	Stream No.____
Name/ID			
Source/Supplier			
Component/Attribute of Concern			
Annual Consumption Rate			
Overall			
Component(s) of Concern			
Purchase Price, $ per ______			
Overall Annual Cost			
Delivery Mode[1]			
Shipping Container Size & Type[2]			
Storage Mode[3]			
Transfer Mode[4]			
Empty Container Disposal/Management[5]			
Shelf Life			
Supplier Would			
- accept expired material (Y/N)			
- accept shipping containers (Y/N)			
- revise expiration date (Y/N)			
Acceptable Substitute(s), if any			
Alternate Supplier(s)			

1 e.g., pipeline, tank car, 100 bbl. tank truck, truck, etc.
2 e.g., 55 gal. drum, 100 lb. paper bag, tank, etc.
3 e.g., outdoor, warehouse, underground, aboveground, etc.
4 e.g., pump, forklift, pneumatic transport, conveyor, etc.
5 e.g., crush and landfill, clean and recycle, return to supplier, etc.

Firm ____________	Waste Minimization Assessment Simplified Worksheets	Prepared By ____________
Site ____________		Checked By ____________
Date ____________	Proj. No. ____________	Sheet 1 of 1 Page ___ of ___

WORKSHEET **S5**

PRODUCTS SUMMARY

EPA

Attribute	Description		
	Stream No.____	Stream No.____	Stream No.____
Name/ID			
Component/Attribute of Concern			
Annual Production Rate			
Overall			
Component(s) of Concern			
Annual Revenues, $ ______			
Shipping Mode			
Shipping Container Size & Type			
Onsite Storage Mode			
Containers Returnable (Y/N)			
Shelf Life			
Rework Possible (Y/N)			
Customer Would			
- relax specification (Y/N)			
- accept larger containers (Y/N)			

Firm ____	Waste Minimization Assessment Simplified Worksheets	Prepared By ____
Site ____	Proc. Unit/Oper. ____	Checked By ____
Date ____	Proj. No. ____	Sheet 1 of 1 Page __ of __

WORKSHEET S6

WASTE STREAM SUMMARY

EPA

Attribute		Description					
		Stream No.____		Stream No.____		Stream No.____	
Waste ID/Name:							
Source/Origin							
Component/or Property of Concern							
Annual Generation Rate (units ________)							
Overall							
Component(s) of Concern							
Cost of Disposal							
Unit Cost ($ per: ________)							
Overall (per year)							
Method of Management[1]							
Priority Rating Criteria[2]	**Relative Wt. (W)**	**Rating (R)**	**R x W**	**Rating (R)**	**R x W**	**Rating (R)**	**R x W**
Regulatory Compliance							
Treatment/Disposal Cost							
Potential Liability							
Waste Quantity Generated							
Waste Hazard							
Safety Hazard							
Minimization Potential							
Potential to Remove Bottleneck							
Potential By-product Recovery							
Sum of Priority Rating Scores		$\Sigma(R \times W)$		$\Sigma(R \times W)$		$\Sigma(R \times W)$	
Priority Rank							

Notes: 1. For example, sanitary landfill, hazardous waste landfill, onsite recycle, incineration, combustion with heat recovery, distillation, dewatering, etc.

2. Rate each stream in each category on a scale from 0 (none) to 10 (high).

Firm ____________	**Waste Minimization Assessment Simplified Worksheets**	Prepared By ____________
Site ____________	Proc. Unit/Oper. ____________	Checked By ____________
Date ____________	Proj. No. ____________	Sheet 1 of 1 Page ___ of ___

WORKSHEET S7

OPTION GENERATION

EPA

Meeting format (e.g., brainstorming, nominal group technique) ____________

Meeting Coordinator ____________

Meeting Participants ____________

List Suggested Options	Rationale/Remarks on Option

Firm ________	Waste Minimization Assessment Simplified Worksheets	Prepared By ________
Site ________	Proc. Unit/Oper. ________	Checked By ________
Date ________	Proj. No. ________	Sheet 1 of 1 Page ___ of ___

WORKSHEET S8

OPTION DESCRIPTION

EPA

Option Name: ____________________

Briefly describe the option ____________________

____

____

____

____

____

____

____

Waste Stream(s) Affected: ____________________

____

Input Material(s) Affected: ____________________

____

Product(s) Affected: ____________________

____

Indicate Type:

☐ **Source Reduction**

- ___ **Equipment-Related Change**
- ___ **Personnel/Procedure-Related Change**
- ___ **Materials-Related Change**

☐ **Recycling/Reuse**

___	**Onsite**	___	**Material reused for original purpose**
___	**Offsite**	___	**Material used for a lower-quality purpose**
		___	**Material sold**
		___	**Material burned for heat recovery**

Originally proposed by: ____________________ **Date:** ________

Reviewed by: ____________________ **Date:** ________

Approved for study? ________ **yes** ________ **no, by:** ____________________

Reason for Acceptance or Rejection ____________________

Firm ______	**Waste Minimization Assessment Simplified Worksheets**	Prepared By ______
Site ______	Proc. Unit/Oper. ______	Checked By ______
Date ______	Proj. No. ______	Sheet 1 of 1 Page ___ of ___

WORKSHEET S9

PROFITABILITY

EPA

Capital Costs

- **Purchased Equipment** ______
- **Materials** ______
- **Installation** ______
- **Utility Connections** ______
- **Engineering** ______
- **Start-up and Training** ______
- **Other Capital Costs** ______
  - **Total Capital Costs** ______

Incremental Annual Operating Costs

- **Change in Disposal Costs** ______
- **Change in Raw Material Costs** ______
- **Change in Other Costs** ______
  - **Annual Net Operating Cost Savings** ______

$$\text{Payback Period (in years)} = \frac{\text{Total Capital Costs}}{\text{Annual Net Operating Cost Savings}} = \_\_\_\_\_\_$$

Appendix C
Waste Minimization Assessment Example
Amalgamated Metal Refinishing Corporation

The following case study is an example of a waste minimization assessment of a metal plating operation. This example is reconstructed from an actual assessment, but uses fictitious names. The example presents the background process and facility data, and then describes the waste minimization options that are identified and recommended for this facility.

Amalgamated Metal Refinishing Corporation is in the business of refinishing decorative items. The corporation owns and operates a small facility in Beverly Hills, California. The principal metals plated at this facility are nickel, brass, silver, and gold.

Preparing for the Assessment

Since the facility is a small one with a rather small number of employees, an assessment team was assembled that included both company personnel and outside consultants. The team was made up of the following people:

- Plant manager (assessment team leader)
- First shift plating supervisor
- Corporate process engineer
- Plating chemistry consultant
- Environmental engineering consultant

The assessment team chose to look at all of the plating operations, rather than focusing on one or two specific plating processes.

The assessment began by collecting recent production records, input material information, equipment layout drawings and flow diagrams, waste records, and plant operator instructions. After each of the team members had reviewed the information, a comprehensive inspection of the plating room was carried out. The following process, layout, and waste descriptions summarize the information that was collected for the assessment.

Process Description

Items brought in for refinishing are cleaned, electroplated and polished The basic operations include paint stripping, cleaning, electroplating, drying, and polishing.

In silver plating, the original plated metal is stripped off the item by dipping it into a sodium cyanide solution with the system run in reverse current. This is followed by an acid wash in a 50% muriatic acid solution. The item is then polished to a bright finish. The polished item is then cleaned with caustic solution to remove dirt, rinsed with a 5% sulfuric acid solution to neutralize any remaining caustic solution on the item, and rinsed with water. The item is now ready for electroplating.

After the item is immersed in the plating tank for the required amount of time, it is rinsed in a still rinse tank, followed by a continuous water rinse. Tap water is used for both the still and continuous rinsing steps. Solution from the still rinse tank is used as make-up for the plating baths.In places where two still rinse tanks are used, water from the second tank is used to replenish the first still rinse tank. Overflow from the continuous rinse tank is discharged as wastewater. The item is polished following the plating step.

Gold plating generally does not require stripping. After the initial cleaning operation, the item is electroplated. Nickel and brass plating are also done in a similar manner. Vapor degreasing using 1,1,1-trichloroethane is often perfomed on brass- and nickel-plated items to remove oil and grease. In some cases, items are first nickel-plated and then plated with gold, silver, or brass.

For electroplating operations, the constituents of the cyanide solutions must be kept at an optimum concentration. The solutions are analyzed twice a month by an outside laboratory. A representative sample from a tank is obtained by dipping a tube to the bottom of the plating tank. The sample is analyzed and recommendations for make-up are made based on the test results. Table C-1 shows a typical analysis for brass and nickel electroplating solutions, respectively. This table also shows the optimum concentrations for each constituent in the baths, as well as the recommended make-up and/or dilution requirements.

All plating operations at the facility are performed manually. The facility operates one shift per day and employs eight operators.

Equipment Layout Description

All plating, cleaning, and rinse tanks are located in one room at the plating shop, while an adjacent room houses all equipment used for buffing and polishing.

Table C-1. Electroplating Solution Analyses

	Concentrations Optimum	Actual
Brass Plating		
Copper metal	-	7.52 oz/gal
Zinc metal	0.3 oz/gal	0.80
Sodium cyanide	6.0	3.54
Sodium hydroxide	8.0	7.50
Copper cyanide	10.0	10.60
Zinc cyanide	0.5	1.45
Rochelle salts	2.0	3.59
Nickel Plating		
Nickel metal	-	16.65 oz/gal
Nickel chloride	8.0 oz/gal	15.66
Boric acid	6.0	6.92
Nickel sulfate	40.0	57.26
A-5	2.5%	2.86%
SA-1	1.2%	1.38%
pH	4.0	4.5

Table C-2. Wastewater characteristics

Sampling date	August 8, 1987
Sampling location	Clarifier Sample Box
Type of sample	Time Composite
Reporting period	July '87 to August '87
Total flow in	322 gallons
Total flow out	290 gallons
Peak flow	1.5 gallons per minute
Suspended solids	1.0 mg/L
pH	7.5
Total cyanide	1.0 mg/L
Total chromium	0.42 mg/L
Copper	1.30 mg/L
Nickel	0.93 mg/L
Silver	<0.05 mg/L
Oil and grease	0.2 mg/L
Temperature	70 °F

Figure C-1 is a plan of the facility. The area north of the buffing room is used for drying and storage purposes. Finished goods, as well as raw materials, are stored in the front of the building.

Thirty tanks are used in cleaning and electroplating operations. Figure C-1 includes the names and normal working volumes of these tanks. The configuration of a typical plating unit includes a plating bath, followed by one ore two still tanks and a continuous rinse tank. Except for nickel plating, all plating and stripping solutions used at the facility are cyanide-based.

Waste Stream Description

Cyanide waste is generated from silver stripping; from silver, gold, brass, and copper electroplating; and from the associated rinsing operations. The principal waste streams are wastewater from the continuous rinse tanks and from floor washings, and plating tank filter waste.

Aqueous streams generated from paint stripping, from metal stripping and electroplating, and from floor washings are routed to a common sump. This sump discharges to the sanitary sewer. Table C-2 presents the results of a typical analysis on the wastewater.

Metal sludges accumulate in the plating tanks. This sludge is filtered out of the plating solution once a month using a portable dual cartridge filter. Two filter cartridges are used for each plating tank. Cartridges are typically replaced every two to three months.

The sump is pumped out and disposed of as hazardous waste once every six months. When pumped out the sump usually contains 300 to 400 gallons of sludge comprised of dirt, stripped paint, and a solution containing cyanide and heavy metals.

Proposed Waste Minimization Options

After the site inspection was completed and additional information was reviewed, the team held a brainstorming session to identify potential waste minimization options for the facility. The following options were proposed during the meeting:

- Reduce solution drag-out from the plating tanks by:
  - Proper positioning of workpiece on the plating rack.
  - Increasing plating solution temperatures.
  - Lowering the concentration of plating solution constituents.
  - Increase the recovery of drag-out with drain boards.

- Extend plating solution bath life by:
  - Reducing drag-in by better rinsing.
  - Using deionized make-up water.
  - Using purer anodes.
  - Returning spent solutions to the suppliers.

- Reduce the use of rinse water by:
  - Using multiple countercurrent rinse tanks.
  - Using still rinsing.
  - Using spray or fog rinsing.

- Prevent dust from the adjacent buffing and polishing room from entering the plating room and contaminating the plating baths.

- Segregate cyanide wastes from the rinse tanks from other wastewater streams, such as floor washings and paint stripping wastes.

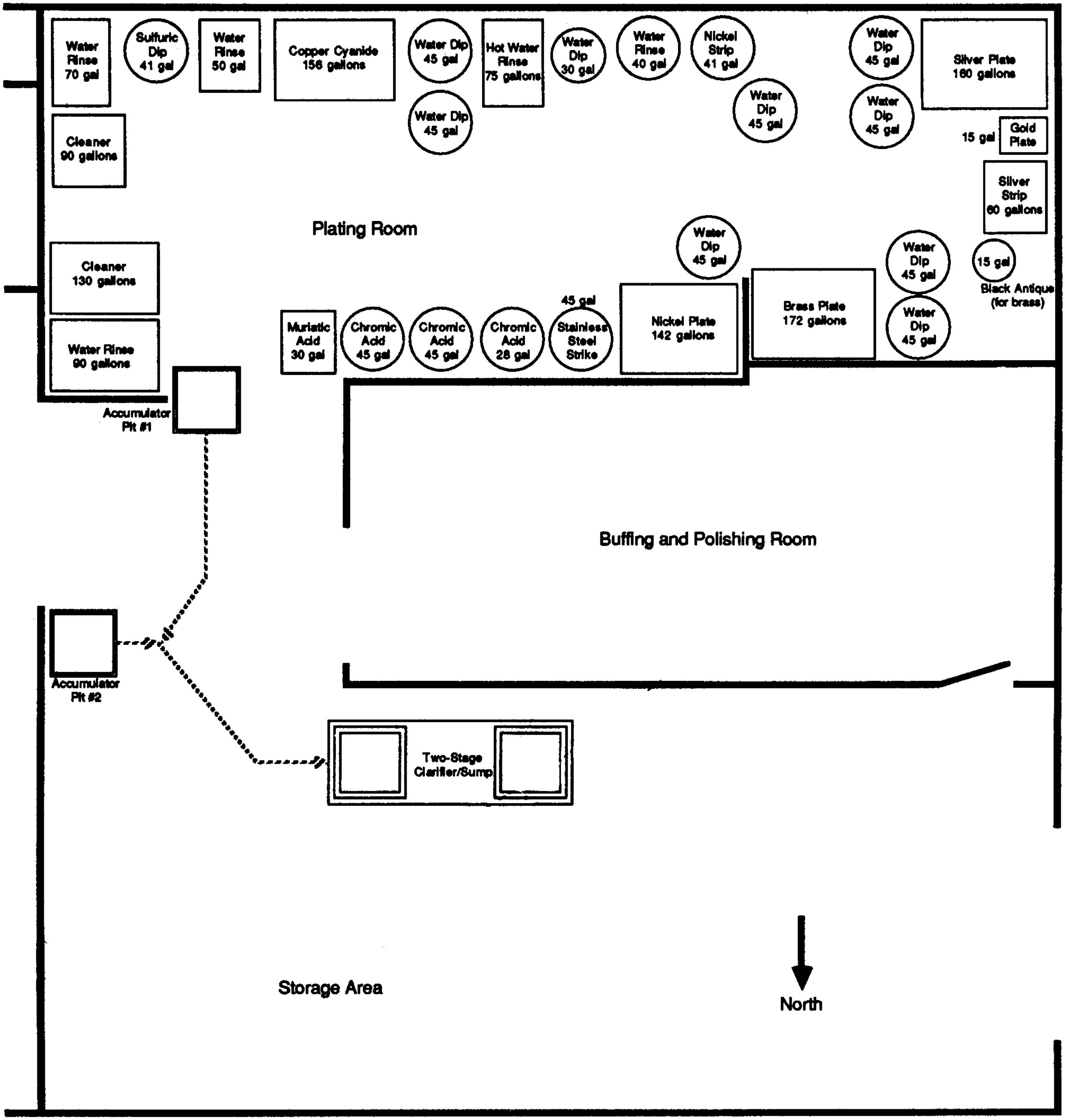


Figure C-1. PLANT LAYOUT

Amalgamated Metal Refinishing Corporation
Worldwide Headquarters and Production Facilities
Beverly Hills, California

The team members each independently reviewed the options and then met to decide which options to study further. The team chose the following options for the feasibility analysis:

- Reduce drag-out by using drain boards.
- Extend bath life using deionized water for make-up.
- Use spray rinsing to reduce rinsewater usage.
- Segregate hazardous waste from nonhazardous waste.

Feasibility Analysis

The assessment team conducted technical and economic feasibility analyses on each of the four options.

Segregate Hazardous Wastes

The assessment team recognized that segregating hazardous wastes from nonhazardous wastes could be implemented at virtually no cost and would save money immediately. There were no identified technical problems.

Use Drain Boards to Reduce Drag-out

Drain boards are used to collect plating solution that drips off the rack and the workpiece after they are pulled out of the plating tank. The plating solution drains back into the plating tank. This option reduces the amount of dilute rinse water waste, but impurities build up faster in the plating solution. Since drag-out is reduced, make-up chemical consumption is reduced.

The purchase price of drain boards is estimated at $115, with installation costs of $200, for a total capital cost of $315. This option is expected to reduce rinse water disposal costs by $500 per year, and reduce make-up chemicals costs by $400 per year. The resulting payback period is 0.35 years, or about 4 months.

Use Deionized Water for Make-up Solutions and Rinse Water

Using DI water will reduce the build-up of impurities in the plating solutions. In particular, the build-uphardness minerals from tap water will be avoided. This, in turn, will avoid the precipitation of carbonates in the plating tanks.

The assessment team decided to combine the evaluation of this option with the previous option of using drain boards. The initial purchase and installation of the deionizer was $267. When adding the cost of the drain boards, the total capital cost of this option is $582. The deionizer is rented and serviced by an outside water treating service company for $450 per year. The savings in disposal costs and make-up chemical costs is $900 per year. Therefore, the annual net operating cost savings is $450 per year. The payback period is 1.3 years.

Install Spray Rinses

Installing spray rinses will reduce the amount of rinse water required to clean the items. With spray rinse nozzles and controls, rinsing can be done on demand. Rinse water usage was estimated to be reduced by 50%. The resulting rinse wastewater is more concentrated and some can be returned to the plating tanks as a water make-up.

The assessment team determined that four spray rinse units would cost $2,120, plus an additional $705 for piping, valves, and installation labor. The total capital cost was $2825. The reduction in disposal costs were estimated at $350 per year, based on a 50% reduction in rinse wastewater. This resulted in a payback of over 8 years.

Implementation

The procedures for segregating hazardous wastes from nonhazardous wastes was implemented before the feasibility analysis was completed for the other three options. The installation of drain boards and the purchase of a water deionizer were made shortly after the feasibility analysis was completed. The DI water system was online two months later. The assessment team decided not to implement the spray rinse option because of the long payback period.

Future WM Assessments

During the next cycle of waste minimization assessments, the assessment team will review previously suggested options in the plating area and will look at ways to reduce the generation of metallic dust in the buffing and polishing area. In the meantime, the assessment team will continue to look for additional opportunities to reduce waste throughout the facility.

Appendix D
Typical Causes and Sources of Waste

In order to develop a comprehensive list of waste minimization options for a facility, it is necessary to understand the sources, causes, and controlling factors that influence waste generation. The tables in this Appendix list this information for common industrial operations.

Table D-1. Typical Wastes from Plant Operations

Table D-2. Causes and Controlling Factors of Waste Generation

Table D-1. Typical Wastes from Plant Operations

Plant Function	Location/Operation	Potential Waste Material
Material Receiving	Loading docks, incoming pipelines, receiving areas	Packaging materials, off-spec materials, damaged containers, inadvertant spills, transfer hose emptying
Raw Material and Product Storage	Tanks, warehouses, drum storage yards, bins, storerooms	Tank bottoms; off-spec and excess materials; spill residues; leaking pumps, valves, tanks, and pipes; damaged containers, empty containers
Production	Melting, curing, baking, distilling, washing, coating, formulating, reaction	Washwater; rinse water; solvents; still bottoms; off-spec products; catalysts;empty containers; sweepings; ductwork clean-out; additives; oil; filters; spill residue; excess materials; process solution dumps; leaking pipes, valves, hoses, tanks, and process equipment
Support Services	Laboratories	Reagents, off-spec chemicals, samples, empty sample and chemical containers
	Maintenance shops	Solvents, cleaning agents, degreasing sludges, sand-blasting waste, caustic, scrap metal, oils, greases
	Garages	Oils, filters, solvents, acids, caustics, cleaning bath sludges, batteries
	Powerhouses/boilers	Fly ash, slag, tube clean-out material, chemical additives, oil empty containers, boiler blowdown, water-treating chemical wastes
	Cooling towers	Chemical additives, empty containers, cooling tower bottom sediment, cooling tower blowdown, fan lube oils

Source: adapted from Gary Hunt and Roger Schecter, "Minimization of Hazardous Waste Generation", Standard Handbook of Hazardous Waste Management, Harry Freeman, editor, McGraw-Hill, New York (currently in press).

Table D-2. Causes and Controlling Factors in Waste Generation

Waste/Origin	Typical Causes	Operational Factors	Design Factors
Chemical Reaction	• Incomplete conversion • By-product formation • Catalyst deactivation (by poisoning or sintering)	• Inadequate temperature control • Inadequate mixing • Poor feed flow control • Poor feed purity control	• Proper reactor design • Proper catalyst selection • Choice of process • Choice of reaction conditions
Contact between aqueous and organic phases	• Condensate from steam jet ejectors • Presence of water as a reaction by-product • Use of water for product rinse • Equipment cleaning • Spill clean-up	• Indiscriminate use of water for cleaning or washing	• Vacuum pumps instead of steam jet ejectors • Choice of process • Use of reboilers instead of steam stripping
Process equipment cleaning	• Presence of cling • Deposit formation • Use of filter aids • Use of chemical cleaners	• Drainage prior to cleaning • Production scheduling to reduce cleaning frequency	• Design reactors or tanks wiper blades • Reduce cling • Equipment dedication
Heat exchanger cleaning	• Presence of cling (process side) or scale (cooling water side) • Deposit formation • Use of chemical cleaners	• Inadequate cooling water treatment • Excessive cooling water temperature	• Design for lower film temperature and high turbulence • Controls to prevent cooling water from overheating
Metal parts cleaning	• Disposal of spent solvents, spent cleaning solution, or cleaning sludge	• Indiscriminate use of solvent or water	• Choice between cold dip tank or vapor degreasing • Choice between solvent or aqueous cleaning solution
Metal surface treating	• Dragout • Disposal of spent treating solution	• Poor rack maintenance • Excessive rinsing with water • Fast removal of workpiece	• Countercurrent rinsing • Fog rinsing • Dragout collection tanks or trays
Disposal of unusable raw materials or off-spec products	• Obsolete raw materials • Off-spec products caused by contamination, improper reactant controls, inadequate pre-cleaning of equipment or workpiece, temperature or pressure excursions	• Poor operator training or supervision • Inadequate quality control • Inadequate production planning and inventory control of feedstocks	• Use of automation • Maximize dedication of equipment to a single function
Clean-up of spills and leaks	• Manual material transfer and handling operations • Leaking pump seals • Leaking flange gaskets	• Inadequate maintenance • Poor operator training • Lack of attention by operator • Excessive use of water in cleaning	• Choice of gasketing materials • Choice of seals • Use of welded or seal-welded construction

Source: Jacobs Engineering Group

Appendix E
Waste Minimization Techniques

The tables in this appendix lists techniques and practices for waste reduction in operations that are applied in a wide range of industries. Most of the techniques listed here are source reduction techniques.

Table E-1. Waste Minimization Options for Coating Operations

Table E-2. Waste Minimization Options for Equipment Cleaning Operations

Table E-3. Waste Minimization through Good Operating Practices

Table E-4. Waste Minimization Options in Materials Handling, Storage, and Transfer

Table E-5. Waste Minimization Options for Parts Cleaning Operations

Source: Jacobs Engineering Group

Table E-1. Waste Minimization Options for Coating Operations

Waste	Source/Origin	Waste Reduction Measures	Remarks	References
Coating overspray	Coating material that fails to reach the object being coated	• Maintain 50% overlap between spray pattern	The coated object does not look streaked, and wastage of coating material is avoided. If the spray gun is arched 45°, the overspray can be as high as 65%.	1,2
		• Maintain 6" - 8" distance between spray gun and the workpiece		
		• Maintain a gun speed of about 250 feet/minute		
		• Hold gun perpendicular to the surface		
		• Trigger gun at the beginning and end of each pass		
		• Proper training of operators		2
		• Use robots for spraying		2
		• Avoid excessive air pressure for coating atomization	By air pressure adjustment, overspray can be reduced to 40%.	2
		• Recycle overspray		3
		• Use electrostatic spray systems	Overspray can be reduced by 40%.	4
		• Use air-assisted airless spray guns in place of air-spray guns	Increases transfer efficiency.	4
Stripping wastes	Coating removal from parts before applying a new coat	• Avoid adding excess thinner	Reduces stripping wastes due to rework.	5
		• Use abrasive media stripping	Solvent usage is eliminated.	
		• Use bead-blasting for paint stripping	Solvent usage is eliminated.	6
		• Use cryogenic stripping	Solvent usage is eliminated.	7
		• Use caustic stripping solutions	Solvent usage is eliminated.	8
		• Clean coating equipment after each use		1
Solvent emissions	Evaporative losses from process equipment and coated parts	• Keep solvent soak tanks away from heat sources		9
		• Use high-solids formulations	Lower usage of solvents.	
		• Use powder coatings	Avoids solvent usage.	10,11
		• Use water-based formulations	Avoids solvent usage.	4,12
Equipment cleanup wastes	Process equipment cleaning with solvents	• Light-to-dark batch sequencing		13
		• Produce large batches of similarly coated objects instead of small batches of differently coated items		
		• Isolate solvent-based paint spray booths from water-based paint spray booths		20
		• Reuse cleaning solution/solvent		
		• Standardize solvent usage		
Overall		• Reexamine the need for coating, as well as available alternatives		

Table E-2. Waste Minimization Options for Equipment Cleaning Operations

Waste	Source/Origin	Waste Reduction Measures	Remarks	References
Spent solvent- or inorganic-based cleaning solutions	Tank cleaning operations	• Maximize dedication of process equipment		
		• Use squeegees to recover cling of product prior to rinsing		
		• Avoid unnecessary cleaning		
		• Closed storage and transfer systems	Scaling and drying up can be prevented.	
		• Provide sufficient drain time for liquids	Minimizes leftover material.	
		• Lining the equipment to prevent cling	Reduces cling.	18
		• "Pigging" process lines		19
		• Use high-pressure spray nozzles	Minimizes solvent consumption.	
		• Use countercurrent rinsing		
		• Use clean-in-place systems		
		• Clean equipment immediately after use	Prevents hardening of scale that requires more severe cleaning.	
		• Reuse cleanup solvent		
		• Rework cleanup solvent into useful products		
		• Segregate wastes by solvent type		
		• Standardize solvent usage		
		• Reclaim solvent by distillation		
		• Schedule production to lower cleaning frequency		
Wastewater sludges, spent acidic solutions	Heat exchanger cleaning	• Use bypass control or pumped recycle to maintain turbulence during turndown	Onsite or offsite recycling.	
		• Use smooth heat exchange surfaces	Electroplated or Teflon® tubes.	20
		• Use on-stream cleaning techniques	"Superscrubber", for example.	21
		• Use hydroblasting over chemical cleaning where possible		

Table E-3. Waste Minimization through Good Operating Practices

Good Operating Practice	Program Ingredients	Remarks	References
Waste minimization assessments	• Form a team of qualified individuals • Establish practical short-term and long-term goals • Allocate resources and budget for the program • Establish assessment targets • Identify and select options to minimize waste Periodically monitor the program's effectiveness	These programs are conducted to reduce waste in a facility.	22
Environmental audits/reviews	• Assemble pertinent documents • Conduct environmental process reviews • Carry out a site inspection • Report on and follow up on the findings	These audits are conducted to monitor compliance with regulations.	23,24
Loss prevention programs	• Establish Spill Prevention, Control, and Countermeasures (SPCC) plans • Conduct hazard assessment in the design and operating phases	SPCC plans are required by law for oil storage facilities.	3,25,26
Waste Segregation	• Prevent mixing of hazardous wastes with non-hazardous wastes • Isolate hazardous wastes by contaminant • Isolate liquid wastes from solid wastes	These measures can result in lower waste haulage volumes and easier disposal of the hazardous wastes.	4
Preventive maintenance programs	• Use equipment data cards on equipment location, characteristics, and maintenance • Maintain a master preventive maintenance (PM) schedule • Deferred PM reports on equipment • Maintain equipment history cards • Maintain equipment breakdown reports • Keep vendor maintenance manuals handy • Maintain a manual or computerized repair history file	These programs are conducted to cut production costs and decrease equipment downtime, in addition to preventing waste releases due to equipment failure.	27,28,29

Table E-3. Waste Minimization through Good Operating Practices (continued)

Good Operating Practice	Program Ingredients	Remarks	References
Training/Awareness-building programs	• Provide training for - Safe operation of the equipment - Proper materials handling - Economic and environmental ramifications of hazardous waste generation and disposal - Detecting releases of hazardous materials - Emergency procedures - Use of safety gear	These programs are conducted to reduce occupational health and safety hazards, in addition to reducing waste generation due to operator or procedural errors.	2
Effective supervision	• Closer supervision may improve production efficiency and reduce inadvertent waste generation • Management by objectives (MBO), with goals for waste reduction	Increased opportunity for early detection of mistakes. Better coordination among the various parts of an overall operation.	
Employee participation	• "Quality circles" (free forums between employees and supervisors) can identify ways to reduce waste • Solicit employee suggestions for waste reduction ideas	Employees who intimately understand the operations can identify ways to reduce waste.	
Production scheduling/planning	• Maximize batch size • Dedicate equipment to a single product • Alter batch sequencing to minimize cleaning frequency (light-to-dark batch sequence, for example) • Schedule production to minimizing cleaning frequency	Altering production schedule can have a major impact on waste minimization.	
Cost accounting/allocation	• Cost accounting done for all waste streams leaving the facilities • Allocate waste treatment and disposal costs to the operations that generate the waste	Allocating costs to the waste-producing operations will give them an incentive to cut their wastes.	

Table E-4. Waste Minimization Options in Materials Handling, Storage, and Transfer

Waste/Source	Waste Reduction Measures	Remarks	References
Material/waste tracking and inventory control	• Avoid over-purchasing • Accept raw material only after inspection • Ensure that inventory quantity does not go to waste • Ensure that no containers stay in inventory longer than a specified period • Review material procurement specifications • Return expired material to supplier • Validate shelf-life expiration dates • Test outdated material for effectiveness • Eliminate shelf-life requirements for stable compounds • Conduct frequent inventory checks • Use computer-assisted plant inventory system • Conduct periodic materials tracking • Proper labeling of all containers • Set up manned stations for dispensing chemicals and collecting wastes	These procedures are employed to find areas where the waste minimization efforts are to be concentrated.	30,31
Loss prevention programs	• Use properly designed tanks and vessels only for their intended purposes • Install overflow alarms for all tanks and vessels • Maintain physical integrity of all tanks and vessels • Set up written procedures for all loading/unloading and transfer operations • Install secondary containment areas • Forbid operators to bypass interlocks, alarms, or significantly alter setpoints without authorization • Isolate equipment or process lines that leak or are not in service • Use seal-less pumps • Use bellows-seal valves • Document all spillage • Perform overall material balances and estimate the quantity and dollar value of all losses • Use floating-roof tanks for VOC control • Use conservation vents on fixed roof tanks • Use vapor recovery systems		

Table E-4. Waste Minimization Options in Materials Handling, Storage, and Transfer (continued)

Waste/Source	Waste Reduction Measures	Remarks	References
Spills and leaks	• Store containers in such a way as to allow for visual inspection for corrosion and leaks • Stack containers in a way to minimize the chance of tipping, puncturing, or breaking • Prevent concrete "sweating" by raising the drum off storage areas • Maintain MSDSs to correctly handle spill situations • Provide adequate lighting in the storage area • Maintain a clean, even surface in transportation areas • Keep aisles clear of obstruction • Maintain distance between incompatible chemicals • Maintain distance between different types of chemicals to prevent cross-contamination • Avoid stacking containers against process equipment • Follow manufacturers' suggestions on the storage and handling of all raw materials • Insulation and inspection of electric circuitry for corrosion and potential sparking		
Cling	• Use large containers instead of small containers whenever possible • Use containers with height-to-diameter ratio equal to one to minimize wetted area • Empty drums and containers thoroughly before cleaning or disposal		

Table E-5. Waste Minimization Options for Parts Cleaning Operations

Waste	Source/Origin	Waste Reduction Measures	Remarks	References
Spent solvent	Contaminated solvent from parts cleaning operations	• Use water-soluble cutting fluids instead of oil-based fluids	This could eliminate the need for solvent cleaning.	
		• Use peel coatings in place of protective oils		
		• Use aqueous cleaners		
		• Use aqueous paint stripping solutions		8
		• Use cryogenic stripping		7
		• Use bead blasting for paint stripping		6
		• Use multi-stage countercurrent cleaning		
		• Prevent cross-contamination		
		• Prevent drag-in from other processes		
		• Prompt removal of sludge from the tank		
		• Reduce the number of different solvents used	A single, larger waste that is more amenable to recycling.	
Air emissions	Solvent loss from degreasers and cold tanks	• Use roll-type covers, not hinged covers	24 to 50% reduction in emissions.	15
		• Increase freeboard height	39% reduction in solvent emissions.	15
		• Install freeboard chillers		15
		• Use silhouette entry covers		
		• Proper equipment layout		
		• Avoid rapid insertion and removal of items	The speed that items are put into the tank should be less than 11 feet/min.	16
		• Avoid inserting oversized objects into the tank	Cross-sectional area of the item should be less that 50% of tank area to reduce piston effect.	17
		• Allow for proper drainage before removing item		
		• Avoid water contamination of solvent in degreasers		
Rinse water	Water rinse to remove solvent carried out with the parts leaving the cleaning tank	• Reduce solvent dragout by proper design and operation of rack system	The dragout can be 0.4 gal/1000 sqft, versus 24 gal/1000 sqft for poorly drained parts.	15
		• Install air jets to blow parts dry		
		• Use fog nozzles on rinse tanks		
		• Proper design and operation of barrel system		15
		• Use countercurrent rinse tanks		15
		• Use water sprays on rinse tanks	More efficient rinsing is achieved.	15

Appendix E
References

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Appendix F
Government Technical/Financial Assistance Programs

The EPA's Office of Solid Waste and Emergency Response has set up a telephone call-in service to answer questions regarding RCRA and Superfund (CERCLA):

(800) 424-9346 (outside the District of Columbia)
(202) 382-3000 (in the District of Columbia)

The following states have programs that offer technical and/or financial assistance in the areas of waste minimization and treatment.

Alabama
Hazardous Material Management and Resource Recovery Program
University of Alabama
P.O. Box 6373
Tuscaloosa, AL 35487-6373
(205) 348-8401

Alaska
Alaska Health Project
Waste Reduction Assistance Program
431 West Seventh Avenue, Suite 101
Anchorage, AK 99501
(907)276-2864

Arkansas
Arkansas Industrial Development Commission
One State Capitol Mall
Little Rock, AR 72201
(501) 371-1370

California
Alternative Technology Section
Toxic Substances Control Division
California State Department of Health Services
714/744 P Street
Sacramento, CA 94234-7320
(916) 324-1807

Connecticut
Connecticut Hazardous Waste Management Service
Suite 360
900 Asylum Avenue
Hartford, CT 06105
(203) 244-2007

Connecticut Department of Economic Development
210 Washington Street
Hartford CT 06106
(203) 566-7196

Georgia
Hazardous Waste Technical Assistance Program
Georgia Institute of Technology
Georgia Technical Research Institute
Environmental Health and Safety Division
O'Keefe Building, Room 027
Atlanta, GA 30332
(404) 894-3806

Georgia (continued)
Environmental Protection Division
Georgia Department of Natural Resources
Floyd Towers East, Suite 1154
205 Butler Street
Atlanta, CA 30334
(404) 656-2833

Illinois
Hazardous Waste Research and Information Center
Illinois Department of Energy and Natural Resources
1808 Woodfield Drive
Savoy, IL 61874
(217) 333-8940

Illinois Waste Elimination Research Center
Pritzker Department of Environmental Engineering
Alumni Building, Room 102
Illinois Institute of Technology
3200 South Federal Street
Chicago, IL 60616
(312) 567-3535

Indiana
Environmental Management and Education Program
Young Graduate House, Room 120
Purdue University
West Lafayette, IN 47907
(317) 494-5036

Indiana Department of Environmental Management
Office of Technical Assistance
P.O. Box 6015
105 South Meridian Street
Indianapolis, IN 46206-6015
(317) 232-8172

Iowa
Iowa Department of Natural Resources
Air Quality and Solid Waste Protection Bureau
Wallace State Office Building
900 East Grand Avenue
Des Moines, IA 50319-0034
(515) 281-8690

Center for Industrial Research and Service
205 Engineering Annex
Iowa State University
Ames, IA 50011
(515) 294-3420

Kansas

Bureau of Waste Management
Department of Health and Environment
Forbes Field, Building 730
Topeka, KS 66620
(913) 296-1607

Kentucky

Division of Waste Management
Natural Resources and Environmental Protection Cabinet
18 Reilly Road
Frankfort, KY 40601
(502) 564-6716

Louisiana

Department of Environmental Quality
Office of Solid and Hazardous Waste
P.O. Box 44307
Baton Rouge, LA 70804
(504) 342-1354

Maryland

Maryland Hazardous Waste Facilities Siting Board
60 West Street, Suite 200A
Annapolis, MD 21401
(301) 974-3432

Maryland Environmental Service
2020 Industrial Drive
Annapolis, MD 21401
(301) 269-3291
(800) 492-9188 (in Maryland)

Massachusetts

Office of Safe Waste Management
Department of Environmental Management
100 Cambridge Street, Room 1094
Boston, MA 02202
(617) 727-3260

Source Reduction Program
Massachusetts Department of Environmental Quality Engineering
1 Winter Street
Boston, MA 02108
(617) 292-5982

Michigan

Resource Recovery Section
Department of Natural Resources
P.O. Box 30028
Lansing, MI 48909
(517) 373-0540

Minnesota

Minnesota Pollution Control Agency
Solid and Hazardous Waste Division
520 Lafayette Road
St. Paul, MN 55155
(612) 296-6300

Minnesota (continued)

Minnesota Technical Assistance Program
W-140 Boynton Health Service
University of Minnesota
Minneapolis, MN 55455
(612) 625-9677
(800) 247-0015 (in Minnesota)

Minnesota Waste Management Board
123 Thorson Center
7323 Fifty-Eighth Avenue North
Crystal, MN 55428
(612) 536-0816

Missouri

State Environmental Improvement and Energy Resources Agency
P.O. Box 744
Jefferson City, MO 65102
(314) 751-4919

New Jersey

New Jersey Hazardous Waste Facilities Siting Commission
Room 614
28 West State Street
Trenton, NJ 08608
(609) 292-1459
(609) 292-1026

Hazardous Waste Advisement Program
Bureau of Regulation and Classification
New Jersey Department of Environmental Protection
401 East State Street
Trenton, NJ 08625

Risk Reduction Unit
Office of Science and Research
New Jersey Department of Environmental Protection
401 East State Street
Trenton, NJ 08625

New York

New York State Environmental Facilities Corporation
50 Wolf Road
Albany, NY 12205
(518) 457-3273

North Carolina

Pollution Prevention Pays Program
Department of Natural Resources and Community Development
P.O. Box 27687
512 North Salisbury Street
Raleigh, NC 27611
(919) 733-7015

Governor's Waste Management Board
325 North Salisbury Street
Raleigh, NC 27611
(919) 733-9020

North Carolina (continued)

Technical Assistance Unit
Solid and Hazardous Waste Management Branch
North Carolina Department of Human Resources
P.O. Box 2091
306 North Wilmington Street
Raleigh, NC 27602
(919) 733-2178

Ohio

Division of Solid and Hazardous Waste Management
Ohio Environmental Protection Agency
P.O. Box 1049
1800 WaterMark Drive
Columbus, OH 43266-1049
(614) 481-7200

Ohio Technology Transfer Organization
Suite 200
65 East State Street
Columbus, OH 43266-0330
(614) 466-4286

Oklahoma

Industrial Waste Elimination Program
Oklahoma State Department of Health
P.O. Box 53551
Oklahoma City, OK 73152
(405) 271-7353

Oregon

Oregon Hazardous Waste Reduction Program
Department of Environmental Quality
811 Southwest Sixth Avenue
Portland, OR 97204
(503) 229-5913

Pennsylvania

Pennsylvania Technical Assistance Program
501 F. Orvis Keller Building
University Park, PA 16802
(814) 865-0427

Bureau of Waste Management
Pennsylvania Department of Environmental Resources
P.O. Box 2063
Fulton Building
3rd and Locust Streets
Harrisburg, PA 17120
(717) 787-6239

Center of Hazardous Material Research
320 William Pitt Way
Pittsburgh, PA 15238
(412) 826-5320

Rhode Island

Ocean State Cleanup and Recycling Program
Rhode Island Department of Environmental Management
9 Hayes Street
Providence, RI 02908-5003
(401) 277-3434
(800) 253-2674 (in Rhode Island)

Rhode Island (continued)

Center of Environmental Studies
Brown University
P.O. Box 1943
135 Angell Street
Providence, RI 02912
(401) 863-3449

Tennessee

Center for Industrial Services
102 Alumni Hall
University of Tennessee
Knoxville, TN 37996
(615) 974-2456

Virginia

Office of Policy and Planning
Virginia Department of Waste Management
11th Floor, Monroe Building
101 North 14th Street
Richmond, VA 23219
(804) 225-2667

Washington

Hazardous Waste Section
Mail Stop PV-11
Washington Department of Ecology
Olympia, WA 98504-8711
(206) 459-6322

Wisconsin

Bureau of Solid Waste Management
Wisconsin Department of Natural Resources
P.O. Box 7921
101 South Webster Street
Madison, WI 53707
(608) 266-2699

Wyoming

Solid Waste Management Program
Wyoming Department of Environmental Quality
Herschler Building, 4th Floor, West Wing
122 West 25th Street
Cheyenne, WY 82002
(307) 777-7752

Appendix G
Option Rating
Weighted Sum Method

The Weighted Sum Method is a quantitative method for screening and ranking waste minimization options. This method provides a means of quantifying the important criteria that affect waste management in a particular facility. This method involves three steps.

1. Determine what the important criteria are in terms of the WM assessment program goals a constraints, and the overall corporate goals an constraints. Examples of criteria are the following:

   - Reduction in waste quantity
   - Reduction in waste hazard (e.g., toxicity, flammability, reactivity, corrosivity, etc.)
   - Reduction in waste treatment/disposal costs
   - Reduction in raw material costs
   - Reduction in liability and insurance costs
   - Previous successful use within the company
   - Previous successful use in industry
   - Not detrimental to product quality
   - Low capital cost
   - Low operating and maintenance costs
   - Short implementation period (and minimal disruption of plant operations)
   - Ease of implementation

   The weights (on a scale of 0 to 10, for example) are determined for each of the criteria in relation to their importance.For example, if reduction in waste treatment and disposal costs are very important, while previous successful use within the company is of minor importance, then the reduction in waste costs is given a weight of 10 and the previous use within the company is given a weight of 1 or 2. Criteria that are not important are not included (or given a weight of 0).

2. Each option is then rated on each of the criteria. Again, a scale of 0 to 10 can be used (0 for low and 10 for high).

3. Finally, the rating of each option from particular criteria is multiplied by the weight of the criteria. An option's overall rating is the sum of the products of rating times the weight of the criteria.

The options with the best overall ratings are then selected for the technical and economic feasibility analyses. Worksheet 13 in Appendix A is used to rate options using the Weighted Sum method. Table G-1 presents an example using the Weighted Sum Method for screening and ranking options.

Table G-1. Sample Calculation using the Weighted Sum Method

ABC Corporation has determined that reduction in waste treatment costs is the most important criterion, with a weight factor of 10. Other significant criteria include reduction in safety hazard (weight of 8), reduction in liability (weight of 7), and ease of implementation (weight of 5). Options X, Y, and Z are then each assigned effectiveness factors. For example, option X is expected to reduce waste by nearly 80%, and is given an rating of 8. It is given a rating of 6 for reducing safety hazards, 4 for reducing liability, and because it is somewhat difficult to implement, 2 for ease of implementation. The table below shows how the options are rated overall, with effectiveness factors estimated for options Y and Z.

		Ratings for each option		
Rating Criteria	Weight	X	Y	Z
Reduce treatment costs	10	8	6	3
Reduce safety hazards	8	6	3	8
Reduce liability	7	4	4	5
Ease of implementation	5	2	2	8
Sum of weight times ratings		166	122	169

From this screening, option Z rates the highest with a score of 169. Option X's score is 166 and option Y's score is 122. In this case, option Z and option X should both be selected for further evaluation because both of their scores are high and relatively close to each other.

Appendix H
Economic Evaluation Example

The following example presents a profitability analysis for a relatively large hypothetical waste minimization project. This project represents the installation of a package unit that improves plant production while reducing raw material consumption and disposal costs. The analysis was done on a personal computer using a standard spreadsheet program. The salient data used in this evaluation are summarized below.

Capital Costs

- The delivered price of the equipment is quoted by the vendor at $170,000. This includes taxes and insurance.
- Materials costs (piping, wiring, and concrete) are estimated at $35,000.
- Installation labor is estimated at $25,000.
- Internal engineering staff costs are estimated at $7,000. Outside consultant and contractor costs are estimated at $15,000.
- Miscellaneous environmental permitting costs are estimated at $15,000.
- Working capital (including chemical inventories, and materials and supplies) is estimated at $5,000.
- Start-up costs are estimated by the vendor at $3,000.
- A contingency of $20,000 for unforeseen costs and/or overruns is included.
- Planning, design, and installation are expected to take one year.

Financing

- The project will be financed 60% by retained earnings and 40% by a bank loan.
- The bank loan will be repaid over 5 years of equal installments of principal, plus interest at an annual percentage rate of 13%. Interest accrued during installation will be added into the total capital costs.
- All capital costs, except working capital and interest accrued during construction, will be depreciated over 7 years using the double-declining balance method, switching to the straight-line method when the charges by this method become greater.
- The marginal income tax rate is 34%.
- Escalation of all costs is assumed to be 5% per year for the life of the project.
- The firm's cost of capital is 15%.

Operating Costs and Revenues

- The WM project is estimated to decrease raw materials consumption by 300 units per year at a cost of $50 per unit. The project will not result in an increased production. However, it will produce a marketable by-product to be recovered at a rate of 200 units per year and a price of $25 per unit.
- The project will reduce the quantity of hazardous waste disposed by 200 tons per year. The following items make the total unit disposal costs:

	Costs per ton of waste
Offsite disposal fees	$500
State generator taxes	10
Transportation costs	25
Other costs	25
TOTAL DISPOSAL COSTS	$560

- Incremental operating labor costs are estimated on the basis that the project is expected to require one hour of operator's time per eight-hour shift. There are three shifts per day and the plant operates 350 days per year. The wage rate for operators is $12.50 per hour.
- Operating supplies expenses are estimated at 30% of operating labor costs.
- Maintenance labor costs are estimated at 2% of the sum of the capital costs for equipment, materials, and installation. Maintenance supplies costs are estimated at 1% of these costs.
- Incremental supervision costs are estimated at 30% of the combined costs of operating and maintenance labor.
- The following overhead costs are estimated as a percentage of the sum of operating and maintenance labor and supervision costs.

Labor burden and benefit	28%
Plant overhead	25%
Headquarter overhead	20%

- Escalation of all costs is assumed to be 5% per year for the life of the project.
- The project life is expected to be 8 years.
- The salvage value of the project is expected to be zero after eight years.

Results

The four-page printout in Figures H-1 through H-4 presents the WM project profitability spreadsheet program. Figure H-1 represents the input section of the program. Each of the numbers in the first three columns represents an input variable in the program. The righthand side of Figure H-1 is a summary of the capital requirement. This includes a calculation of the interest accrued during construction and the financing structure of the project.

Figure H-2 is a table of the revenues and operating cost items for each of the eight years of the project's operating life. These costs are escalated by 5% each year for the life of the project.

Figure H-3 presents the annual cash flows for the project. The calculation of depreciation charges and the payment of interest and repayment of loan principal is also shown here. The calculation of the internal rate of return (IRR) and the net present value (NPV) are based on the annual cash flows. Since the project is leveraged (financed partly by a bank loan), the equity portion of the investment is used as the initial cash flow. The NPV and the IRR are calculated on this basis. The IRR calculated this way is referred to as the "return on equity". The program is structured to present the NPV and IRR after each year of the project's operating life. In the example, after six years, the IRR is 19.92% and the NPV is $27,227.

Figure H-4 is a cash flow table based entirely on equity financing. Therefore, there are no interest payments or deb principal repayments. The NPV and the IRR in this case are based on the entire capital investment in the project. The IRR calculated this way is referred to as the "return on investment".

The results of the profitability analysis for this project are summarized below:

Method of Financing	*IRR*	*NPV*
60% equity/40% debt	26.47%	$84,844
100% equity	23.09%	$81,625

The IRR values are greater than the 15% cost of capital, and the NPVs are positive. Therefore, the project is attractive, and should be implemented.

Waste Minimization		started 5/22/87					
Profitability Program		last changed 8/1/87					
		INPUT				**CAPITAL REQUIREMENT**	
Capital Cost Factors		**Operating Cost/Revenue Factors**					
						Construction Year	1
Capital Cost		Increased Production		Operating Labor			
Equipment	$170,000	Increased Rate, units/year	0	Operator hours/shift	1	Capital Expenditures	
Materials	$35,000	Price, $/unit	$100	Shifts/day	3	Equipment	$170,000
Installation	$25,000			Operating days/year	350	Materials	$35,000
Plant Engineering	$7,000	Marketable By-products		Wage rate, $/man-hour	$13.50	Installation	$25,000
Contractor/Engineering	$15,000	Rate, units/year	200			Plant Engineering	$7,000
Permitting Costs	$15,000	Price, $/unit	$40	Operating Supplies	30%	Contractor/Engineering	$15,000
Contingency	$20,000			(% of Operating Labor)		Permitting Costs	$15,000
Working Capital	$5,000	Decreased Raw Materials				Contingency	$20,000
Start-up Costs	$3,000	Decreased Rate, units/year	300	Maintenance Costs		Start-up Costs	$3,000
		Price, $/unit	$50	(% of Capital Costs)		Depreciable Capital	$290,000
% Equity	60%			Labor	2.00%	Working Capital	$5,000
% Debt	40%	Decreased Waste Disposal		Materials	1.00%	Subtotal	$295,000
Interest Rate on Debt, %	13.00%	Reduced Waste, tons/year	200			Interest on Debt	$14,230
Debt Repayment, years	5	Offsite Fees, $/ton	$500	Other Labor Costs		Total Capital Requirement	$309,230
		State Taxes, $/ton	$10	(% of O&M Labor)			
Depreciation period	7	Transportation, $/ton	$25	Supervision	30.0%	Equity Investment	$185,538
Income Tax Rate, %	34.00%	Other Disposal Costs, $/ton	$25	(% of O&M Labor + Supervision)		Debt Principal	$109,462
		Total Disposal Costs, $/ton	$560	Plant Overhead	25.0%	Interest on Debt	$14,230
Escalation Rates, %	5.0%			Home Office Overhead	20.0%	Total Financing	$309,230
				Labor Burden	28.0%		
Cost of Capital (for NPV)	15.00%						

Figure H-1. Input Information and Capital Investment

REVENUE AND COST FACTORS									
Operating Year Number		1	2	3	4	5	6	7	8
Escalation Factor	1.000	1.050	1.103	1.158	1.216	1.277	1.341	1.408	1.478
INCREASED REVENUES									
Increased Production		$0	$0	$0	$0	$0	$0	$0	$0
Marketable By-products		$8,400	$8,824	$9,264	$9,728	$10,216	$10,728	$11,264	$11,824
Annual Revenue		$8,400	$8,824	$9,264	$9,728	$10,216	$10,728	$11,264	$11,824
OPERATING COST/SAVINGS									
Raw Materials		$15,750	$16,545	$17,370	$18,240	$19,155	$20,115	$21,120	$22,170
Disposal Costs		$117,600	$123,536	$129,696	$136,192	$143,024	$150,192	$157,696	$165,536
Maintenance Labor		($4,830)	($5,074)	($5,327)	($5,594)	($5,874)	($6,169)	($6,477)	($6,799)
Maintenance Supplies		($2,415)	($2,537)	($2,663)	($2,797)	($2,937)	($3,084)	($3,238)	($3,399)
Operating Labor		($14,884)	($15,635)	($16,415)	($17,237)	($18,101)	($19,009)	($19,958)	($20,951)
Operating Supplies		($4,465)	($4,691)	($4,925)	($5,171)	($5,430)	($5,703)	($5,987)	($6,285)
Supervision		($5,914)	($6,213)	($6,523)	($6,849)	($7,193)	($7,553)	($7,931)	($8,325)
Labor Burden		($7,176)	($7,538)	($7,914)	($8,310)	($8,727)	($9,165)	($9,622)	($10,101)
Plant Overhead		($6,407)	($6,731)	($7,066)	($7,420)	($7,792)	($8,183)	($8,592)	($9,019)
Home Office Overhead		($5,126)	($5,384)	($5,653)	($5,936)	($6,234)	($6,546)	($6,873)	($7,215)
Total Operating Costs		$82,133	$86,278	$90,580	$95,118	$99,891	$104,895	$110,138	$115,612

Figure H-2. Revenues and Operating Costs

RETURN ON EQUITY/RETURN ON ASSETS									
Construction Year	1								
Operating Year		1	2	3	4	5	6	7	8
Book Value	$290,000	$207,143	$147,959	$105,685	$64,256	$22,827	$0	$0	$0
Depreciation (by straight-line)		$41,429	$41,429	$41,429	$41,429	$41,429	$41,429	$0	$0
Depreciation (by doubleDB)		$82,857	$59,184	$42,274	$30,196	$18,359	$6,522	$0	$0
Depreciation		$82,857	$59,184	$42,274	$41,429	$41,429	$22,827	$0	$0
Debt Balance	$123,692	$123,692	$98,954	$74,216	$49,478	$24,740	$2	$0	$0
Interest Payment		$16,080	$12,864	$9,648	$6,432	$3,216	$0	$0	$0
Principal Repayment		$24,738	$24,738	$24,738	$24,738	$24,738	$2	$0	$0
CASH FLOWS									
Construction Year	1								
Operating Year		1	2	3	4	5	6	7	8
Revenues		$8,400	$8,824	$9,264	$9,728	$10,216	$10,728	$11,264	$11,824
+ Operating Savings		$82,133	$86,278	$90,580	$95,118	$99,891	$104,895	$110,138	$115,612
Net Revenues		$90,533	$95,102	$99,844	$104,846	$110,107	$115,623	$121,402	$127,436
- Depreciation		$82,857	$59,184	$42,274	$41,429	$41,429	$22,827	$0	$0
- Interest on Debt		$16,080	$12,864	$9,648	$6,432	$3,216	$0	$0	$0
Taxable Income		($8,404)	$23,054	$47,922	$56,985	$65,462	$92,796	$121,402	$127,436
- Income Tax		($2,857)	$7,838	$16,293	$19,375	$22,257	$31,551	$41,277	$43,328
Profit after Tax		($5,547)	$15,216	$31,629	$37,610	$43,205	$61,245	$80,125	$84,108
+ Depreciation		$82,857	$59,184	$42,274	$41,429	$41,429	$22,827	$0	$0
- Debt Repayment		$24,738	$24,738	$24,738	$24,738	$24,738	$2	$0	$0
After-Tax Cash Flow		$52,572	$49,662	$49,165	$54,301	$59,896	$84,070	$80,125	$84,108
Cash Flow for ROE	($185,538)	$52,572	$49,662	$49,165	$54,301	$59,896	$84,070	$80,125	$84,108
Net Present Value	($185,538)	($139,823)	($102,272)	($69,945)	($38,898)	($9,119)	$27,227	$57,349	$84,844
Return on Equity		#NUM!	-32.19%	-9.62%	4.24%	12.95%	19.92%	23.85%	26.47%
26.47%									

Figure H-3. Cash Flows for Return on Equity

RETURN ON INVESTMENT									
Construction Year	1								
Operating Year		1	2	3	4	5	6	7	8
Book Value	$290,000	$207,143	$147,959	$105,685	$64,256	$22,827	$0	$0	$0
Depreciation (by straight-line)		$41,429	$41,429	$41,429	$41,429	$41,429	$41,429	$0	$0
Depreciation (by double DB)		$82,857	$59,184	$42,274	$30,196	$18,359	$6,522	$0	$0
Depreciation		$82,857	$59,184	$42,274	$41,429	$41,429	$22,827	$0	$0
CASH FLOWS									
Construction Year	1								
Operating Year		1	2	3	4	5	6	7	8
Revenues		$8,400	$8,824	$9,264	$9,728	$10,216	$10,728	$11,264	$11,824
+ Operating Savings		$82,133	$86,278	$90,580	$95,118	$99,891	$104,895	$110,138	$115,612
Net Revenues		$90,533	$95,102	$99,844	$104,846	$110,107	$115,623	$121,402	$127,436
- Depreciation		$82,857	$59,184	$42,274	$41,429	$41,429	$22,827	$0	$0
Taxable Income		$7,676	$35,918	$57,570	$63,417	$68,678	$92,796	$121,402	$127,436
- Income Tax		$2,610	$12,212	$19,574	$21,562	$23,351	$31,551	$41,277	$43,328
Profit after Tax		$5,066	$23,706	$37,996	$41,855	$45,327	$61,245	$80,125	$84,108
+ Depreciation		$82,857	$59,184	$42,274	$41,429	$41,429	$22,827	$0	$0
After-Tax Cash Flow		$87,923	$82,890	$80,270	$83,284	$86,756	$84,072	$80,125	$84,108
Cash Flow for ROI	($295,000)	$87,923	$82,890	$80,270	$83,284	$86,756	$84,072	$80,125	$84,108
Net Present Value	($295,000)	($218,545)	($155,868)	($103,090)	($55,472)	($12,339)	$24,008	$54,130	$81,625
Return on Investment		#NUM!	-30.04%	-7.76%	5.26%	13.21%	17.99%	20.97%	23.09%
23.09%									

Figure H-4. Cash Flows for Return on Investment

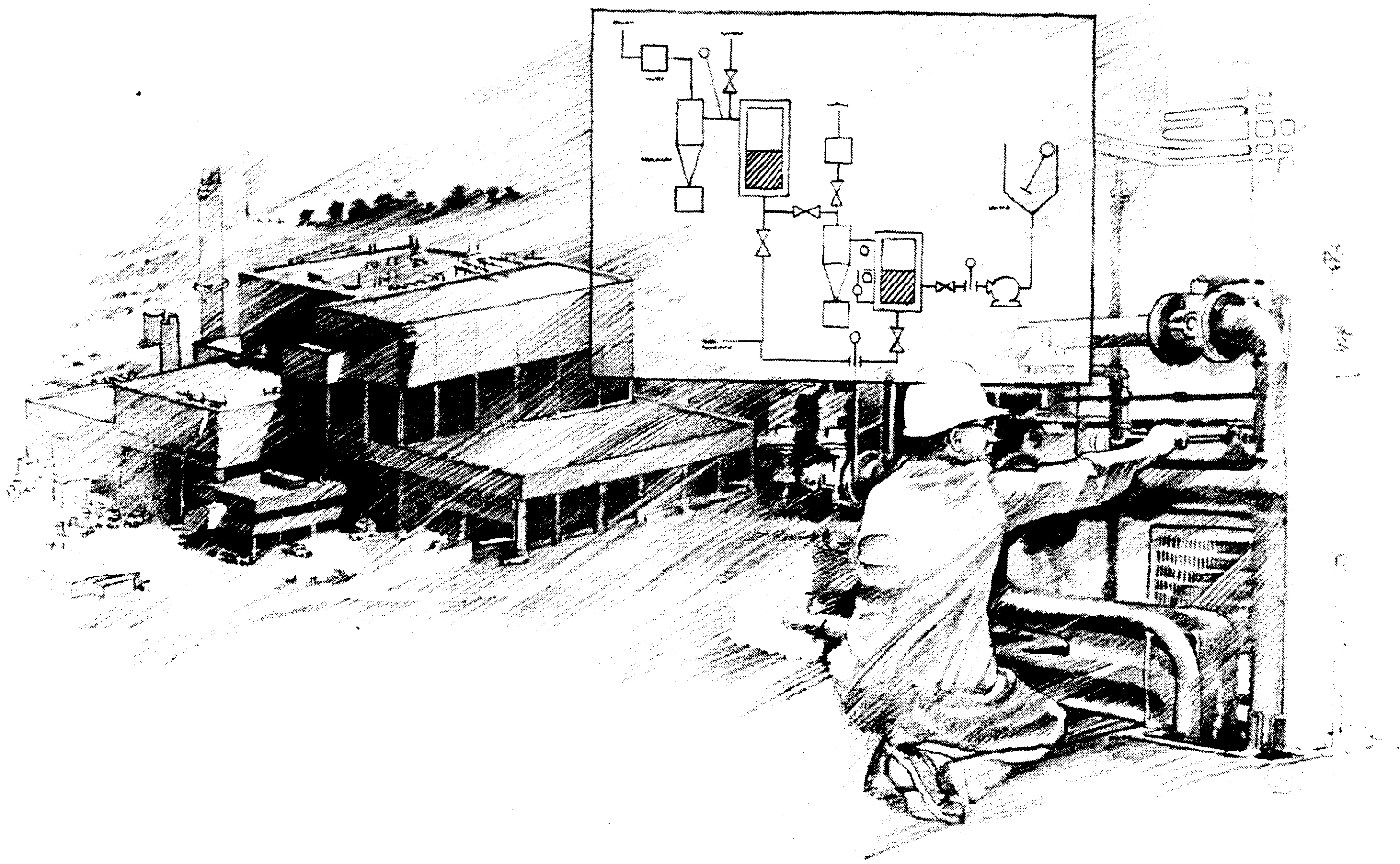
United States
Environmental Protection
Agency

Office of Research and
Development
Washington, DC 20460

EPA/600/R-92/088
May 1992

EPA

Facility Pollution Prevention Guide



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APPENDIX

FIGURES

LIST OF ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygienists
DOE	Department of Energy
EPA	Environmental Protection Agency
ES&H	Environmental, Safety, & Health
MNCAW	Materials Not Categorized As Waste
MSDS	Material Safety Data Sheet
NPDES	National Pollutant Discharge Elimination System
ODC	Ozone Depleting Compound
OSHA	Occupational Safety and Health Administration
PCB	Polychlorinated biphenyl
PM/WSL	Priority Material/Waste Stream List
POTW	Publicly Owned Treatment Works
PPOA	Pollution Prevention Opportunity Assessment
PWA	Process Waste Assessment
VOC	Volatile Organic Compound
WMin/PP	Waste Minimization/Pollution Prevention

ACKNOWLEDGMENT

In July, 1988, DOE Defense Programs recognized the need for a waste minimization program that would focus beyond pollution control and the traditional media-by-media approach to containment and treatment of environmental releases. Defense Programs was proactive in initiating a Waste Minimization Program that included the completion of process waste assessments as a means to identify opportunities which would reduce the generation of waste.

The Waste Minimization Program evolved to a Pollution Prevention Program through the auspices of the DOE Defense Programs' Pollution Prevention Strategic Plan issued in April, 1992. The Strategic Plan reiterated the hierarchy of preferred environmental practices outlined in the Pollution Prevention Act of 1990 (i.e. source reduction, recycling, treatment, and finally, disposal).

The first Model PWA Guidance was assembled by Defense Programs' contractors based on the published EPA guidance and previous work performed at the Y-12 Plant. The manual was originally issued in February 1990, and distributed throughout the Weapons Complex. This is the first revision to the document, and it replaces the term "PWA" with a more positive term, "Pollution Prevention Opportunity Assessment". The new term avoids the implication that assessments should be limited to process wastes, rather, they should address all releases.

The following DOE personnel and DOE contractors assisted in the suggestions for this revision. Their time and effort were greatly appreciated.

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I. INTRODUCTION

A. PURPOSE OF GUIDANCE

The purpose of this document is to provide a guide for DOE sites to conduct pollution prevention opportunity assessments (PPOAs), commonly known through the DOE as process waste assessments (PWAs). This will avoid the implication that assessments should be limited to process wastes - PPOAs address all releases. This guidance describes those activities and methods that can be employed to characterize all waste generating processes and identifies opportunities to reduce or eliminate waste generation. The document also includes a methodology to evaluate proposed modifications to site processes and other options to minimize waste and prevent pollution.

B. GUIDANCE SCOPE AND OBJECTIVES

PPOAs will be conducted as part of an ongoing program to identify opportunities to eliminate or reduce the generation of waste. A PPOA documents the amount of material that is disposed of as waste during operations. It provides a summary of material usage, process by-products, and waste generation; and it targets those processes and operations that need to be improved or replaced to promote waste minimization and pollution prevention. The assessment also establishes a basis to prioritize modifications to site processes or other pollution prevention options that are developed during the assessment.

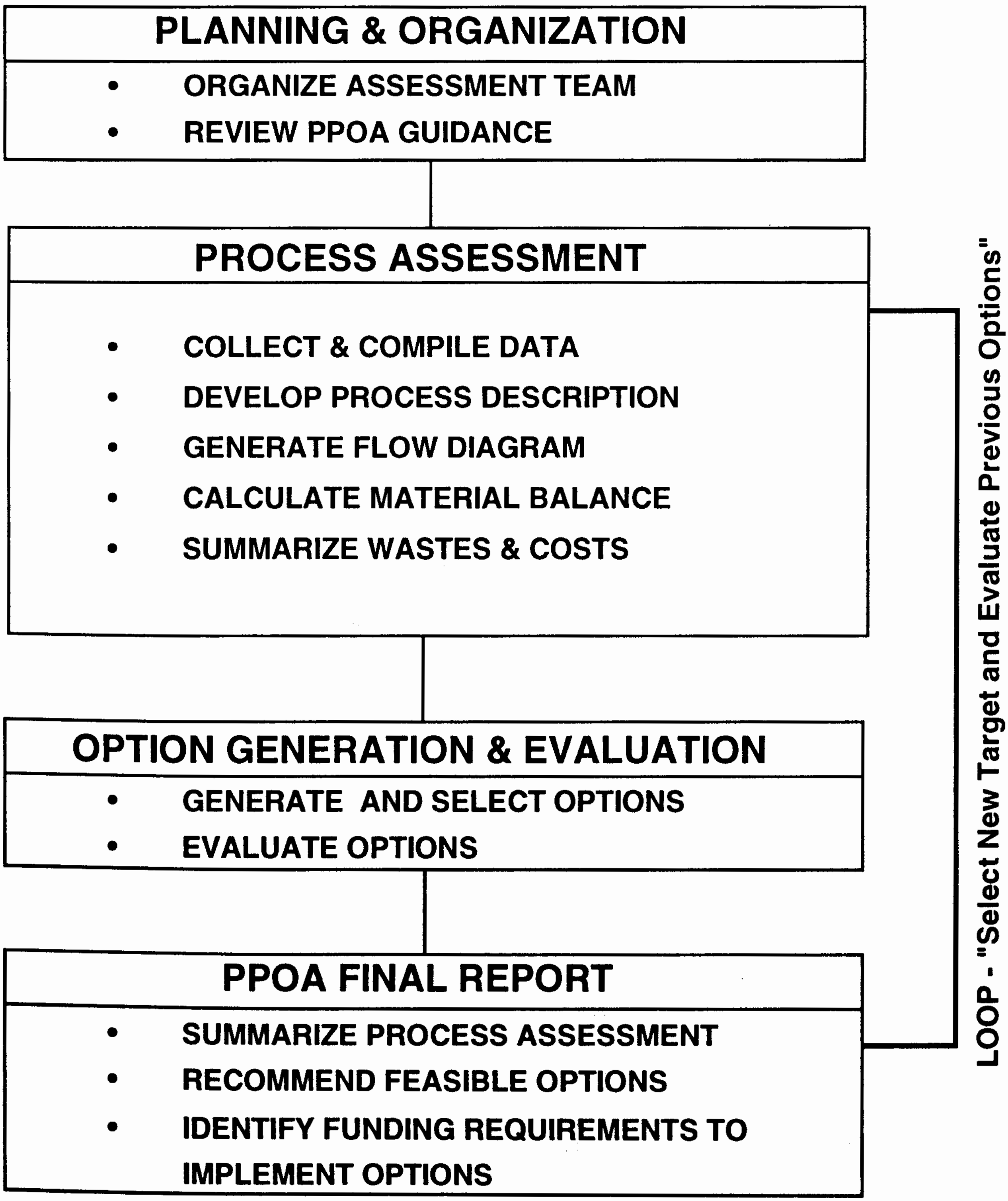
The objective of a PPOA is to document a facility's processes, operating procedures, and waste streams in a manner that will permit the identification of the best improvements to avoid or minimize waste generation. This guide shall not be used as an audit tool. The assessment consists of a systematic approach which may include the following:

- GRADED APPROACH LEVEL DETERMINATION
- ORGANIZATION OF PPOA TEAMS
- ASSESSMENT OF PROCESSES AND WASTE STREAMS
- DEVELOPMENT AND EVALUATION OF POLLUTION PREVENTION OPTIONS
- RECOMMENDATIONS OF POLLUTION PREVENTION OPTIONS & FINAL REPORT

A step-by-step process for completing a PPOA is shown in Figure 1. These steps are sequential and should be performed in that order for best results.

POLLUTION PREVENTION OPPORTUNITY ASSESSMENT FLOW CHART

FIGURE 1



II. GRADED APPROACH

A. INTRODUCTION

The DOE Complex is comprised of numerous sites located in many different states. These facilities range from single-mission to multiple-disciplinary facilities, and vary in size from quite small to very large. The facilities as a whole represent a tremendous diversity of technologies, processes and activities. Due to this diversity, there is also a wide variety and number of waste streams generated. Many of these waste streams are small and intermittent, and not of consistent composition. The value added of detailed analysis for individual, small waste streams is often not sufficient to justify the cost, nor is the analysis necessarily meaningful since many of these waste streams are constantly changing.

Although waste minimization activities have been implemented at DOE sites, these efforts are not being sufficiently documented. A DOE survey of PPOA activities across several sites indicated that these waste minimization practices need to be documented so that waste generation baselines can be more accurately established. Furthermore, the documentation can ensure that the site receives credit for accomplishing waste minimization.

The PPOA Graded Approach addresses these complexities and recognizes that processes vary in the quantity of pollution they generate, as well as in the perceived risk and hazards associated with an operation. It also recognizes the variance due to the cost and function of the final product. Therefore, the graded approach is intended to provide a **cost-effective** and **flexible** methodology which allows individual sites to prioritize their local concerns and align their efforts with the resources allocated, while also providing some consistency throughout the DOE to perform PPOAs. In order to achieve this, the approach has defined three levels of effort to satisfy the requirement of completing a PPOA. This section documents the minimum amount of effort required, Level I, Activity Characterization, and provides a systematic approach using the Weighted Sums Evaluation to determine if additional and more detailed analysis should be conducted for either a Level II, Informal Assessment, or a Level III, Formal Assessment.

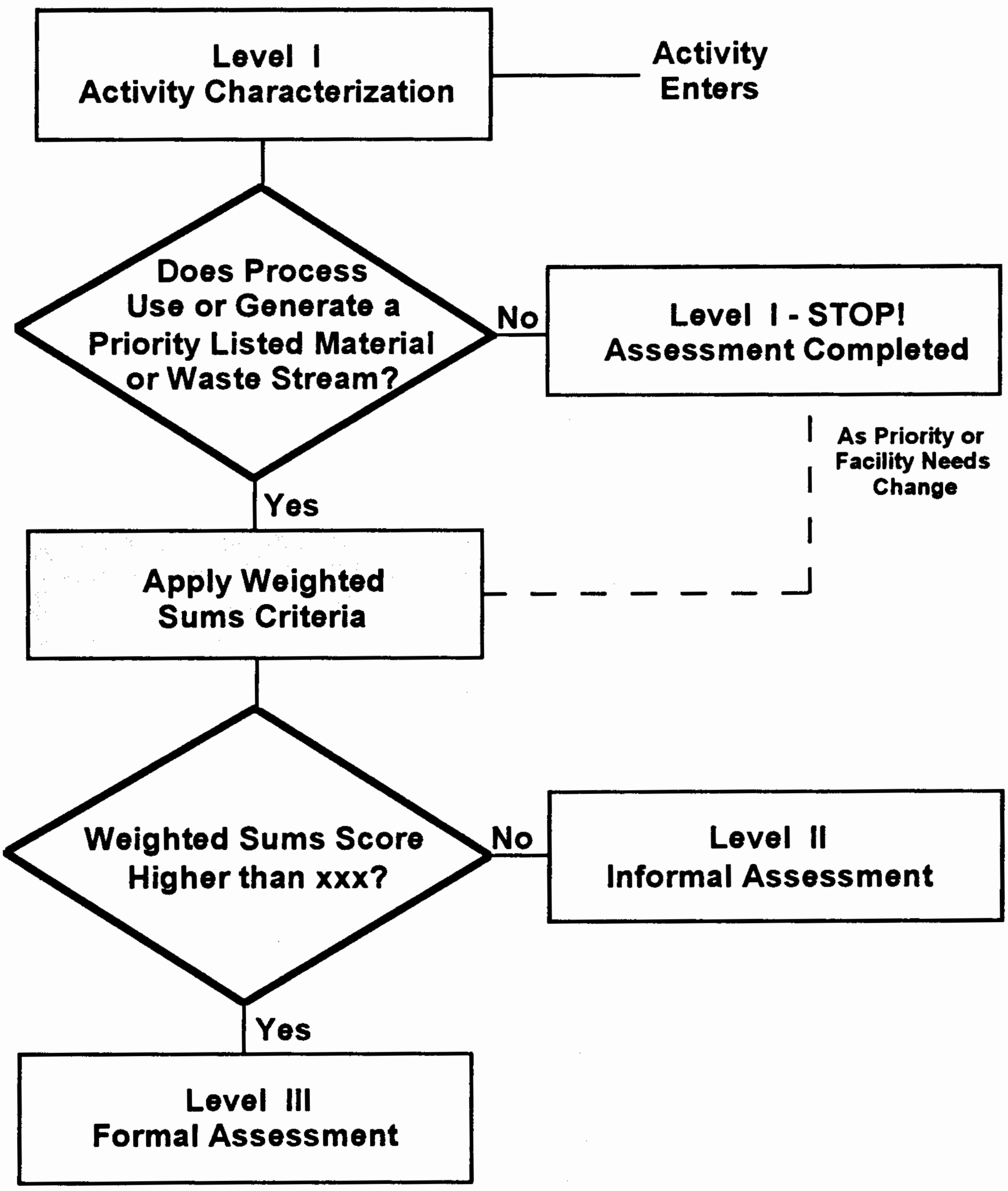
If used properly, the graded approach will allow a site to concentrate its shrinking resources on the most important waste problems first. While all of the site's waste streams and processes will be assessed, the most critical areas will be assessed first and to the greatest extent.

B. GRADED APPROACH LOGIC DIAGRAM & PRIORITY MATERIAL /WASTE STREAM LIST

Figure 2, the Graded Approach Logic Diagram, illustrates graphically how the graded approach methodology works. The diagram starts at the top with the Level I, minimum effort assessment and works down to an informal and/or formal assessment. The methodology shown in the logic diagram allows flexibility and provides a consistent

FIGURE 2

Pollution Prevention Graded Approach Logic Diagram



structure. A site must develop the priority material / waste stream list (PM/WSL) to use the graded approach. This list is not limited to the requirements specified below but can include any other additional concerns. (See Appendix A for an additional list of considerations.) The priority list provides the site an opportunity to identify their individual regulatory and/or prioritized needs to cost-effectively determine if additional, more detailed analysis is necessary. DOE has established requirements and suggestions for this list as follows.

PRIORITY MATERIAL / WASTE STREAM LIST

Required or Mandatory PM/WSL:

- Waste of any amount for which an approved disposal method does not exist (i.e., mixed wastes, classified waste, etc.)
- Waste which is equal to 5% or more of the facility's total waste stream (Total waste = Manifest records (Hazardous) + Radioactive + Mixed)
- Clean Air Act, Class I Materials (ODCs - Ozone Depleting Compounds)
- EPA's 33/50 Materials
- Known Human Carcinogens (ACGIH, Type 1)

Suggested Additions to PM/WSL:

- Federal, State, & Local Requirements
- Permitted Waste & Materials (e.g., VOCs, NPDES, POTW, etc.)
- Site Health Risks for Hazardous Materials & Hazardous Wastes (e.g., OSHA - Suspect carcinogens, teratogens, explosives, PCBs, Asbestos, etc.)
- Municipal Solid Waste
- Materials Not Categorized As Waste Inventory (MNCAW)

C. LEVEL I - ACTIVITY CHARACTERIZATION

Level I, Activity Characterization, requires a minimal amount of descriptive, quantitative, and qualitative information to document each of the facility's processes and activities which are defined as "Any existing or planned operation or activity (including remediation projects) which generates waste or pollution to the air, land, or water." In gathering this information, the facility begins the initial step to determine whether any waste reduction or pollution prevention opportunities exist. The collection of this information will also provide the basis to determine whether or not any of the facility's

processes/activities necessitate further analysis per the graded approach methodology. Therefore the principle objectives of Level I are to:

- define the process,
- document Waste Minimization / Pollution Prevention (WMin/PP) activities (past or current),
- determine the level of effort that should be performed for a cost-effective Pollution Prevention Opportunity Assessment Program, and
- provide information to determine if more analysis is necessary.

Level I Required Documentation

1. A brief process description / simple flow diagram;
2. A quantitative estimate of the material inputs, products, by-products, and wastes;
3. A preliminary evaluation of WMin/PP potential; and
4. A decision to determine if further analysis is necessary.

Level I process assessments will establish the site's baseline of operational information. These process/activity descriptions should include input materials, process products, by-products and/or waste generated. Identification of these elements and estimates of quantities is made using the best available information source, or combination of sources. Possible information sources are listed in Appendix B.

In addition to the descriptive information, the potential for WMin/PP can be initially evaluated based on the activity or process expert's knowledge. These recommendations should be included in the Level I documentation. If opportunities do exist and are easily implemented, then the actions taken or planned to be taken should be documented. Furthermore, for WMin/PP options identified and implemented, upstream / downstream impacts should also be included in the documentation.

After collecting the process/activity information, it is necessary to determine whether the process/activity continues to a Level II or III analysis as defined by the graded approach logic diagram and the site's priority material / waste stream list.

If the process does not contain any of the materials or waste streams on the priority list, then the Level I documentation satisfies the PPOA requirement. Conversely, those processes/activities which are captured by the site's priority list are included in the Weighted Sums Evaluation to determine the next level of effort to be performed.

A completed example Level I Activity Characterization is shown in Appendix C. PPOA Worksheets 1S-3S can be used to document the information required in a Level I assessment.

D. GRADED APPROACH WEIGHTED SUMS EVALUATION

The graded approach methodology continues when the site selects a core team to determine which processes require Level II and Level III assessments. The core team

should be cross-functional and consist of key site personnel with knowledge about the site's processes, waste management, and regulations. The team's objectives are to assign weights to the criteria, to determine the numeric value that distinguishes a Level II from a Level III, and to provide consistency in scoring across processes. The form to aid in this evaluation (weighted sums) is shown in Figure 3. (Appendix D contains the weighted sums form, criteria, and instructions.) First the site assigns a weight to each criteria listed in the first column of the weighted sums. Then, for each process being evaluated, the team determines a scale for the five listed criteria and a multiplier. From the products and sums, a total point value is assigned. Finally, the team determines the cut-off value for which Level II assessments will be completed versus Level III assessments. Processes identified by the Weighted Sums Evaluation which require a Level III, Formal Assessment, are those processes that are critical to the site's priorities and would benefit by the allocation of resources to examine how to best implement pollution prevention technologies to these critical areas.

E. LEVEL II - INFORMAL ASSESSMENT

After completing the Graded Approach Weighted Sums Evaluation, the facility has distinguished which processes/activities require the Level II, Informal Assessment. The principal objectives of Level II are to:

- develop and screen WMin/PP opportunities and
- recommend viable options for implementation.

This level of effort does not require the collection of new data. Much of the documentation has already been completed in the Level I assessment. However, due to some aspect of the process, the facility needs to further explore the WMin/PP opportunities available to reduce the quantity of waste or the risk/hazard associated with the operation.

<u>Level II Required Documentation</u>

{1.} Brief process description / simple flow diagram;
{2.} Quantitative estimate of the material inputs, products, by-products, and wastes;
{3.} Preliminary evaluation of WMin/PP potential;
4. WMin/PP options identification and evaluation;
5. Consideration of potential upstream / downstream impacts; and
6. Recommendations for option implementation.

{} - denotes those items already completed in Level I, Activity Characterization

Further suggested reading for Level II information can be found in sections IV: A-C and V: A-B. A completed example Level II, Informal Assessment, is shown in Appendix E. PPOA Worksheets 1S-5S can be used to complete the requirements of a Level II assessment.

Date: ________

Page ______ of ________

FIGURE 3
Pollution Prevention Opportunity Assessment Graded Approach

Weighted Sums Evaluation

Evaluation Criteria	Weight 'W'	Process: ________ Scale 'S'	'WxS'	Process: ________ Scale 'S'	'WxS'	Process: ________ Scale 'S'	'WxS'	Process: ________ Scale 'S'	'WxS'	Process: ________ Scale 'S'	'WxS'
Environmental, Safety, & Health Hazards	Site Assigns										
Quantity of Waste Generated	" "										
Site Liabilities	" "										
Economic Factors - Process & Waste Costs (Unit &/or Annual)	"										
Process By-Product Management	" "										
Other											
Subtotal											
WMin/PP Potential Multiplier		x		x		x		x		x	
Total											
PPOA Level											

F. LEVEL III - FORMAL ASSESSMENT

In addition to the information completed in the Level I assessment, the Level III requires considerably more documentation to complete the PPOA. For example, both the process description and a corresponding block flow diagram are required to illustrate the basis of generation. The use of narratives, calculations, photographs, illustrations, figures and/or data sufficient to convey an understanding of the process are certainly recommended. The Level III assessment also requires collection of quantitative data for a material balance. A material balance should be completed to account for all waste generated. This information, if not already available, may need to be tracked to accurately establish the current process waste generation information necessary to complete the WMin/PP options analysis.

The primary objectives of the Level III Assessment are to:

- conduct a detailed analysis of the process for WMin/PP opportunities and
- document the results of the process evaluation in a written report.

Level III Required Documentation

{1.} Brief process description / simple flow diagram;
{2.} Quantitative estimate of the material inputs, products, by-products, and wastes;
{3.} Preliminary evaluation of WMin/PP potential;
4. Process description;
5. Flow diagram;
6. Material balance;
7. WMin/PP options identification;
8. Analysis of WMin/PP options generated: economic, technical, upstream / downstream impacts, and other benefits;
9. Prioritized list of options; and
10. Formal report with documentation and recommendations for option implementation.

{} - denotes those items already completed in Level I, Activity Characterization

A completed example Level III, Formal Assessment, is shown in Appendix F.

The following sections of this guidance describe the details necessary to achieve the requirements of a Level III, Formal Assessment. Each of these sections can also be used as a reference for the information required in the Informal Assessment and Activity Characterization, Levels II and I, respectively. Blank Model Worksheets have been included in Appendix G to help guide a team through the PPOA requirements. They are only suggested forms - they are not requirements. A site may prefer to modify them to fit their individual site needs. Model PPOA Worksheets 1-10 were developed for the Level III assessment, PPOA Worksheets 1S-3S were developed for Level I, and Worksheets 1S-5S were developed for a Level II.

III. POLLUTION PREVENTION OPPORTUNITY ASSESSMENT TEAMS

The Waste Minimization and Pollution Prevention Awareness Program Plan states that assessments of all waste-generating operations at the site will be conducted by PPOA teams. The team leader should have the authority to complete the assessment, line responsibility, familiarity with the site's process and waste management operations, and proven technical and problem-solving abilities (e.g. Value Engineering Specialist).

The remainder of each assessment team should be drawn from line staff, or subcontractor organizations that can furnish the type of specialized expertise that will be needed to conduct the assessment. Each PPOA team should consist of a small core of individuals familiar with the site's operations, who will direct the assessment efforts and guide the data gathering. The careful selection of personnel to conduct the assessment is essential. Experienced people familiar with the site's operations are crucial to completing an accurate and timely assessment. Subsets of this team are satisfactory for Levels I and II of the graded approach. Other personnel with specialized skills will be used on a part-time, as-needed basis. Each team may include members who have knowledge in the following areas:

- process operations;
- federal, state, and local hazardous waste statutes and regulations;
- operation and waste minimization principles and techniques;
- quality control requirements;
- purchasing procedures;
- material control/inventory procedures; and/or
- value engineering skills.

Model Worksheets 1 and 1S can be used to record the PPOA team members and the assessment title and identification (ID) code. The PPOA ID Code should be unique for each PPOA at the site. For uniformity, the site should determine the structure of this code.

PPOA team leaders should receive training on the procedures, methodologies, techniques and documentation requirements for PPOAs before the assessments are conducted. The team leader needs to have clear authority from the WMin/PP Coordinator or line management to select other team members, obtain support services, and to direct the efforts of the assessment team in its interaction with operating personnel. The team should be given unrestricted access to all facility personnel and information that may, in the team's estimation, be relevant to the assessment.

IV. ASSESSMENT OF PROCESSES AND WASTE STREAMS

A. INITIAL DATA GATHERING

For each assigned process, the PPOA team begins with gathering data about that process and associated waste streams. The boundaries of the process must be established. The team should consider the following process boundary criteria: (1) the process must have a distinct starting and ending point, (2) the process input materials must be accounted for, (3) the time frame must be considered, and (4) the process must be manageable - an appropriate size to collect information and provide focus. The team will collect information through interviews and the review of process documents that will permit a thorough understanding of the process to be assessed and the development of a written analysis on how that process generates waste (see Appendix B for sources of additional information). The team should also visit the process areas to witness how the process is conducted and to validate the written information that has been collected.

Each PPOA team should develop and/or collect information as defined in the graded approach level. The following assessment tools may be used:

- process descriptions,
- process flow diagrams,
- material balances, and/or
- waste stream characterizations for assessment area or process.

Additional guidance may be found in the EPA *Facility Pollution Prevention Guide* (Reference #8 of Appendix H) to complete the PPOA.

PPOA team members may identify ways to reduce waste during the data collection phase. It is at this point that observations about operations, schedules, and procedures can be noted which may easily be changed to prevent waste. These changes can have a wide impact. The knowledge and experience of team members and their colleagues will help to develop these ideas into potential options. The team members should also make effective use of technical literature from equipment vendors and trade associations; the experience of plant engineers, operators, and consultants; and the databases available from environmental agencies.

B. PROCESS DESCRIPTION

The PPOA will include a general description of each process step in the waste generating operation. The narrative should describe the following:

- purpose of the process;
- material and equipment used in the process;
- equipment layout;
- personnel and their experience / training level; and
- products, by-products, and waste streams generated.

Model Worksheets 2 and 2S can be used to complete the process description. Chemicals and other materials purchased or otherwise introduced into the process should be identified. The description should also include other information that adequately describes the process and may be relevant to WMin/PP planning. For example, process or product specifications, requirements, assumptions, and upstream and downstream impacts may have a critical bearing on waste generation and should be included in the description.

To further understand the process, the team may perform a function analysis as explained in the DOE/Defense Program's *Prioritization of Pollution Prevention Options Using Value Engineering* (Reference #13 of Appendix H). The principal objective of function analysis is to discover the basic purposes of a process in contrast to its secondary or support uses. It aids the team in determining the process' primary functions and in minimizing or eliminating secondary functions which, in turn, may produce unnecessary wastes. The function analysis can help answer the question as to whether this process is actually necessary.

C. PROCESS FLOW DIAGRAM

The analytical work of the waste assessment effort starts with the development of a simple process flow diagram for the operation being assessed. The requirement for this flow diagram is based on the maxim that a picture is worth a 1000 words. It is also the foundation upon which the material balance is built. The process flow diagram should identify the major steps within an operation and diagram the flow of materials into and out of each step during the process. The diagram should indicate the following:

- process steps,
- material inputs, and
- process outputs (e.g., product, by-products and waste streams).

The diagram should also characterize the streams according to the nature of the release and waste classification, including but not limited to the following:

- air,
- liquid,
- solid,
- radioactive,
- mixed,
- hazardous, and/or
- non-hazardous.

Model Worksheets 3 and 2S can be used for the completion of the process flow diagram. There are three styles to chose from for Model Worksheet 3 depending on the complexity of the analysis and whether radioactive materials and waste streams are involved.

D. MATERIAL BALANCE

The PPOA shall account for all input materials that enter the process which are either consumed, transferred, or disposed of as waste. This accounting, which is called a "material balance", will be indicated on the process flow diagram and transferred to a spreadsheet. A material balance is a tool which is used to provide an input/output summary of the process being assessed. Closing the balance on an unknown stream can help identify the constituents in that stream. The material balance should indicate the following:

- amount of input materials introduced into the process,
- amount of materials consumed,
- amount of materials withdrawn as a product or by-product, and
- amount of materials flowing out of a process as a waste stream.

Using the best available information, the material balance should be closed (i.e., all input materials and transfers should be accounted for in the product, by-product and waste streams). The purpose of closing the balance is to identify streams which are difficult to quantify, e.g. fugitive and point-source emission streams. The material balance should show the average material flows over a representative time period which is logical for the site's operations. For example, it may be appropriate to gather data for Operation A from monthly averages, while a longer time span may be more appropriate for Operation B. Material balances performed over the duration of a complete production run are typically the easiest to construct and are reasonably accurate.

In its simplest form, the material balance is represented by the mass conservation principle:

Mass in = Mass out + Mass Accumulated

That is, materials placed into a process can be accounted for through products, by-products, air emissions, water discharges, spills, recycling streams, waste streams, scrap, out-of-shelf life materials, or out-of-specification materials. All materials (hazardous and non hazardous) should be accounted for in the input and output streams. The quantification units for the material balance should be consistent, i.e. pounds. The Material Safety Data Sheet (MSDS) can be helpful in converting materials into a common unit.

<u>Measurement of Feed Materials:</u> All input materials that are introduced into a process must be identified. The amount and type of the input materials can be determined by examining the following:

- procurement and inventory records;
- processing logs; and/or
- other records that show purchase, transfer, donation, or other receipt of materials by production unit.

Other examples of information sources are found in Appendix B.

Products and By-products: The material balance should indicate the amount of materials leaving the work unit as a product or by-product.

Transfer of Materials: Some materials may be used in a process and then transferred to another area or process for further processing. The material balance should account for the transfer of the materials.

E. MEASUREMENT OF WASTE

Information about the quantity and character of the waste streams is a critical component of the PPOA. Waste stream information should be obtained from sources such as:

- site tracking system,
- permits and permit applications,
- monitoring reports,
- hazardous waste manifests,
- emission factors,
- experiments,
- emission or toxic substance release inventories,
- hazardous waste reports,
- waste analyses, and/or
- environmental audit reports.

If the waste data is not available from the above sources, it may be necessary to monitor the process and record the needed information. Model Worksheet 4 can be used to record material balance data. The completed material balance should be a database of process information that represents the process area over a time period long enough to characterize that operation. The suggested time period to record this data is an annual basis to coincide with other site reporting requirements. If data was taken over a shorter time period, extrapolation can be used. The material balance will show the source of waste streams and the contribution that different activities make to the waste streams. It will serve as a baseline for tracking WMin/PP efforts and will provide data needed for evaluation of WMin/PP options. The process data used to calculate a baseline of operations should be as representative of current operations as possible.

Monitoring waste stream flows and compositions is something that should be done periodically. By tracking waste streams, seasonal variations in waste flows or single, large waste streams can be distinguished from continual, constant flows. Changes in waste generation cannot be meaningfully measured unless the information is collected both before and after a pollution prevention option is implemented.

F. WASTE STREAM CHARACTERIZATION

Each waste stream identified in the process flow diagram will be characterized, including but not limited to the following:

- source of waste;
- composition;
- rate of generation from work unit operation; and
- costs associated with treatment, storage, or disposal of wastes.

The waste stream characterization information is also part of Model Worksheet 4. The cost information for the input materials and waste streams can be recorded on Model Worksheet 5. After characterization, consideration should be given to each waste stream to determine where WMin/PP is most needed.

V. DEVELOPMENT AND EVALUATION OF WASTE MINIMIZATION/ POLLUTION PREVENTION OPTIONS

A. IDENTIFICATION OF WMIN/PP OPTIONS

Once the process and causes of waste generation are understood, the PPOA enters the creative phase. Following the collection of data and site inspections, the members of the team will have begun to identify possible ways to minimize waste or prevent pollution in the assessment process. Identifying potential options relies both on the expertise and creativity of the team members. Much of the requisite knowledge may come from their education and on-the-job experience, however, the use of technical literature, contacts, and other sources may also be employed.

The process by which pollution prevention options are identified should occur in an environment that encourages creativity and independent thinking by the members of the assessment team. The key to successful results is the deferral of any critical judgments or comments which might inhibit any of the team members. While the individual team members will suggest many potential options on their own, the process can be enhanced by using some of the common group decision techniques. These techniques allow the assessment team to identify options that the individual members might not have come up with on their own. Employees having practical experience with the process may have given thought to the process' input and output efficiencies or alternative operating methods. Therefore, creativity and brainstorming is strongly encouraged.

To identify WMin/PP options, the PPOA teams will utilize the following priorities:

- source-reduction options:
  - material substitution,
  - process changes,
  - product reformulating,
  - equipment changes,
  - operational improvements,
  - schedule changes,
  - affirmative procurement, and/or
  - administrative controls (e.g., inventory control, employee training, polices, etc.).

- recycling/reuse options

Each of these different approaches may generate many options or none, i.e., while operational improvements are a very broad approach, input or process changes may be difficult to control. Are there any processes / products upstream and downstream which could be affected by changes to the process or product? As these different approaches are discussed several questions should be repeatedly asked:

- Is this operation necessary?
- Why is this waste generated?
- Why do we do this operation in this manner?
- Why must we use these chemicals?
- Are there any non-hazardous substitutions available?

In addition to using the process expert's knowledge, there are numerous outside references to assist in developing a list of options. These include EPA publications, databases, and technical references; state and local environmental agency's publications, bibliographies, and technical assistance; as well as, published literature in technical magazines, trade journals, research briefs, vendor equipment information and chemical supplier information.

Model Worksheet 6 can be used in a team brainstorming session to generate the pollution prevention opportunities. Model Worksheets 7 and 4S can be used to record the detailed description for each of the options generated. The description should include the basic idea behind the option, affected materials and product, any roadblocks to implementation, and the anticipated reduction quantity.

B. PRELIMINARY SCREENING OF WMIN/PP OPTIONS

Many pollution prevention options will be identified in a successful assessment. At this point, it is necessary to identify those options that offer real potential to minimize waste and reduce costs. Since detailed evaluation of technical and economic feasibility is usually costly, the proposed options should be screened to identify those that deserve further evaluation. The screening procedure serves to eliminate suggested options that appear marginal, impractical, or inferior without a detailed and more costly feasibility

study. The screening procedures may include any combination of the following methods:

- information reviews by program managers,
- ballots by team members, and/or
- quantitative tools (e.g. weighted sum method).

Whatever method is used, the preliminary screening procedure should consider the following questions:

- Is implementation of the option cost effective?
- What is the principal benefit of the option?
- What is the expected change in the type or amount of waste generated (toxicity, reactivity, etc.)?
- Does it use existing technology?
- What kind of development effort is required?
- Will implementation be constrained by time?
- Does the option have a dependable performance record?
- Will the option effect product, employee health, or safety?
- What are the upstream/downstream impacts if implemented?

The results of the screening process will be a list of options that are candidates for more detailed technical and economic evaluation. It is important to document the decisions made in the screening process for future reference. Model Worksheet 7 can also be used to record the results from the initial screening process.

C. EVALUATION OF WMIN/PP OPTIONS

The PPOA team should perform an in-depth evaluation on the potential economic and technical feasibility of each option using Model PPOA Worksheets 8 and 9. The options will then be ranked in order of preferred implementation. The highest priority normally should be given to source-reduction projects, after which projects that recycle/reuse all or part of a waste stream or by-product will be considered.

Model Worksheet 8 evaluates each option from a cost perspective. The three major cost categories for weighing options are: Implementation Costs, Incremental Operating Costs, and Incremental Intangible Costs. EPA's *Pollution Prevention Benefits Manual* (Reference #12 of Appendix H) provides more detail on cost analysis and contains examples of each of these cost categories.

The following considerations must be fully evaluated to determine the recommended WMin/PP options. These include: economic evaluation including capital cost, operating cost, waste management costs and return on investment; expected change in the type or amount of waste generated (toxicity, reactivity, etc.); technical feasibility; avoided costs; effect on product, employee health and safety; permits, variances, and compliance schedule of applicable agencies; releases and discharges to all media; previous successes; implementation period; and/or ease of implementation.

This evaluation is most easily accomplished and documented by the use of a simple matrix for scoring and ranking - the suggested evaluation is the weighted sums method shown on Model Worksheet 9. The DOE/DP *Prioritization of Pollution Prevention Options Using Value Engineering* (Reference #13 in Appendix H) also demonstrates how options can be evaluated and prioritized using this method. The evaluation matrix provides a means to quantify the important criteria that affect the site and is a quick visual representation of the factors affecting various WMin/PP options. The scoring system for each criteria, used in the matrix and some rational for selection or weighting of scores should be included in the formal report. Evaluation of this matrix would complete the final requirement for prioritizing the list of options for implementation. The formal report should provide sufficient detail to allow transfer of the measure to other generators with similar processes or operations.

VI. FINAL REPORT

A final report is required for each PPOA. The final report is a compilation of essential facts about the process, pollution prevention options, feasibility of those options, upstream/downstream impacts of those options, and future implementation costs. The final report documents the work performed, assumptions made during the assessment, and identifies funding requirements necessary to implement pollution prevention options. The length of the final report will depend on the complexity of the PPOA. For Level II assessments, Model Worksheet 5S can be used to complete the requirements of the final report.

For a Formal Assessment, Level III, each option will be ranked by the PPOA team according to its economic and technical feasibility using Model Worksheets 8 & 9. Economic feasibility will be a factor, but not the determining factor, in judging the relative merit of each WMin/PP option. The PPOA team will report the results of its evaluation, including final rankings and ranking criteria, to the Waste Minimization Committee or line management. The PPOA team will indicate its preferred options in the report.

Easily implemented options will be completed and documented in the final report. Options that require additional analysis and/or approval shall be addressed via the site's Waste Minimization and Pollution Prevention Program Plan.

Documentation of the WMin/PP options and recommendations should demonstrate a good faith effort undertaken to identify alternatives and should provide a narrative description of these factors in sufficient detail to allow transfer of the measure to other generators with similar processes or operations.

The final report and associated data will be maintained as permanent records for later reference and tracking information. PPOAs should be reviewed on an annual basis after the initial PPOA is completed and should be revised if significant process changes are made.

VII. APPENDIX

APPENDIX A

GENERAL CONSIDERATIONS FOR PRIORITIZING THE ASSESSMENT OF WASTE STREAMS

- Costs savings (direct and indirect)
- Potential for (or ease of) minimization
- Potential recovery of valuable by-products
- Reduced quantity of waste
- Compliance with current and future regulations
- Hazardous properties of the waste (including toxicity, flammability, corrosivity, and reactivity)
- Other safety hazards to employees
- Potential environmental and safety liability/improvements
- Potential for removing bottlenecks in production or waste treatment

APPENDIX B

SOURCES OF MATERIAL BALANCE INFORMATION

Listed below are potential sources of information for preparing a process description, flow diagram or material balance inventory. The list is not meant to be exclusive.

- Process Expert Knowledge
- Operating Logs
- On-site Tracking Systems
- Purchasing Records
- Vendor Information
- Process Design Information
- Batch Makeup Records
- Emission Inventories
- Equipment Cleaning and Validation Procedures
- Material & Chemical Inventories
- Operating Procedures and Manuals
- Production Records
- Product Specifications
- Samples, Analyses, and Flow Measurements
- Waste Disposal Records
- Waste Manifests
- E S & H reports
- Permitting Applications
- Experiments
- Laboratory Notebooks

APPENDIX C

LEVEL I EXAMPLE PPOA

SNL/NM Organization: 7813-5 Process Name: Asbestos Brakes & Clutch Removal

DATA FORM 1

DESCRIPTION OF PROCESS/OPERATIONS

Process Location Area I,II,III,IV,V & Remote Area SNL-Albuquerque NM/SNL-Livermore CA./TTR-Las Vagas NV./KTF-Kauai
(include site, TA, building, room, as appropriate)

Describe the general operations or activities of the organization performing the process. Continue on the back of this sheet, if necessary.

The Crane and Hoist section is responsible for performing annual Inspections, Repairs, and Preventative Maintenance on Cranes and Hoists.

Describe the particular process that generates wastes and/or other pollutants, or uses hazardous materials. Describe how the hazardous materials are used, and how the wastes or pollutants are generated. (See Chapter 2 of the PWA Guidance Manual for guidelines on defining a process.) Continue on the back of this sheet, if necessary.

Asbestos Brakes and Clutches are generated waste in this process.

Asbestos Brakes and Clutches becomes a generated waste when the Asbestos Brakes and Clutches are removed and replaced with Non-Asbestos Brakes and Clutches.

Date: 7/22/93 Prepared by (MinNet Rep): Bernard Alexander Phone: 4-1365
PWA #: Process Contact: Bernard Alexander Phone: 4-1365
(to be completed by WMSC)

PROCESS DEFINITION

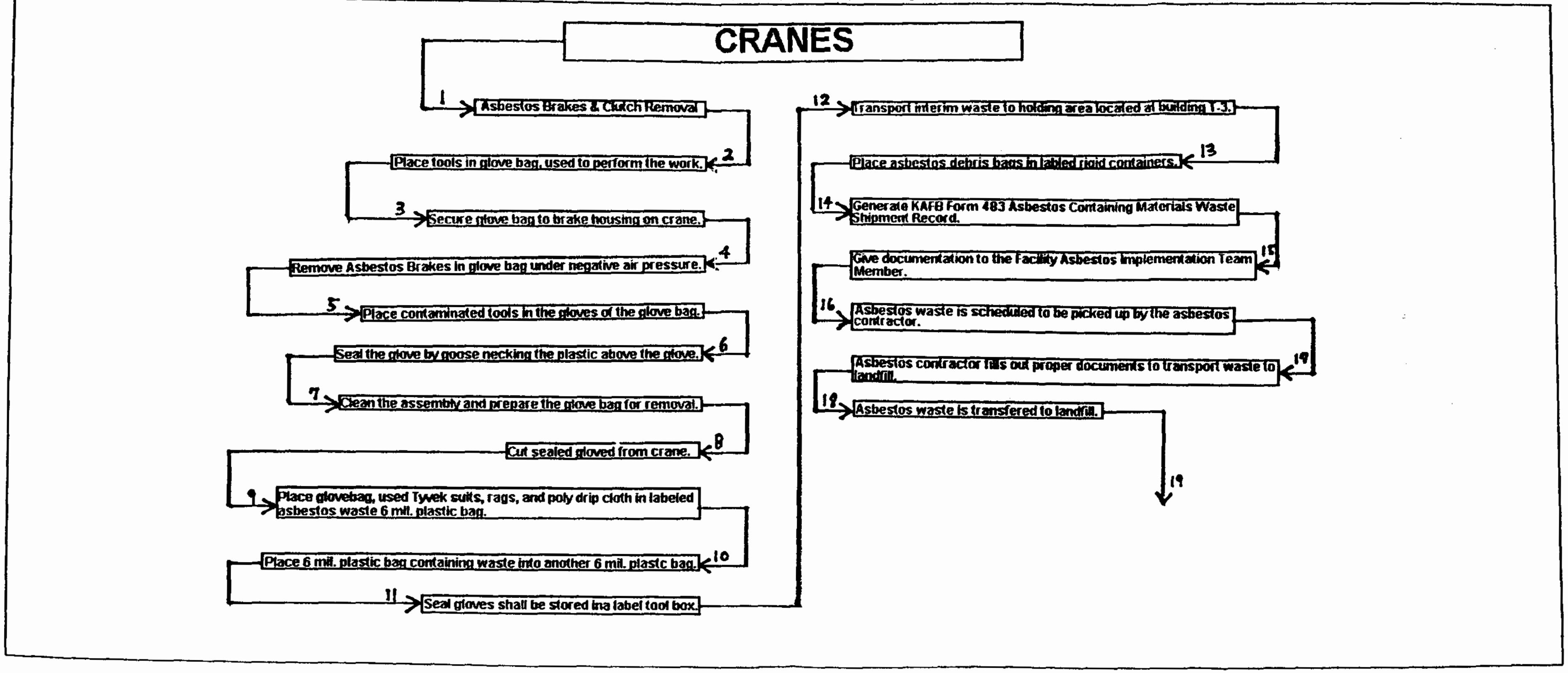
SNL/NM Organization: 7813-5 Process Name: Asbestos Brakes & Clutch Removal

Process Location: Remote Areas Area I,II,III,IV,V/TTR-Las Vegas NV./KTF-Kauai SNL-Albuquerque NM/SNL-Livermore CA.
(include site, TA, building, room, as appropriate)

DATA FORM 2

PROCESS FLOW DIAGRAM

Sketch a flow diagram of the process. Show subprocesses with materials entering the process, as well as products, materials, wastes, and other pollutants generated by the process. Show the sources of the input and destinations of the output materials.



Use additional sheets if necessary.

Date: 7/22/93
PWA #:
(to be completed by WMSC)

Prepared by (MinNet Rep): Bernard Alexander Phone: 4-1365
Process Contact: Bernard Alexander Phone: 4-1365

SNL/NM Organization: 7813-5 Process Name: Asbestos Brakes and Clutches Removal

DATA FORM 3

CALENDAR YEAR 1992 WASTE MINIMIZATION ACTIVITIES

Process Location: Area I,II,III,IV,V, & Remote Areas SNL-Albuquerque NM/SNL-Livermore CA./TTR-Las Vegas NV./KTF-Kauai
(include site, TA, building, room, as appropriate)

Have waste minimization (WM) activities been undertaken in CY92? ☒ Yes ☐ No

If No, briefly discuss factors that have prevented waste minimization activities: __________

If Yes, short name of WM activity (e.g., Increase Input Purity, Improve Rinse Process) (use other sheets if more than one activity taken): Removing and disposing of a hazardous material.

Type of WM activity (check best one that applies):

Source Reduction
- ☒ Good Operating Practice
- ☐ Inventory Control
- ☐ Spill and Leaks Prevention
- ☐ Raw Material Modification
- ☐ Production Modification
- ☐ Process Modification (Clean and Degreasing)
- ☐ Process Modification (Surface Prep and Finish)
- ☐ Process Modification (Other)
- ☐ Other (specify below)

Recycling
- ☐ Began Onsite Recycling
- ☐ Began Offsite Recycling
- ☐ Reuse in Original Process
- ☐ Reuse in Another Process

Energy Recovery
- ☐ Began Onsite Energy Recovery
- ☐ Began Offsite Energy Recovery

Treatment
- ☐ Began Onsite Treatment
- ☐ Began Offsite Treatment

Briefly describe WM activity: Removal of Asbestos Brakes and Clutches to be replace with a non-asbestos material.

Date: 7/22/93 Prepared by (MinNet Rep): Bernard Alexander Phone: 4-1365
PWA #: ______ Process Contact: Bernard Alexander Phone: 4-1365
(to be completed by WMSC)

SNL/NM Organization: 7813-5 Process Name: Asbestos Brakes and Clutches Removal

DATA FORM 3

FISCAL YEAR 1992 WASTE MINIMIZATION ACTIVITIES

Waste stream type affected: ☒ Hazardous (Chemical) Solid Waste ☐ Waste Water Discharge ☐ Radioactive/Mixed Solid Waste ☐ Air Emission

Waste stream name affected (see corresponding Data Form 2): Asbestos Brakes and Clutches

Did WM activity increase the toxicity of waste generated? ☐ Yes ☒ No

Did WM activity increase the quantity or toxicity of wastes emitted to other media (air, waste, land)? ☐ Yes ☒ No

Did WM activity reduce toxicity but not quantity? ☒ Yes ☐ No

Indicate the quantity impact of the WM activity (use most appropriate measure):

Mass before WM activity (kg/yr): ____ Mass after WM activity (kg/yr): ____
Volume before WM activity (ℓ/yr): ____ Volume after WM activity (ℓ/yr): ____
Specific activity before WM activity (Ci/kg/yr): ____ Specific activity after WM activity (Ci/kg/yr): ____

Basis of quantities (e.g., direct measurement, material balance calculation, published emission factors, engineering calculations, engineering/scientific judgment): ____

Has the WM activity been successful? ☒ Yes ☐ No
Is the activity still being used? ☒ Yes ☐ No

If unsuccessful or otherwise not being used, describe why: ____

Date: 7/22/93 Prepared by (MinNet Rep): Bernard Alexander Phone: 4-1365
PWA #: ____ Process Contact: Bernard Alexander Phone: 4-1365
(to be completed by WMSC)

PROCESS CHARACTERIZATION

SNL/NM Organization: 7813-5 Process Name: Asbestos Brakes and Clutches

DATA FORM 4

HAZARDOUS/RADIOACTIVE MATERIAL INPUTS

Name of Hazardous/Radioactive Material	Input Stream Number	Predicted Frequency of Usage[1]	Average Annual Usage Rate (kg/yr)
Asbestos	1		
Glove Bag	2		
Tyvek Suits,Rags,Drip Cloth	9		

[1]Indicate usage as Continuously (C), Daily (D), Weekly (W), Monthly (M), Quarterly (Q), or Annually (A)

Date: 7/22/93 Prepared by (MinNet Rep): Bernard Alexander Phone: 4-1365
PWA #: Process Contact: Bernard Alexander Phone: 4-1365
(to be completed by WMSC)

SNL/NM Organization: 7813-5 Process Name: Asbestos Brakes and Clutches

DATA FORM 5

HAZARDOUS (CHEMICAL) SOLID WASTE

Waste Stream Number (from Worksheet 1): 1,2,9,10

Waste Stream Name (from Data Form 2/Worksheet 1): Asbestos,tyvk suits,rags,drip cloth, plastic bag

Location of waste generation (TA, building, room): SNL-Alb/SNL-CA/TTR-NV/KTF-Kauai

Inside RMMA? ☐ Yes ☒ No

Briefly describe how waste is generated: Asbestos Brakes and Clutches are removed and replaced with non-asbestos material. Glove bages,tyvek suits rags, and drip cloth are used in th removal process to remove the generated waste.

Frequency of waste generation: ☐ Continuously ☐ Daily ☐ Weekly ☒ Monthly ☐ Quarterly ☐ Annually

Which description fits the process step that generates the waste (check best one):

☒ A regularly scheduled process step that is likely to be repeated several times during the upcoming year.
☐ A one-time activity that is not likely to be repeated during the upcoming year.

Predicted average quantity of waste generated annually – normal operations (kg): 200 lbs.

Predicted min/max quantity generated annually – normal operations (kg): Min ______ Max ______

List (describe) all hazardous constituents (e.g., mercury inside switches, benzene-tainted glassware) or brand names (e.g., WD-40) that could be in the waste:

Asbestos

Do the hazardous constituents of the waste stream listed above vary (e.g., sometimes contains lead, sometimes contains lead and cadmium)? ☐ Yes ☒ No If yes, describe how the waste varies:

Describe physical characteristics of wastes (e.g., aqueous solution, solid, sludge, oil, containerized compressed gas - include % of solids or % moisture, if applicable): Solid

Date: 7/22/92 Prepared by (MinNet Rep): Bernard Alexander Phone: 4-1365

PWA #: ______ Process Contact: Bernard Alexander Phone: 4-1365

(to be completed by WMSC)

SNL/NM Organization: 7813-5 Process Name: Asbestos Brakes and Clutches

DATA FORM 5

HAZARDOUS (CHEMICAL) SOLID WASTE

The pH of the waste stream may range from N/A to N/A (answer if appropriate)

Is the waste ignitable? (see Guidance Manual for clarification) ☐ Yes ☒ No ☐ Unknown
Is the waste corrosive? (see Guidance Manual for clarification) ☐ Yes ☒ No ☐ Unknown
Is the waste reactive? (see Guidance Manual for clarification) ☐ Yes ☒ No ☐ Unknown

Does the waste stream contain any of the following toxic metals: ☐ Yes ☒ No (check all that apply)

☐ Arsenic ☐ Barium ☐ Cadmium ☐ Chromium
☐ Lead ☐ Mercury ☐ Selenium ☐ Silver

Does the waste stream contain a toxic volatile, semi-volatile, or pesticide listed in Table 3-2?
☐ Yes ☒ No If yes, list: __________

Does the waste stream contain any of the spent solvents listed in Table 3-3? ☐ Yes ☒ No
If yes, list: __________

Does the waste stream contain, or is it generated from the production of, any of the following benzene derivatives? ☐ Yes ☒ No (check all that apply)

☐ trichlorophenol ☐ tetrachlorobenzene
☐ tetrachlorophenol ☐ pentachlorobenzene
☐ pentachlorophenol ☐ hexachlorobenzene

Is the waste any of the following? ☐ Yes ☒ No (check all that apply)

☐ waste water treatment sludge ☐ wood preserving process waste
☐ petroleum refining waste ☐ leachate from treatment, storage, or disposal of waste

Does the waste contain cyanide or is cyanide used in the process? ☐ Yes ☒ No

Is the waste any of the following? ☐ Yes ☒ No (check all that apply)

☐ waste from the production of inorganic pigments ☐ waste from the production of pesticides
☐ waste from the production of inorganic chemicals ☐ waste from the production of metals
☐ waste from the production of organic chemicals ☐ waste from the production of pharmaceuticals
☐ waste from the production of explosives ☐ coking waste
☐ waste from the production of ink formulations ☐ petroleum refining waste

Date: 7/22/93 Prepared by (MinNet Rep): Bernard Alexander Phone: 4-1365
PWA #: ______ Process Contact: Bernard Alexander Phone: 4-1365
(to be completed by WMSC)

SNL/NM Organization: 7813-5 Process Name: Asbestos Brakesand Clutches

DATA FORM 5

HAZARDOUS (CHEMICAL) SOLID WASTE

Based on the above description of how the waste is generated, select the single best summary of the waste-generating process step.

CLEANING AND DEGREASING

- ☐ Stripping (A01)
- ☐ Acid cleaning ((A02)
- ☐ Caustic (Alkali) cleaning (A03)
- ☐ Flush rinsing (A04)
- ☐ Dip rinsing (A05)
- ☐ Spray rinsing (A06)
- ☐ Vapor degreasing (A07)
- ☐ Physical scraping and removal (A08)
- ☐ Clean out process equipment (A09)
- ☐ Other cleaning and degreasing (A19)

SURFACE PREPARATION AND FINISHING

- ☐ Painting (A21)
- ☐ Electroplating (A22)
- ☐ Electroless plating (A23)
- ☐ Phosphating (A24)
- ☐ Heat treating (A25)
- ☐ Pickling (A26)
- ☐ Etching (A27)
- ☐ Other surface coating/preparation (A29)

PROCESSES OTHER THAN SURFACE PREPARATION

- ☐ Product rinsing (A31)
- ☐ Product filtering (A32)
- ☐ Product distillation (A33)
- ☐ Product solvent extraction (A34)
- ☐ By-product processing (A35)
- ☐ Spent catalyst removal (A36)
- ☐ Spent process liquids removal (A38)
- ☐ Tank sludge removal (A38)
- ☐ Slag removal (A39)
- ☐ Metal forming (A40)
- ☐ Plastics forming (A41)

PRODUCTION OR SERVICE DERIVED ONE-TIME AND INTERMITTENT PROCESSES

- ☐ Leak collection (A51)
- ☐ Cleanup of spill residues (A53)
- ☐ Oil changes (A54)
- ☐ Filter/battery replacement (A55)
- ☐ Discontinue use of process equipment (A56)
- ☒ Discarding off-spec material (A57)
- ☐ Discarding out-of-date products or chemicals (A58)
- ☐ Other production-derived on-time and intermittent processes (A59)
- ☐ Sludge removal (A60)

REMEDIATION DERIVED WASTE

- ☐ Superfund Remedial Action (A61)
- ☐ Superfund Emergency Response (A62)
- ☐ RCRA Corrective Action at solid waste management unit (A63)
- ☐ RCRA closure of hazardous waste management unit (A64)
- ☐ Underground storage tank cleanup (A65)
- ☐ Other remediation (A69)

POLLUTION CONTROL OR WASTE TREATMENT PROCESSES

- ☐ Filtering/screening (A71)
- ☐ Metals recovery (A72)
- ☐ Solvents recovery (A73)
- ☐ Incineration/thermal treatment (A74)
- ☐ Wastewater treatment (A75)
- ☐ Sludge dewatering (A76)
- ☐ Stabilization (A77)
- ☐ Air pollution control devices (A78)
- ☐ Leachate collection (A79)
- ☐ Other pollution control or waste treatment (A89)

OTHER PROCESSES

- ☒ Clothing and personal protective equipment (A91)
- ☒ Routine cleanup wastes (e.g., floor sweepings) (A92)
- ☐ Closure of hazardous waste management unit(s) or equipment other than by remediation (A93)
- ☐ Laboratory wastes (A94)
- ☐ Other (A99)

Date: 7/22/93 Prepared by (MinNet Rep): Bernard Alexander Phone: 4-1365
PWA #: ______ Process Contact: Bernard Alexander Phone: 4-1365
(to be completed by WMSC)

APPENDIX D

PPOA GRADED APPROACH WEIGHTED SUMS FORM, CRITERIA, AND INSTRUCTIONS

Pollution Prevention Opportunity Assessment Graded Approach

Weighted Sums Evaluation

Evaluation Criteria	Weight 'W'	Process: Scale 'S'	'WxS'	Process: Scale 'S'	'WxS'	Process: Scale 'S'	'WxS'	Process: Scale 'S'	'WxS'	Process: Scale 'S'	'WxS'
Environmental, Safety, & Health Hazards	Site Assigns										
Quantity of Waste Generated	" "										
Site Liabilities	" "										
Economic Factors - Process & Waste Costs (Unit &/or Annual)	"										
Process By-Product Management	" "										
Other											
Subtotal											
WMin/PP Potential Multiplier		x		x		x		x		x	
Total											
PPOA Level											

Date: ______

Page ______ of ______

Pollution Prevention Opportunity Assessment Graded Approach

Weighted Sums Evaluation

Evaluation Criteria	Weight 'W'	Process: ______ Scale 'S'	'WxS'	Process: ______ Scale 'S'	'WxS'	Process: ______ Scale 'S'	'WxS'	Process: ______ Scale 'S'	'WxS'	Process: ______ Scale 'S'	'WxS'
Environmental, Safety, & Health Hazards	Site Assigns										
Quantity of Waste Generated	" "										
Site Liabilities	" "										
Economic Factors - Process & Waste Costs (Unit &/or Annual)	"										
Process By-Product Management	" "										
Other											
Subtotal											
WMin/PP Potential Multiplier		X		X		X		X		X	
Total											
PPOA Level											

Graded Approach Worksheet

The purpose of this worksheet is to determine the PPOA level for each of the facility processes. To begin, a list of these processes or areas should be generated for each facility. Then for each item listed, complete one column on this worksheet. For consistency, each facility should establish site-specific weights for each of the criteria. Once each item has received a weighted sum value, then each facility should establish the dividing line from which to require informal (Level II) or formal PPOAs (Level III).

Weighted Sums Instructions:

a. The values in the Weight column (designated by 'W') represent the facility's priority for the criteria.

b. In the Scale column for each process (designated by 'S'), rate each criteria by assigning a value from 0-10 (lowest to highest).

c. In the 'W x S' column for each process, enter the product of the weight and scale.

d. Sum the 'W x S' column for each process to obtain a subtotal.

e. Calculate the process ratio for waste generated/input material used (0 - 1). This is the multiplier.

f. Multiply the subtotal by the multiplier and enter the product in the Total column for each process.

g. Determine the level of PPOA required by comparing the Total weighted sums value with the site guidelines in the following table.

Weighted Sums Total	PPOA Level Required
If 0 to (?)	Level II Informal PPOA
If ≥ (?)	Level III Formal PPOA

APPENDIX E

LEVEL II EXAMPLE PPOA

PPOA-1

Original Issue Date: 8/31/91
Revision No.:
Revision Date:

Pollution Prevention Opportunity Assessment

Team & Scope

Assessment ID Code: SNL/CA MS001

Assessment Title: Machine and Fabrication Shop

Name	Job Classification	Phone
* Alice Johnson-Duarte	WMin Coordinator	4-3266
Andy Cardiel	Shop Supervisor	4-2544
Charlie Schmitz	Machinist	4-2315
Kim Shepodd	Waste Manager	4-1475

* Team Leader

Assessment Scope:

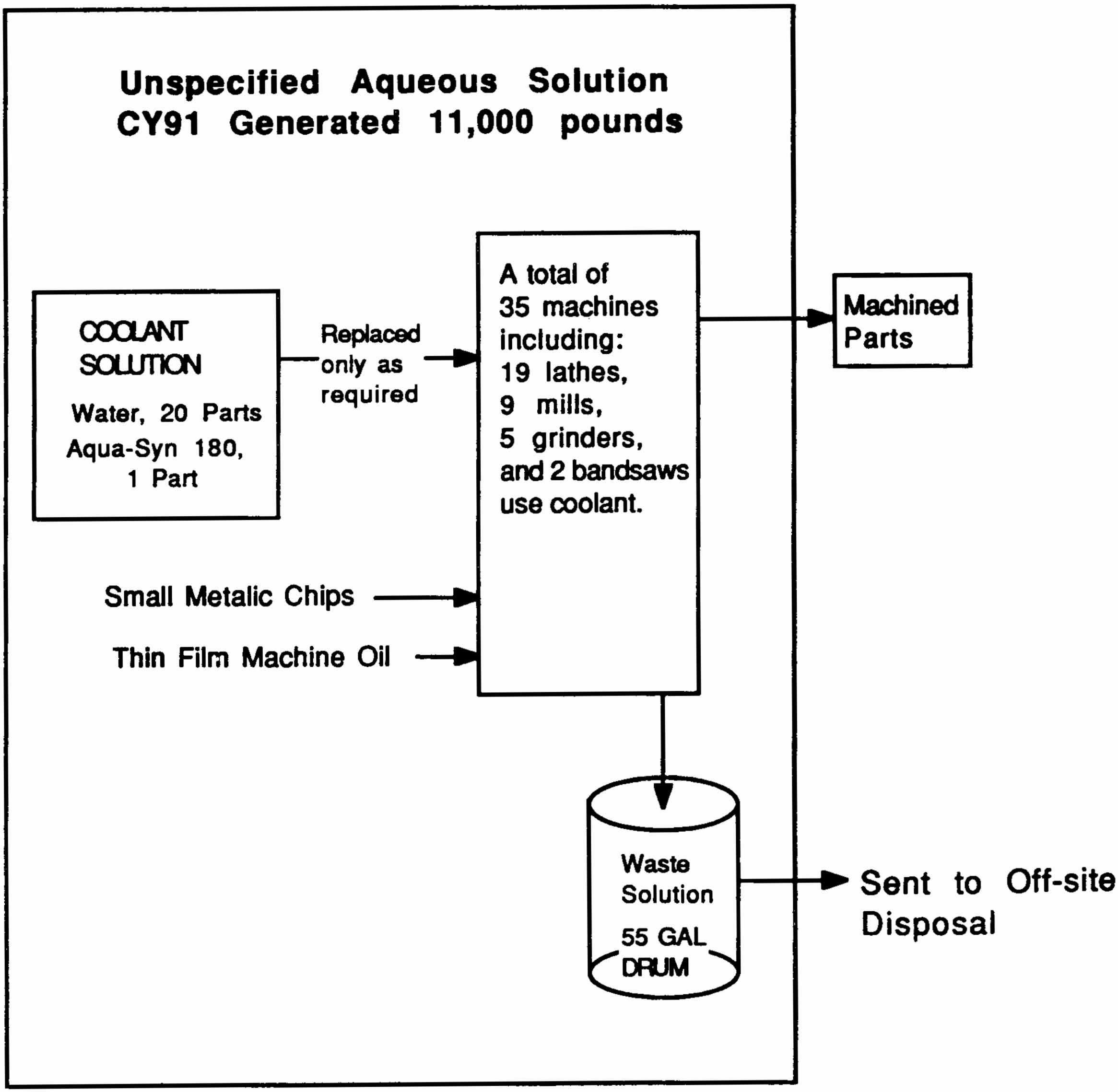
The Machining and Fabrication Shop is a support function whose principal purpose is machining parts requiring a quick turn-around, restriction of access due to classification, and/or close liaison with the designer and engineer. The shop maintains equipment suitable to perform turning, milling and grinding operations. The major hazardous waste stream generated by this facility is the spent coolant used in the machining process. The diluted Aqua-Syn 180 itself is a non-hazardous material per 29CFR 1910.1200(c); however, in the machining process it is mixed with small amounts of machine oil and metal shavings. The coolant is routinely changed after 3 to 4 months of service except as noted in the shop's operating procedures.

Potential for Pollution Prevention / Waste Minimization or Recommendations:

There are limited operational and administrative pollution prevention opportunities to reduce the spent coolant waste.

POLLUTION PREVENTION OPPORTUNITY ASSESSMENT
PROCESS FLOW DIAGRAM

PWA ASSESSMENT ID CODE: SNL/CA MS001
TITLE: Machine and Fabrication Shop



PPOA-2

Pollution Prevention Opportunity Assessment

Material & Waste Stream Summary

Assessment ID Code: SNL/CA MS001

Title: Machine and Fabrication Shop

Input Material Name/No.	Annual Quantity Used	% Product	% Recycled	Total Releases % Air	% Liquid	% Solid
Water	10400.0			5	95	
Aqua-Syn	520.0			1	99	
Metalic chips	65.0					100
Machine oil	15.0				100	

Totals/Page: 11000.0

Total Annual Quantity 11000.0

Does the process require further analysis based on the site's Priority Material/Waste Stream List?

● Yes ○ No

☒ Level II ☐ Level II

9/16/93

PPOA-3

Pollution Prevention Opportunity Assessment

Option Summary

Assessment ID Code: SNL/CA MS001

Title: Machine and Fabrication Shop

Option No. 1

Description

One consideration for an operational improvement would be to recycle the spent coolant. According to industrial sources, a reduction of approximately 50% in the present amount of coolant disposed of.

Type	Consider?	Feasibility	Estimated Cost	Estimated Savings	Anticipated Reduction Qty
Recycling	● Yes ○ No	Fair	$25,000.00	$100.00	5,000.00

Option No. 2

Description

Analyze the spent coolant solution for contaiminants and determine if it is indeed hazardous.

Type	Consider?	Feasibility	Estimated Cost	Estimated Savings	Anticipated Reduction Qty
Disposal	○ Yes ● No	Poor	$5,000.00	$100.00	1,0000

PPOA-4

Date
8/31/91

Pollution Prevention Opportunity Assessment

Final Summary

Assessment ID Code SNL/CA MS001

Title: Machine and Fabrication Shop

Assessment:

A Level I and Level II PWA were completed on the Machining and Fabrication Shop coolant waste stream. The machinist responsible for the operational maintenance of the machine shop equipment had limited suggestions for reducing the amount of spent coolant generated. Recycling and treatment options were generated and evaluated. Assumptions made during this assessment were: the level of activity of the machine shop is relatively stable; the coolant must be changed on a periodic basis which is dependent on use and/or time and; disposal costs are relatively stable.

Conclusions:

The PWA team concluded the options are not economically feasible at this time since: 1) option one would require a considerable investment with the possibility of increasing the actual amount of coolant waste caused by contamination; 2) the recycling equipment presently available is not designed to treat the small quantity of spent coolant generated; 3) a conservative approach regarding waste management is consistent with the site's policy.

Recommendations:

The Line Management will continue monitoring the amount of waste generated and the availability of recycling equipment for improvement in the economical feasibility of implementation.

APPENDIX F

LEVEL III EXAMPLE PPOA

Worksheet 1

Level III

Original Issue Date: 01-Dec-1993
Revision No.: 0
Revision Date:

Pollution Prevention Opportunity Assessment

PPOA Team

PPOA Title: Polyurethane Foam Mixing and Curing

PPOA ID Code(s): G517-034-Machine_Mix

Name	Job Classification	Phone
*Bill Harrison	Process Engineer	X1234
John Taylor	Area Supervisor	X1235
Albert Green	Foam Machine Operator	X1235
Mary White	Foam Machine Operator	X1235
Violet Jones	Area Production Planner	X1236

*Team Leader

Additional Resources	Name	Phone
PPOA Coordinator	Nancy Notrebmep	X5432
Waste Management	Hakim Senoj	X5433
Industrial Hygiene		
Environmental Protection	Tim Sregge	X5434
Safety		
Fire Protection		
Process Engineering		
Materials Engineering		
Utilities Engineering		
Facilities Engineering		
Maintenance (Equipment)		
Analytical Lab Testing	Dottie Muldune	X5431
Scheduling		
Purchasing		

Worksheet 2

Level III

Revision No.: ______
Revision Date: ______

Pollution Prevention Opportunity Assessment

Process Description

PPOA Title: Polyurethane Foam Mixing and Curing

PPOA ID Code(s): G517-034-Machine_Mix

Process Location: Main Building #105, Post FN33

Process Description:

The foam mixing process is a process in which the required material components are metered and mixed at a defined ratio. The ratio of the two component streams is set and calibrated by production personnel. The materials are then mixed during the dispense cycle by the action of a motorized impeller. The mixed material "foam" is transferred manually to a mold and cured at temperatures from 165 to 350 deg. F. for four to six hours. Input materials include polyol resins, isocyanates, cleaning solvent and processing supplies. Five foam dispensing units are used. They range in age from four to fifteen years. The cure ovens are ventilated as is the foam pouring area. The foam machine operators have sufficient training to operate the dispensing units. Their previous training did not emphasize pollution prevention.
Waste streams include solid and liquid waste from the foaming operations as well as air emissions from the foam pouring and curing activities.

Description of Major Product(s) of Process:

Molded Polyurethane Foam Products

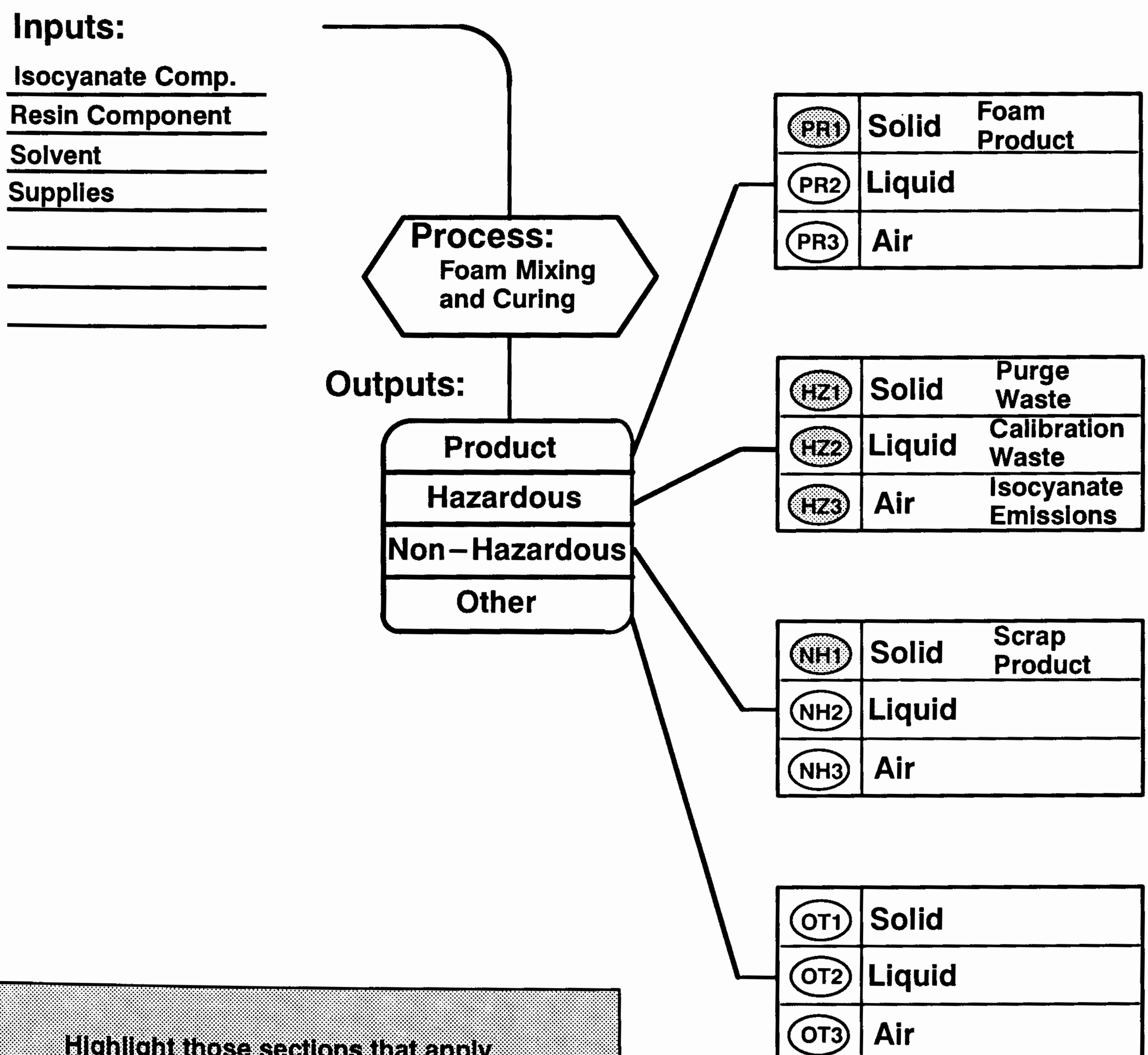
Worksheet 3
Style 1
Level III

Revision No. : 0
Revision Date: ____________

Pollution Prevention Opportunity Assessment

Process Flow Diagram

PPOA Title or PPOA ID Code(s): G517–034–Machine_Mix



Highlight those sections that apply.
Use Worksheet 4 to identify and quantify the appropriate stream.

Worksheet 4

Level III

Pollution Prevention Opportunity Assessment

Material Balance Summary

Revision No.: 0
Revision Date:

Time frame
From: 01–Jan–92
To: 31–Dec–92

PPOA Title or PPOA ID Code(s): G517–034–Machine_Mix

Material Description	Total Input	Total Output	OUTPUT QUANTITY (Units: lbs.) Stream ID Code Foam Product PR1	Stream ID Code Purge Waste HZ1	Stream ID Code Calibration Waste HZ2	Stream ID Code Isocyanate Emissions HZ3	Stream ID Code Scrap Product NH1	Stream ID Code	Stream ID Code	Stream ID Code	Stream ID Code
Isocyanate	313.6	124.5		98.3	24.4	1.8					
Resin	186.4	73.5		58.9	14.6						
Solvent	80.0	80.0		80.0							
Supplies	94.0	94.0		94.0							
Foam	0.0	302.0	237.0				65.0				
Totals/Subtotals	674.0	674.0	237.0	331.2	39.0	1.8	65.0				

Worksheet 5

Level III

Revision No.: 0

Revision Date: ______

Pollution Prevention Opportunity Assessment

Material Cost

PPOA Title or PPOA ID Code(s): G517-034-Machine_Mix

Material	Stock Number (if applicable)	Cost Per Unit	Annual Cost
Isocyanate Component		$1.96/lb	$614.65
Resin Component		$2.25/lb	$419.40
Solvent		$0.27/lb	$ 21.60
Supplies (paper cups, etc.)		$0.57/lb	$ 53.60
		Total / Subtotal	$1109.25

Waste Disposal Cost:

Material / Waste Stream	Waste Stream Category	Cost Per Unit	Annual Cost
Waste Liquid	Haz. Liquid	$4.60/lb	$179.40
Waste Solid	Haz. Solid	$2.97/lb	$983.66
Scrap Product	Non Haz. Solid	$0.69/lb	$ 44.85
		Total / Subtotal	$1207.91

Worksheet 6

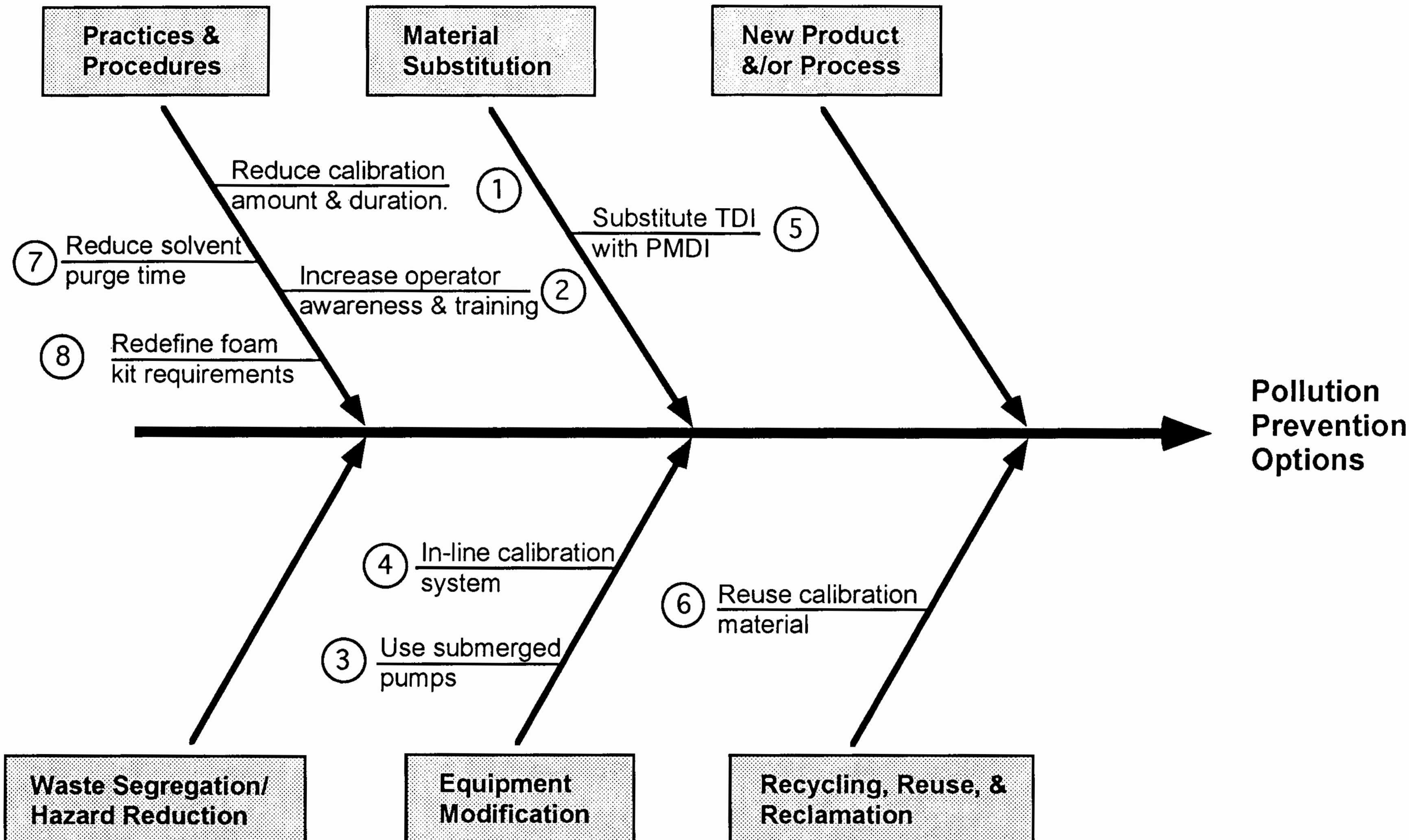
Level III

Revision No.: 0
Revision Date:

Pollution Prevention Opportunity Assessment

Option Generation

PPOA Title or PPOA ID Code(s): G517-034-Machine-Mix



Worksheet 7

Level III

Pollution Prevention Opportunity Assessment

Option Description

PPOA Title or PPOA ID Code(s): G517-034-Machine_Mix

Option Name and Description
(Include input materials, products affected, and anticipated reduction quantity.)

Option No. 1 : Calibration Reduction. Reduce the amount and duration of the calibration shots for the foam dispensers. Use new analytical methods "nitrogen testing" to justify the reduced level.

Consider: Yes X No__

Practices & Procedures	X	Waste Segregation/Hazard Reduction	
Material Substitution		Equipment Modification	
New Product &/or Process		Recycling, Reuse, & Reclamation	

Option No. 2 : Increase Awareness and Training. Conduct training session to increase pollution prevention awareness. Instruct in the importance of the individual in the waste generation process.

Consider: Yes X No__

Practices & Procedures	X	Waste Segregation/Hazard Reduction	
Material Substitution		Equipment Modification	
New Product &/or Process		Recycling, Reuse, & Reclamation	

Option No. 3 : Use Submerged Pumps. Replace gear pumps on foam machines with in-tank pumps. Leakage will be into material tanks. This will eliminate material waste and exposure as the result of clean-up

Consider: Yes X No__

Practices & Procedures		Waste Segregation/Hazard Reduction	
Material Substitution		Equipment Modification	
New Product &/or Process	X	Recycling, Reuse, & Reclamation	

Option No. 4 : In-Line Calibration System. Purchase new foam equipment with "in-line" calibration capability. This would replace the open cup method and would reduce the liquid and solid waste streams

Consider: Yes X No__

Practices & Procedures		Waste Segregation/Hazard Reduction	
Material Substitution		Equipment Modification	X
New Product &/or Process		Recycling, Reuse, & Reclamation	

Worksheet 7

Level III

Pollution Prevention Opportunity Assessment

Option Description

PPOA Title or PPOA ID Code(s): G517-034-Machine_Mix

Option Name and Description
(Include input materials, products affected, and anticipated reduction quantity.)

Option No. 5 : Substitute for TDI. Lessen the toxicity of the waste stream by replacing TDI isocyanate with a PMDI based foam system. PMDI is not a carcinogen and is not a RCRC Hazardous waste.

Consider: Yes X No__

Practices & Procedures ________ Waste Segregation/Hazard Reduction ______
Material Substitution X Equipment Modification ______
New Product &/or Process ______ Recycling, Reuse, & Reclamation ______

Option No. 6 : Reuse Calibration Material. Retain spent calibration material for use on low end product requirements. This could include machine tryout parts, or foam billets used as base material for holding fixtures.

Consider: Yes X No__

Practices & Procedures ________ Waste Segregation/Hazard Reduction ______
Material Substitution ________ Equipment Modification ______
New Product &/or Process ______ Recycling, Reuse, & Reclamation X

Option No. 7 : Reduce Solvent Purge Time. Reset the solvent timers on the foam machine to the absolute minimum to flush the mix head. Subsequent soaking of mixer blade and housing can also reduce the required amount.

Consider: Yes X No__

Practices & Procedures X Waste Segregation/Hazard Reduction ______
Material Substitution ________ Equipment Modification ______
New Product &/or Process ______ Recycling, Reuse, & Reclamation ______

Option No. 8 : Redefine Foam Kit Requirements. Set-up separate material numbers for resin and isocyanate components so ratio/usage of material will be balanced. Current "matched set" distribution result in waste of excess component.

Consider: Yes X No__

Practices & Procedures X Waste Segregation/Hazard Reduction ______
Material Substitution ________ Equipment Modification ______
New Product &/or Process ______ Recycling, Reuse, & Reclamation ______

Worksheet 8

Level III

Revision No.: 0
Revision Date: ______
Page 1 of 2

Pollution Prevention Opportunity Assessment

Options Cost Evaluation

PPOA Title or PPOA ID Code(s): G517-034-Machine_Mix

	Option No.: 1	Option No.: 2	Option No.: 3	Option No.: 4	Option No.: 5
Implementation Costs					
Purchased Equipment			$500	$75,000	
Installation			$100	$10,000	
Materials					
Utility Connections				$2000	
Engineering	$250	$100	$150	$3000	$1000
Development					$500
Start up / Training	$100	$100	$150	$5000	
Administrative	$50	$50			
Other					
Total Implementation Cost	$400	$250	$900	$95,000	$1500
Incremental Operating Costs					
Change in Raw Materials	$215	$100	$150	$750	$500
Change in Maintenance			($150)		
Change in Labor	$500			$500	
Change in Disposal	$50	$50	$100	$600	$500
Other					
Annual Operating Savings/(Cost)	$765	$150	$100	$1850	$1000
Incremental Intangible Costs					
Penalties and Fines					
Future Liabilities					
Other					
Annual Intangible Savings/(Cost)	$0	$0	$0	$0	$0
Total Annual Savings/(Cost)	$765	$150	$100	$1850	$1000
Payback Period	0.5 yrs	1.6 yrs	9.0 yrs	51 yrs	1.5 yrs

Worksheet 8

Level III

Revision No.: 0
Revision Date: ____
Page 2 **of** 2

Pollution Prevention Opportunity Assessment

Options Cost Evaluation

PPOA Title or PPOA ID Code(s): G517-034-Machine_Mix

	Option No.: 6	Option No.: 7	Option No.: 8	Option No.:	Option No.:
Implementation Costs					
Purchased Equipment					
Installation					
Materials					
Utility Connections					
Engineering	$200	$150	$150		
Development					
Start up / Training		$150			
Administrative			$150		
Other					
Total Implementation Cost	$200	$300	$300		
Incremental Operating Costs					
Change in Raw Materials		$15			
Change in Maintenance					
Change in Labor					
Change in Disposal	$180	$125	$350		
Other					
Annual Operating Savings/(Cost)	$180	$140	$350		
Incremental Intangible Costs					
Penalties and Fines					
Future Liabilities					
Other					
Annual Intangible Savings/(Cost)	$0	$0	$0		
Total Annual Savings/(Cost)	$180	$140	$350		
Payback Period	1.1 yrs	2.1 yrs	0.9 yrs		

Worksheet 9

Level III

Revision No.: 0
Revision Date: ______
Page 1 of 2

Pollution Prevention Opportunity Assessment

Weighted Sums Option Evaluation

PPOA Title or PPOA ID Code(s): G517-034-Machine_Mix

Criteria	Weight 'W'	Option No.: 1 Scale 'S'	'WxS'	Option No.: 2 Scale 'S'	'WxS'	Option No.: 3 Scale 'S'	'WxS'	Option No.: 4 Scale 'S'	'WxS'	Option No.: 5 Scale 'S'	'WxS'
Public Health, Safety, & Environment	10	8	80	6	60	6	60	7	70	8	80
Employee Health & Safety	10	8	80	7	70	5	50	8	80	9	90
Regulatory Compliance	8	7	56	7	56	8	64	7	56	9	72
Economic	6	8	48	9	54	7	42	5	30	8	48
Implementation Period	4	7	28	9	36	6	24	6	24	7	28
Improved Operation / Product	2	5	10	8	16	7	14	8	16	8	16
Other											
Subtotal			302		292		254		276		334
Likelihood of Technical Success (Multiplier)		X	0.8	X	1.0	X	0.9	X	0.9	X	1.0
Likelihood of Useful Results (Multiplier)		X	0.9	X	0.9	X	0.9	X	0.9	X	1.0
Total			217		262		205		224		339
Rank			7		4		8		5		1

Worksheet 9

Level III

Revision No.: 0
Revision Date: ____

Pollution Prevention Opportunity Assessment

Weighted Sums Option Evaluation

PPOA Title or PPOA ID Code(s): G517-034-Machine_Mix

Criteria	Weight 'W'	Option No.: 6 Scale 'S'	'WxS'	Option No.: 7 Scale 'S'	'WxS'	Option No.: 8 Scale 'S'	'WxS'	Option No.: ___ Scale 'S'	'WxS'	Option No.: ___ Scale 'S'	'WxS'
Public Health, Safety, & Environment	10	6	60	8	80	6	60				
Employee Health & Safety	10	7	70	8	80	7	70				
Regulatory Compliance	8	6	48	7	56	7	56				
Economic	6	7	42	9	54	8	48				
Implementation Period	4	7	28	9	36	8	32				
Improved Operation / Product	2	7	14	6	12	9	18				
Other											
Subtotal			262		318		284				
Likelihood of Technical Success (Multiplier)		X	0.9	X	1.0	X	1.0	X		X	
Likelihood of Useful Results (Multiplier)		X	0.9	X	0.9	X	1.0	X		X	
Total			212		286		284				
Rank			6		2		3				

Worksheet 10

Level III

Revision No.: 0 .
Revision Date: ______
Page 1 of 1

Pollution Prevention Opportunity Assessment

Final Report Check Sheet

PPOA Title or PPOA ID Code(s): G517-034-Machine_Mix

Requirement	***Completed***
Title Page	X
PPOA Title	
PPOA ID Code(s)	
Team members	
Issue date/revision date/revision no.	
Executive Summary	X
Process description	
Process assessment	
Option summary and analysis	
Conclusions	
Recommendations	
Introduction	X
Background of evaluation	
Process Description	X
Associated equipment	
Process flow diagram	
Process Assessment	X
Methodology	
Material Balance	
Unusual occurrences	
Option Summary and Analysis	X
Option description and rank	
Upstream/Downstream impacts	
Material usage	
Anticipated reduction	
Estimated costs	
Estimated benefits	
Feasibility	
Waste streams affected	
Conclusion	X
Concluding evaluation	
Option analysis decisions	
Concerns	
Options already implemented	
Lessons learned	
Recommendations	X
Future work	
New equipment	
Implementation strategies	
Worksheets	X
1-10	

APPENDIX G

MODEL PPOA WORKSHEETS

Worksheet 1
Level III

Original Issue Date: ________
Revision No.: ________
Revision Date: ________

Pollution Prevention Opportunity Assessment

PPOA Team

PPOA Title: ______________________________

PPOA ID Code(s): ______________________________

Name	Job Classification	Phone
*		

*Team Leader

Additional Resources	Name	Phone
PPOA Coordinator		
Waste Management		
Industrial Hygiene		
Environmental Protection		
Safety		
Fire Protection		
Process Engineering		
Materials Engineering		
Utilities Engineering		
Facilities Engineering		
Maintenance (Equipment)		
Analytical Lab Testing		
Scheduling		
Purchasing		

Worksheet 1

Worksheet 1 provides the identification of the PPOA assessment team. For the PPOA to be successful, employees involved with the process should be members of the team. The assessment team needs a leader, members, and additional resources, as required.

The team leader should have technical knowledge of the process, knowledge of the current production operations, and the personnel involved. The leader shall assemble the team to perform the assessment. Team members may include process engineers, product engineers, knowledgeable department personnel such as production operator(s), and material experts. Additional resources may be called in to provide information not available within the team. The size of the team may be large for complicated processes, but should be kept to a minimum to maintain focus.

1. **Original Issue Date:** List the original issue date of the PPOA.

2. **Revision No.:** List the revision number for this worksheet. {Original issue = 0.}

3. **Revision Date:** List the most recent revision date for this worksheet.

4. **PPOA Title:** List the PPOA title selected by the team.

5. **PPOA ID Code(s):** List the PPOA ID Code(s) selected by the team.

6. **Name, Job Classification, Phone:** To facilitate team meetings and for future reference, this information should be completed when the PPOA team is formed.

Worksheet 2

Level III

Revision No.: ________
Revision Date: ________

Pollution Prevention Opportunity Assessment

Process Description

PPOA Title: ____________________

PPOA ID Code(s): ____________________

Process Location: ____________________

Process Description: ____________________

Description of Major Product(s) of Process: ____________________

Worksheet 2

Worksheet 2 provides a brief description of the process. The main elements of the process description are the process location, input materials, equipment, summary of operations performed, process controls, operator training, major products, and the waste streams affected.

1. **Revision No.:** List the revision number for this worksheet.

2. **Revision Date:** List the most recent revision date for this worksheet.

3. **PPOA Title:** List the PPOA Title given on Worksheet 1.

4. **PPOA ID Code(s):** List the PPOA ID Code(s) given on Worksheet 1.

5. **Process Location:** List the best descriptor of the process location. It may be a department, building, room, etc..

6. **Process Description:** The process description should detail important attributes of the process. Equipment, summary of operations performed, process controls, input materials, and operator training (qualification or certification) should be included.

7. **Description of Major Product(s) of Process:** Describe the major products which result from this process or the reason the process is being perfromed.

Worksheet 3
Style 1
Level III

Revision No. : ____________
Revision Date: ____________

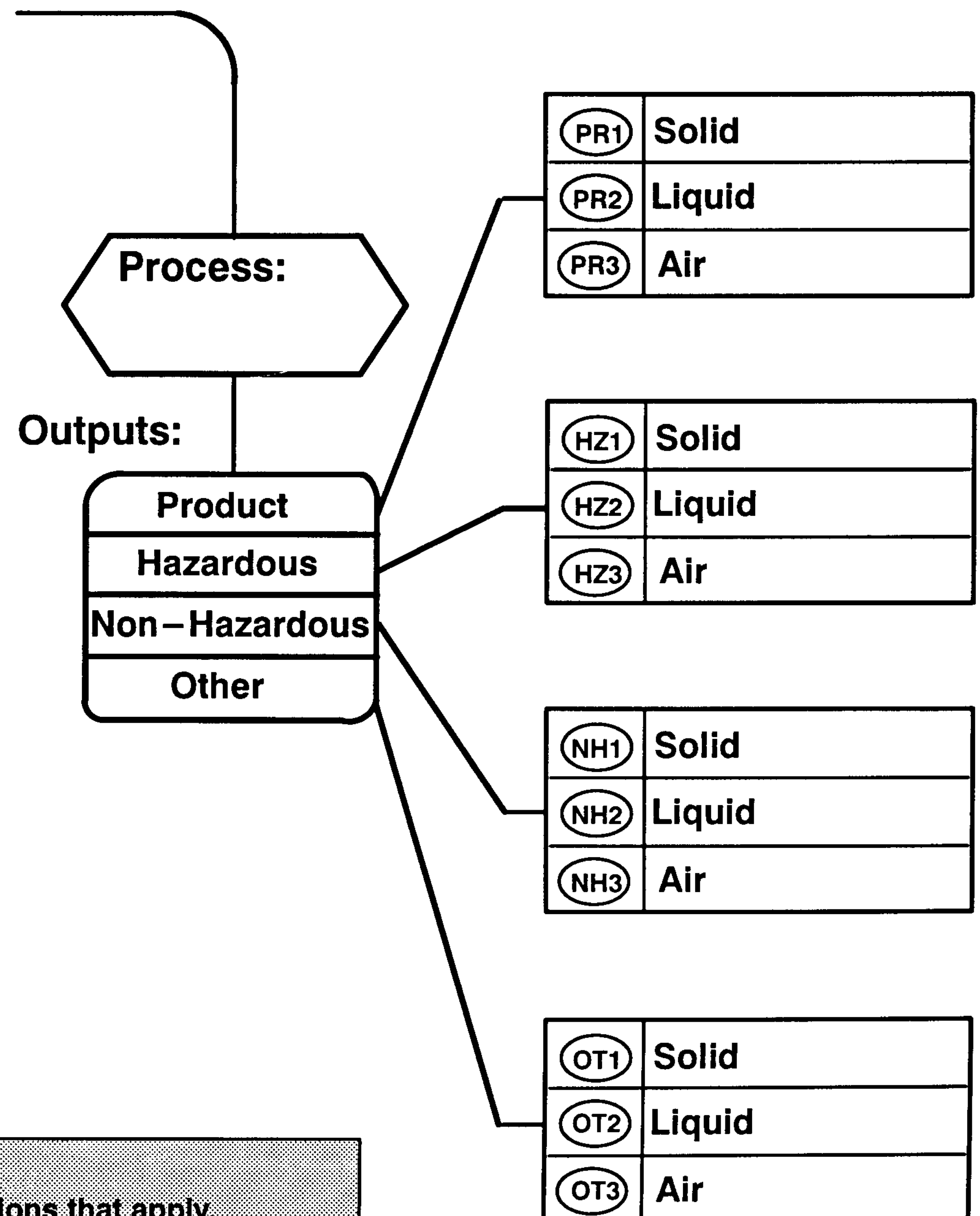
Pollution Prevention Opportunity Assessment

Process Flow Diagram

PPOA Title or PPOA ID Code(s): ____

Inputs:

____
____
____
____
____
____
____



Highlight those sections that apply.
Use Worksheet 4 to identify and
quantify the appropriate stream.

Worksheet 3

Worksheet 3 provides a process flow diagram for the PPOA. The flow diagram should identify all PPOA ID Code(s) associated with the process, all input materials, and outputs (products/wastes). The flow diagram should track materials from the time they enter the process boundary until they leave. This diagram represents a very simplistic flow model; a more detailed diagram may be required to identify all waste streams, especially for complex, multi-step processes.

1. **Revision No.:** List the revision number for this worksheet.

2. **Revision Date:** List the most recent revision date for this worksheet.

3. **PPOA Title or PPOA ID Code(s)**: List the PPOA Title or PPOA ID Code(s) given on Worksheet 1.

4. **Process Flow Diagram**: List the input materials on the lines provided. Fill in the Process Name box. Then highlight those outputs that are applicable to the process (e.g. Product, Hazardous, etc.). Then sub-categorize those outputs into solid, liquid, or air emission streams by highlighting the corresponding output stream. A **Stream ID Code** is provided for each sub-category of waste.

5. **Outputs:** The Stream ID Code provides a uniform coding scheme for the release information requested on Worksheet 4. A brief waste description may be recorded in the box to the right of the Stream ID Code.

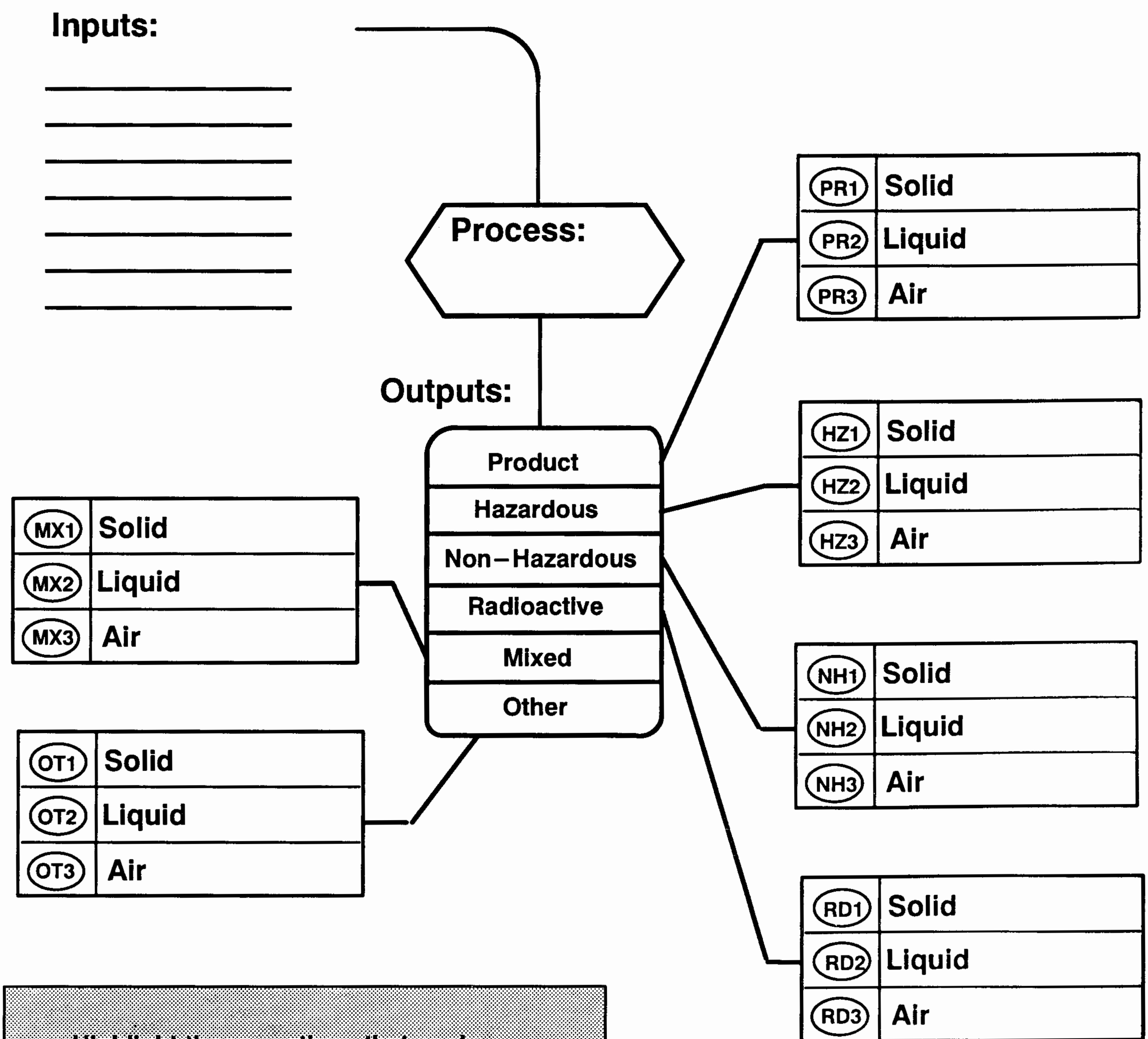
Worksheet 3
Style 2
Level III

Revision No.: ______
Revision Date: ______

Pollution Prevention Opportunity Assessment

Process Flow Diagram

PPOA Title or PPOA ID Code(s): ________________________________



Highlight those sections that apply.
Use Worksheet 4 to identify and quantify the appropriate stream.

Worksheet 3

Worksheet 3 provides a process flow diagram for the PPOA. The flow diagram should identify all PPOA ID Code(s) associated with the process, all input materials, and outputs (products/wastes). The flow diagram should track materials from the time they enter the process boundary until they leave. This diagram represents a very simplistic flow model; a more detailed diagram may be required to identify all waste streams, especially for complex, multi-step processes.

1. **Revision No.:** List the revision number for this worksheet.

2. **Revision Date:** List the most recent revision date for this worksheet.

3. **PPOA Title or PPOA ID Code(s)**: List the PPOA Title or PPOA ID Code(s) given on Worksheet 1.

4. **Process Flow Diagram**: List the input materials on the lines provided. Fill in the Process Name box. Then highlight those outputs that are applicable to the process (e.g. Product, Hazardous, etc.). Then sub-categorize those outputs into solid, liquid, or air emission streams by highlighting the corresponding output stream. A **Stream ID Code** is provided for each sub-category of waste.

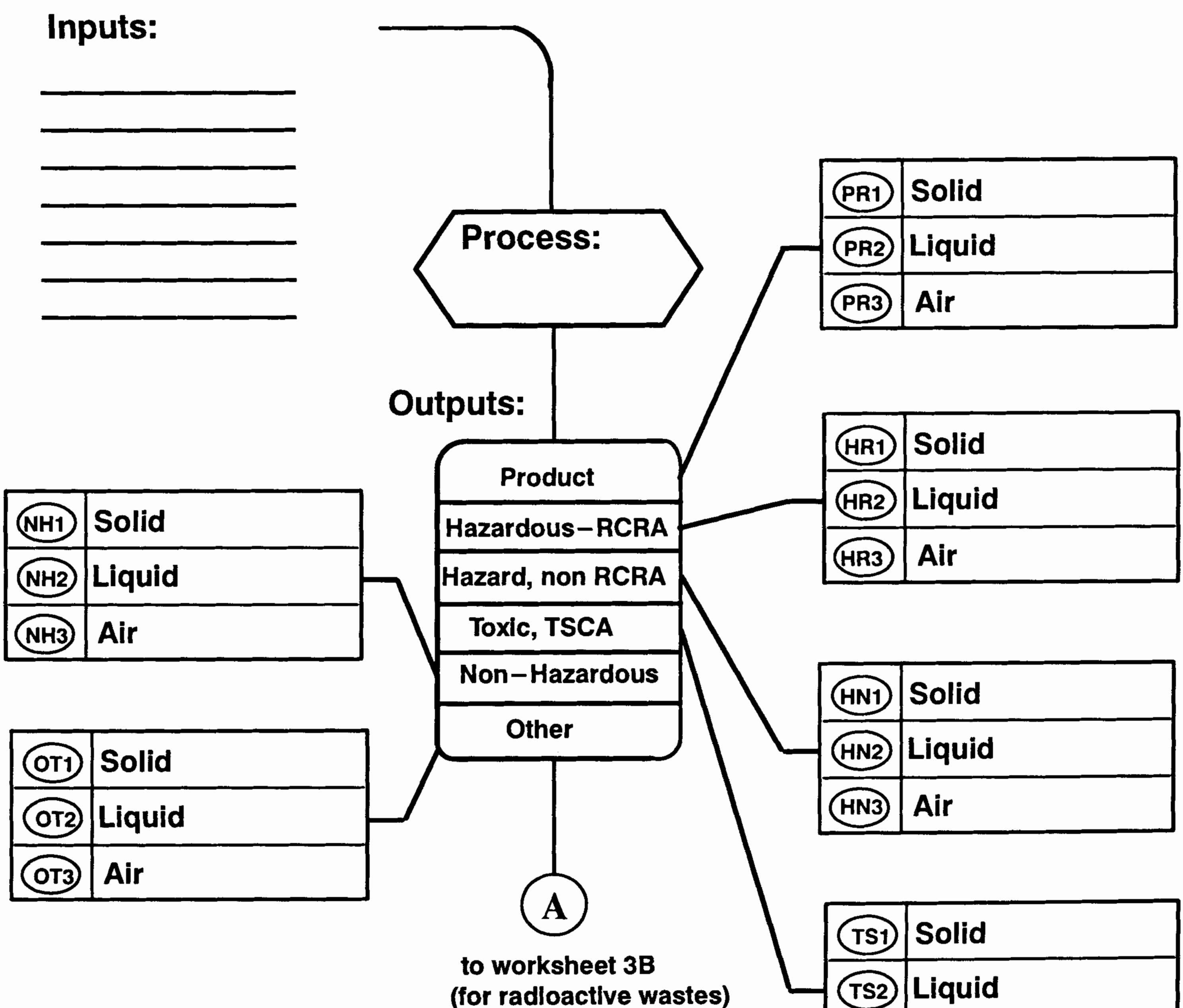
5. **Outputs:** The Stream ID Code provides a uniform coding scheme for the release information requested on Worksheet 4. A brief waste description may be recorded in the box to the right of the Stream ID Code.

Worksheet 3A
Style 3
Level III

Revision No.: ______
Revision Date: ______

Pollution Prevention Opportunity Assessment
Process Flow Diagram

PPOA Title or PPOA ID Code(s): ____________________



Highlight those sections that apply.
Use Worksheet 4 to identify and quantify the appropriate stream.

11/93

Worksheet 3A

Worksheet 3 provides a process flow diagram for the PPOA. The flow diagram should represent all PPOA ID Code(s) associated with the process, all input materials, and outputs (products/wastes). The flow diagram should track materials from the time they enter the process boundary until they leave. This diagram represents a very simplistic flow model; a more detailed diagram may be required to identify all waste streams, especially for complex, multi-step processes.

1. **Revision No.:** List the revision number for this worksheet.

2. **Revision Date:** List the most recent revision date for this worksheet.

3. **PPOA Title or PPOA ID Code(s)**: List the PPOA Title or PPOA ID Code(s) given on Worksheet 1.

4. **Process Flow Diagram**: List the input materials on the lines provided. Fill in the Process Name box. Then highlight those outputs that are applicable to the process (e.g. Product, Hazardous, etc.). Then categorize those outputs into solid, liquid, or air emission streams by highlighting the corresponding output stream. A **Stream ID Code** is provided for each category of waste.

5. **Outputs:** The Stream ID Code provides a uniform coding scheme for the release information requested on Worksheet 4. A brief waste description may be recorded in the box to the right of the Stream ID Code.

DOE Definitions:

Hazardous Waste - Waste, which because of its quantitiy, concentration, or physical, chemical or infectious nature may (a) cause or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible illness, or (b) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, disposed of, or otherwise managed. Hazardous waste can be further defined as:

RCRA-regulated - solid waste not specifically excluded from regulation under 40 CFR 261.4, or delisted by petition, that is either a listed hazardous waste (40 CFR 261.30 - 261.33) or exhibits the characteristics of a hazardous waste (40 CFR 261.20 - 261.24).

Non RCRA-regulated - any other hazardous waste not specifically regulated under TSCA or RCRA, which may be regulated by the state or local authorities, such as used oil.

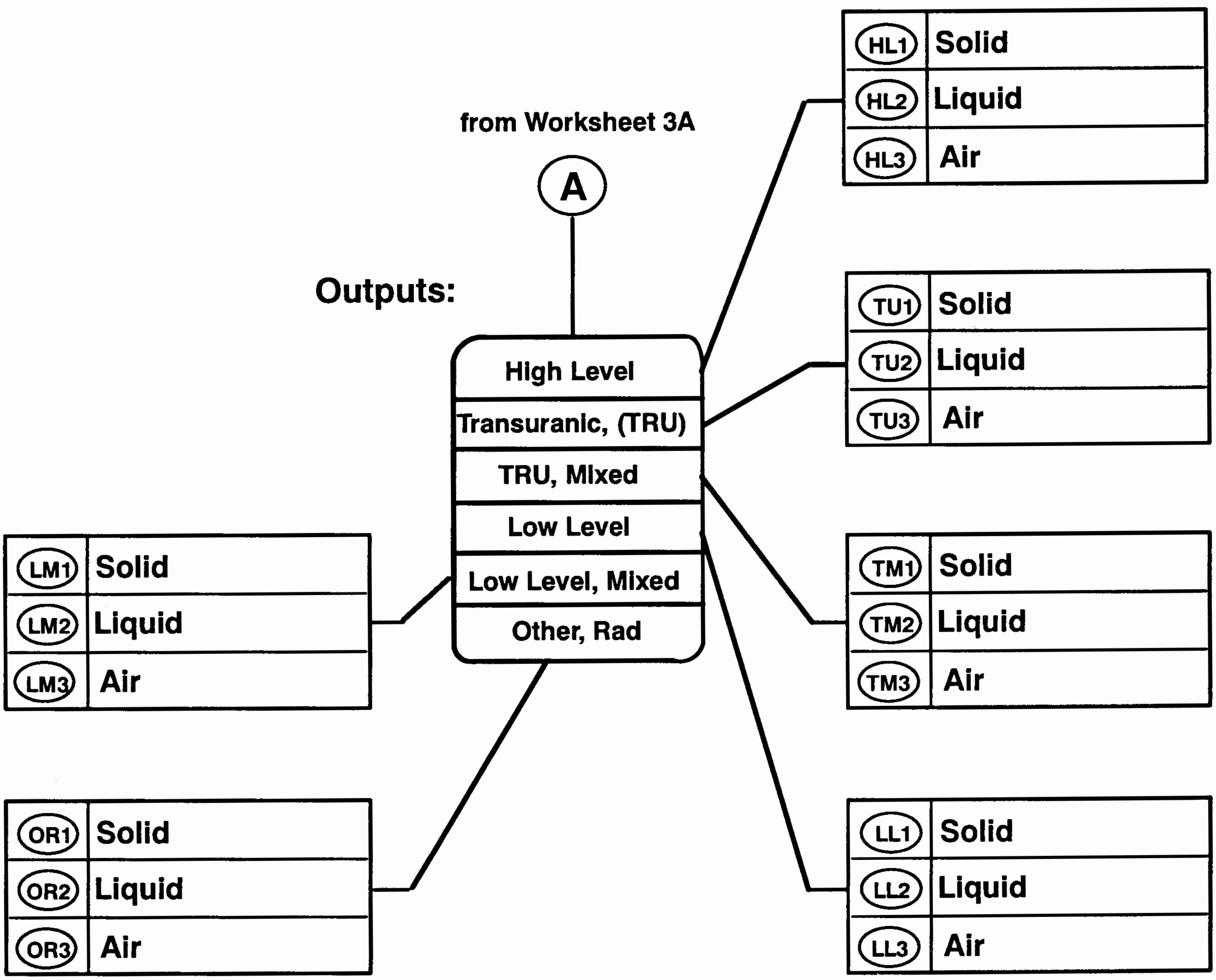
TSCA Waste - Individual chemical wastes (both liquid and solid), such as polychlorinated biphenyls (PCBs).

Worksheet 3B
Style 3
Level III

Revision No. : ____________
Revision Date: ____________

Pollution Prevention Opportunity Assessment
Process Flow Diagram

PPOA Title or PPOA ID Code(s): ______________________________



Highlight those sections that apply. Use Worksheet 4 to identify and quantify the appropriate stream.

Worksheet 3B

Worksheet 3 provides a process flow diagram for the PPOA. The flow diagram should represent all PPOA ID Code(s) associated with the process, all input materials, and outputs (products/wastes). The flow diagram should track materials from the time they enter the process boundary until they leave. This diagram represents a very simplistic flow model; a more detailed diagram may be required to identify all waste streams, especially for complex, multi-step processes.

1. **Revision No.:** List the revision number for this worksheet.

2. **Revision Date:** List the most recent revision date for this worksheet.

3. **PPOA Title or PPOA ID Code(s)**: List the PPOA Title or PPOA ID Code(s) given on Worksheet 1.

4. **Process Flow Diagram**: List the input materials on the lines provided. Fill in the Process Name box. Then highlight those outputs that are applicable to the process (e.g. Product, Hazardous, etc.). Then categorize those outputs into solid, liquid, or air emission streams by highlighting the corresponding output stream. A **Stream ID Code** is provided for each category of waste.

5. **Outputs:** The Stream ID Code provides a uniform coding scheme for the release information requested on Worksheet 4. A brief waste description may be recorded in the box to the right of the Stream ID Code.

DOE Definitions:

High Level Waste- Irradiated reactor fuel, liquid wastes resulting from operation of the first cycle solvent extraction system, or equivalent, and the concentrated wastes from subsequent extraction cycles, or equivalent, in a facility for reprocessing irradiated reactor fuel, and solids into which such liquid wastes have been converted. (10 CFR 60.2)

Transuranic Waste - Waste that is contaminated with alpha-emitting radionuclides with (1) an atomic number greater than 92 (heavier than uranium); (2) half-lives greater than 20 years; and (3) concentrations greater than 100 nanocuries per gram of waste.

Transuranic Mixed Waste: - Waste which contains both transuranic waste and hazardous components, as defined by the Atomic Energy Act and RCRA, respectively.

Low Level Waste: - Radioactive Waste not classified as high level waste, transuranic waste, spent nuclear fuel, or by-product material [specified as uranium or thorium tailings and waste in accordance with DOE Order 5820.2A].

Low Level Mixed Waste: - Waste which contains both low level waste and hazardous components, as defined by the Atomic Energy Act and RCRA, respectively.

Worksheet 4

Level III

Pollution Prevention Opportunity Assessment

Mass Balance Summary

Revision No.: ____________
Revision Date: ____________
Page ________ of ________

Time frame
From: ________
To: ________

PPOA Title or PPOA ID Code(s): ______________________________

Material Description	Total Input	OUTPUT QUANTITY (Units: _____) Total Output	Stream ID Code	Stream ID Code	Stream ID Code	Stream ID Code	Stream ID Code	Stream ID Code	Stream ID Code	Stream ID Code	Stream ID Code
Totals/Subtotals											

11/93

Worksheet 4

A material balance is a summation of the total quantity of input material to a process and the releases to the environment, another process, or made into product. The purpose of Worksheet 4 is to tabulate this information and total the inputs and outputs for all streams.

1. **Revision No.:** List the revision number of the PPOA.

2. **Revision Date**: List the most recent revision date for the PPOA worksheet.

3. **PPOA Title/PPOA ID Code(s)**: List the PPOA Title or ID Code(s) given on Worksheet 1.

4. **Page ____of ____:** Indicate the page number for this worksheet and the number of pages for this worksheet.

5. **From/To**: Report the dates (month and year) for the time period covered. An annual period is suggested for purposes of averaging and documenting performance toward facility goals.

6. **Material Description:** List the material name and stock number (optional) or the output product if different than originating material.

7. **Units ____:** Enter the unit of measure for the input/output summary. A consistent unit of measurement is suggested. If requirements dictate mixing units, designate the units for a particular column under the Stream ID Code heading.

8. **Total Input:** For the material described in the far left column enter the weight of material used in the process during the time frame specified.

9. **Total Output:** For the material specified in the Material Description column enter the weight of the output. This is the sum of all waste streams and any product generated. For processes where chemical reactions take place, input materials are consumed or changed to different compounds, a separate entry in the Material Description column is required to adequately define the output. In these cases, the input and output quantities will not balance for the listed material in that row.

10. **Output Quantity:** Use these columns to break down the total output into output categories. Refer to Worksheet 3 for the appropriate Stream ID Code for the output type. Enter the Stream ID Code at the top of the column (e.g., HZ1 for a hazardous solid waste stream), then enter the discharge amount for the material described in the Material Description column that relates to that Stream ID Code. Continue across the worksheet for all Stream ID Code(s) utilized in Worksheet 3.

11. **Totals/Subtotals:** Sum the Total Input, Total Output, and Output columns. Record the sum at the bottom row of the last worksheet. Subtotals are recorded at the bottom row for other pages of the worksheet. The Total Input column should equal the Total Output column unless there is system accumulation. The Total Output column should also be the sum of all the Stream ID Code output streams.

Stream ID Codes:

Designator	Style 1	Style 2	Style 3
Product	PR	PR	PR
Hazardous	HZ	HZ	
Non-Hazardous	NH	NH	NH
Radioactive		RD	
Mixed		MX	
Other	OT	OT	OT
Hazardous, RCRA			HR
Hazardous, Non-RCRA			HN
Toxic, TSCA			TS
High Level			HL
Transuranic, TRU			TU
TRU, Mixed			TM
Low Level			LL
Low Level, Mixed			LM
Other, Radioactive			OR

Solid Stream = 1, Liquid Stream = 2, Air Stream = 3

Style refers to the version of Worksheet 3 used.

Worksheet 5

Level III

Revision No.: ______
Revision Date: ______
Page _____of ______

Pollution Prevention Opportunity Assessment

Material Cost

PPOA Title or PPOA ID Code(s): ____________________

Input Material Cost:

Material	Stock Number (if applicable)	Cost Per Unit	Annual Cost
		Total / Subtotal	

Waste Disposal Cost:

Material / Waste Stream	Waste Stream Category	Cost Per Unit	Annual Cost
		Total / Subtotal	

Worksheet 5

Worksheet 5 details the cost of the PPOA input materials (use the quantities from Worksheet 4) and the cost of disposal for these materials. The material cost may be obtained from Purchasing or Stores. The cost of disposal may be obtained from Waste Management or Accounting. Annual Cost is calculated from the amount of material placed in the process or from the amount of disposed material, multiplied by the cost per unit.

1. Revision No.: List the revision number for this worksheet.

2. Revision Date: List the most recent revision date for this worksheet.

3. Page_____of_____: Indicate the number of this page and the total number of pages for this worksheet.

4. PPOA Title or PPOA ID Code(s): List the PPOA Title or PPOA ID Code(s) given on Worksheet 1.

5. Input Material Cost: List the material, stock number (if applicable), cost per unit ($/lb., $/gal, etc.), and the annual cost for this process.

6. Waste Disposal Cost: List the material or waste stream, waste stream category, (e.g., hazardous liquid), stock number if applicable, the cost per unit ($/lb., $/gal, etc.) , and annual cost.

7. Totals / Subtotals: Record the sum of the annual costs for the materials or waste streams listed. There will be a total for both the input material cost and waste disposal cost.

Worksheet 6

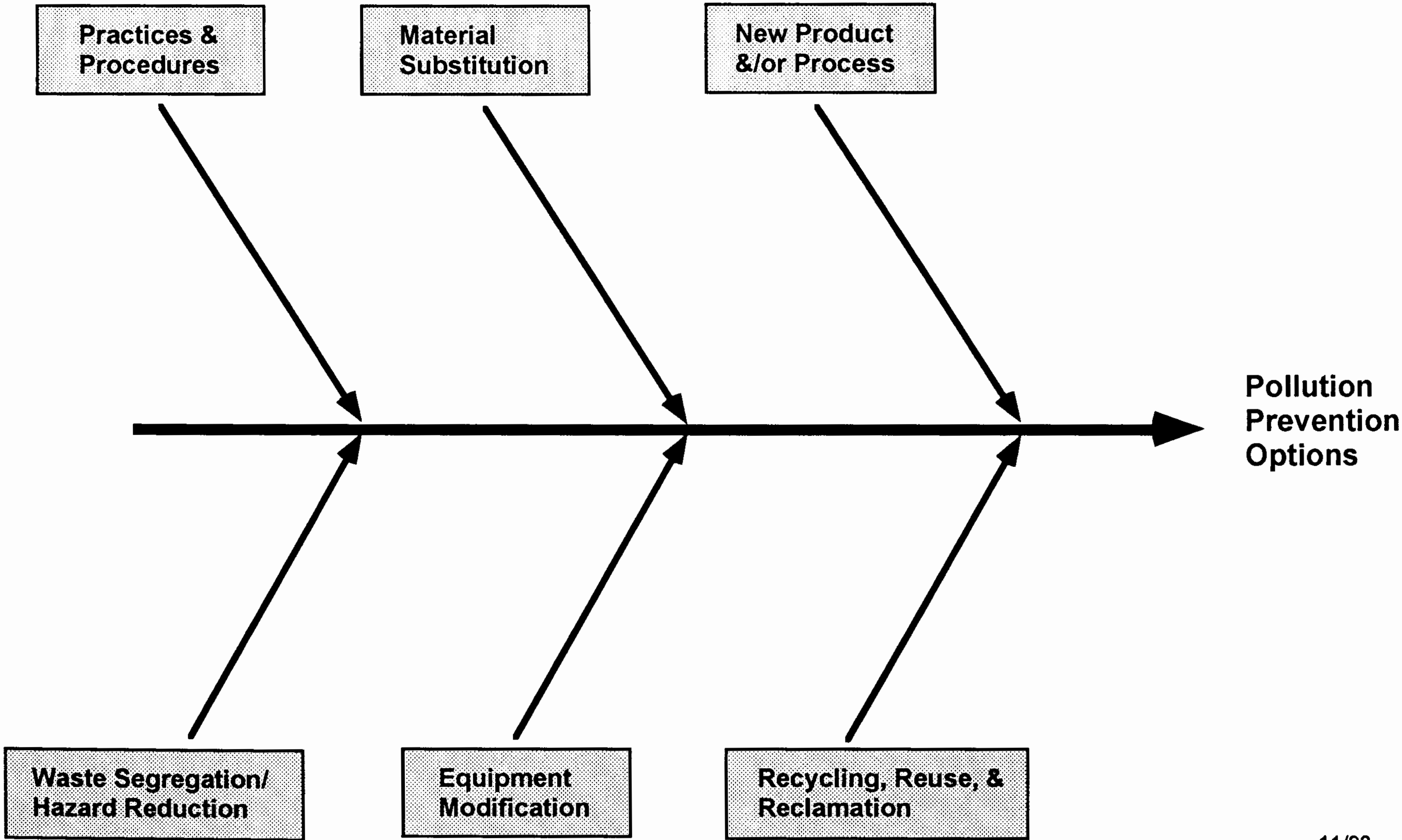
Level III

Pollution Prevention Opportunity Assessment

Revision No.: ____________
Revision Date: ____________

Option Generation

PPOA Title or PPOA ID Code(s): ______________________________



Worksheet 6

Worksheet 6 provides a tool for option generation. The purpose of this diagram (sometimes referred to as a Fishbone Diagram) is to help generate pollution prevention ideas. It is especially useful in a brainstorming session to group ideas undersimilar pollution prevention categories. It also helps insure that all of the pollution prevention categories are considered.

1. **Revision No.:** List the revision number for this worksheet.

2. **Revision Date:** List the most recent revision date for this worksheet.

3. **PPOA Title or PPOA ID Code(s):** List the PPOA title or PPOA ID Code(s) given on Worksheet 1.

4. **Brainstorming ideas:** Using the Fishbone Diagram, briefly document ideas for pollution prevention.

The following definitions clarify each of the major categories.

Practices & Procedures -- Good operating practices and procedures apply to the human aspect of operations. They are largely efficiency improvements. Examples are: Pollution Prevention Programs, personnel training, material handling & inventory practices, material loss prevention, scrap reduction, cost accounting, production scheduling, etc.

Material Substitution -- Changes to the input materials of the process. The result is a reduction or elimination of a pollutant or hazard.

New Product &/or Process -- Product changes which result in the reduction or elimination of waste. In addition, a different process can be used to create the same product with the intent of minimizing waste.

Waste Segregation/Hazard Reduction -- Actions taken to segregate waste streams to prevent nonhazardous waste from being designated and handled as hazardous. Hazard reduction can result from changes to the physical, chemical, or biological character or composition of the waste. These include neutralization, toxicity reduction, or volume reduction.

Equipment Modification -- Changes that occur to the equipment used in a process. These could include minor adjustments, additions, or complete replacements.

Recycling -- A material is recycled if it is used, reused, or reclaimed: (1) if it is used for something other than its original purpose, (2) if it goes back into the original process, or (3) if it is chemically or physically treated for use or reuse.

Worksheet 7

Level III

Revision No.: _____
Revision Date:_____
Page _____**of**_____

Pollution Prevention Opportunity Assessment

Option Description

PPOA Title or PPOA ID Code(s): ______________________________

Option Name and Description
(Include input materials, products affected, and anticipated reduction quantity.)

Option No. _____ **:** ______________________________

Consider: Yes__No__

Practices & Procedures _______ Waste Segregation/Hazard Reduction _____
Material Substitution _________ Equipment Modification _____
New Product &/or Process _____ Recycling, Reuse, & Reclamation _____

Option No. _____ **:** ______________________________

Consider: Yes__No__

Practices & Procedures _______ Waste Segregation/Hazard Reduction _____
Material Substitution _________ Equipment Modification _____
New Product &/or Process _____ Recycling, Reuse, & Reclamation _____

Option No. _____ **:** ______________________________

Consider: Yes__No__

Practices & Procedures _______ Waste Segregation/Hazard Reduction _____
Material Substitution _________ Equipment Modification _____
New Product &/or Process _____ Recycling, Reuse, & Reclamation _____

Option No. _____ **:** ______________________________

Consider: Yes__No__

Practices & Procedures _______ Waste Segregation/Hazard Reduction _____
Material Substitution _________ Equipment Modification _____
New Product &/or Process _____ Recycling, Reuse, & Reclamation _____

Worksheet 7

The purpose of this worksheet is to further document the pollution prevention options identified on Worksheet 6. The process by which options are identified should occur in an environment that encourages creativity and independent thinking. Brainstorming sessions are effective ways for individuals to generate options. Consideration of the options generated in a brainstorming session can lead to questions. Answering these questions may require additional research. Listed below are some of the sources that can help to answer questions and/or generate additional options.

- Literature searches
- Technical conferences
- Equipment exhibitions
- Trips to other plants
- Vendor surveys
- Contact with design engineers
- Contact with personnel in other departments who have participated in similar PPOAs
- Materials engineers
- Benchmarking

1.Revision No.: List the revision number for this worksheet.

2. Revision Date: List the most recent revision date for this worksheet.

3. PPOA Title or PPOA ID Code: List the PPOA Title or PPOA ID Code given on Worksheet 1.

4. Page ___ of ___: Indicate the number of this page and the total number of pages for this worksheet.

5. Option: Options generated should be numbered consecutively and placed on this worksheet (reference Worksheet 6). They may or may not be evaluated. Briefly describe each option, affected materials and product, any roadblocks to implementation, upstream and downstream impacts if implemented, and anticipated reduction quantity.

6. Consider Yes/No: If the suggestion is worth further consideration, check 'Yes'. If the suggestion will not be pursued, check 'No' and indicate briefly in the Option Description why not.

7. Practices & Procedures, Material Substitution, New Product &/or Process, Waste Segregation/ Hazard Reduction, Equipment Modification, and Recycling, Reuse, & Reclamation: Check the appropriate descriptions. See Worksheet 6 for definitions.

Worksheet 8

Level III

Revision No.: ______
Revision Date: ______
Page ______ of ______

Pollution Prevention Opportunity Assessment

Options Cost Evaluation

PPOA Title or PPOA ID Code(s): ______________________________

	Option No.:	Option No.:	Option No.:	Option No.:	Option No.:
Implementation Costs					
Purchased Equipment					
Installation					
Materials					
Utility Connections					
Engineering					
Development					
Start up / Training					
Administrative					
Other					
Total Implementation Cost					
Incremental Operating Costs					
Change in Raw Materials					
Change in Maintenance					
Change in Labor					
Change in Disposal					
Other					
Annual Operating Savings/(Cost)					
Incremental Intangible Costs					
Penalties and Fines					
Future Liabilities					
Other					
Annual Intangible Savings/(Cost)					
Total Annual Savings/(Cost)					
Payback Period					

Worksheet 8

This worksheet provides a method to compare and contrast the pollution prevention options generated on Worksheet 6 from a cost perspective. The three major cost categories for weighing options are: Implementation Costs, Incremental Operating Costs, and Incremental Intangible Costs. These costs are totaled for each option considered from Worksheet 7. This worksheet will aid in completing the economic evaluation portion of Worksheet 9.

1. **Revision No.:** List the revision for this worksheet.

2. **Revision Date:** List the most recent revision date for this worksheet.

3. **Page ____of____:** Indicate the number of this page and the total number of pages for this worksheet.

4. **PPOA Title or PPOA ID Code(s):** List the PPOA Title or PPOA ID Code(s) given on Worksheet 1.

5. **Implementation Cost:** These are the one-time, first-year costs associated with the implementation of each option. Installation costs should be reported as an estimate. Implementation Cost may include materials, utility connections, site preparation, installation, engineering, procurement, start-up, training, permitting, initial catalysts and chemicals, and working capital; minus the salvage value of any existing equipment.

6. **Annual Operating Savings/(Costs):** These are the costs associated with day-to-day operations. List the incremental costs compared to the current process costs (positive for savings or negative for increased costs) that would be incurred if this option is implemented. Incremental operating costs could include waste disposal, raw material consumption, ancillary catalysts and chemicals, labor, maintenance and supplies, insurance, incremental revenues from increased / decreased production, and incremental revenues from marketable by-products.

7. **Annual Intangible Savings/(Cost):** These include hidden, liability, and other costs not immediately obvious for each option. List the incremental costs compared to the current process costs (positive for savings or negative for increased costs) that would be incurred if this option is implemented. These costs could include penalties and fines, future liabilities (storage, transportation, and disposal of hazardous waste), reporting, consulting fees, monitoring/testing, record keeping, preparedness and protective equipment, medical surveillance, manifesting, inspections, and corporate/public image.

8. **Total Annual Cost/Savings:** This is the sum of the **Annual Operating Savings/(Cost)** and the **Annual Intangible Savings/(Cost)**.

9. **Payback Period:** Divide the **Total Implementation Cost** by the **Total Annual Savings/(Cost)**.

Worksheet 9

Level III

Revision No.: ________
Revision Date: ________
Page ______ of ________

Pollution Prevention Opportunity Assessment

Weighted Sums Option Evaluation

PPOA Title or PPOA ID Code(s): ____________________

Criteria	Weight 'W'	Option No.: ____ Scale 'S'	'WxS'	Option No.: ____ Scale 'S'	'WxS'	Option No.: ____ Scale 'S'	'WxS'	Option No.: ____ Scale 'S'	'WxS'	Option No.: ____ Scale 'S'	'WxS'
Public Health, Safety, & Environment	10										
Employee Health & Safety	10										
Regulatory Compliance	8										
Economic	6										
Implementation Period	4										
Improved Operation / Product	2										
Other											
Subtotal											
Likelihood of Technical Success (Multiplier)		x		x		x		x		x	
Likelihood of Useful Results (Multiplier)		x		x		x		x		x	
Total											
Rank											

Many pollution prevention options will be identified in a successful assessment. At this point, it is necessary to identify those options that offer real potential to minimize waste and reduce costs. Worksheet 9 serves as a screening tool to prioritize or eliminate suggested options.

1. **Revision No.:** List the revision number for this worksheet.

2. **Revision Date:** List the most recent revision date for this worksheet.

3. **Page ____ of ____:** Indicate the number of this page and the total number of pages for this worksheet.

4. **PPOA Title or PPOA ID Code(s):** List the PPOA Title or PPOA ID Code(s) given on Worksheet 1.

Additional Instructions:

a. The values in the Weight column (designated by 'W') represent the facility's priority for the criteria.

b. In the Scale column for each option (designated by 'S'), rate each criteria by assigning a value from 0-10 (lowest to highest). Use the definitions which follow to help determine a value.

c. In the 'W x S' column for each option, enter the product of the weight and scale.

d. Sum the 'W x S' column for each option to obtain a subtotal.

e. Multiply the subtotal for each option by the Likelihood of Technical Success.

f. Multiply the value in step e. above for each option by the Likelihood of Useful Results.

g. Enter the product found in step f. in the Total column for each option.

h. Assign a priority rank for each option; #1 for the highest score, #2 for the next highest, and so on.

Worksheet 9 -- (Scale & Multiplier Definitions)

Scale Factor Definitions (0-10)

	Public Health, Safety, & Environment -- Health or safety risk to the general public or damage to the environment.
10	Reduce the risk of loss of life or long-term environmental damage. High concentrations of hazardous materials.
8	Reduce the risk of long-term disability or moderate environmental damage. Moderate concentrations of hazardous materials.
6	Reduce the risk of short-term disability or unplanned releases to the environment. Low concentrations of hazardous materials.
4	No effect.
0	Negative effect.

	Employee Health & Safety -- Health or safety risk to an employee, contractor, or visitor.
10	Reduce the risk of loss of life through an accident or long-term exposure.
8	Reduce the risk of permanent or long-term disability through an accident or long-term exposure.
6	Reduce the risk of short-term disability or lost-time through an accident or long-term exposure.
4	No effect.
0	Negative effect.

	Regulatory Compliance -- Risk of non-compliance to regulatory laws with respect to employees or managers.
10	Reduce the risk and avoid criminal penalties.
8	Reduce the risk and avoid civil penalties.
6	Reduce the risk.
4	No effect.
0	Negative impact.

	Economic -- Potential for cost savings and payback period.
10	Large savings and short payback.
8	Moderate savings and moderate payback.
6	Positive cost savings and extented payback.
4	No cost savings and no possibility of payback.
0	Negative cost savings.

	Implementation Period -- Potential for rapid implementation of pollution prevention options.
10	Immediate (e.g., within 1 month).
8	Short-term (e.g., within 1 year).
6	Intermediate (e.g., within 2 years).
4	Long-term (e.g., within 3 years).
0	Greater than 3 years.

	Improved Operation / Product -- Quality improvement to process or product.
10	Significant improvement.
8	Moderate improvement.
6	Positive improvement.
4	No improvement.
0	Negative effect.

Worksheet 9 -- (Scale & Multiplier Definitions)

Multiplier Definitions (0-1)

	Likelihood of Technical Success
1	High likelihood: No major technical breakthrough required. Well-designed plans to meet objectives and successful track record exists.
0.5	Medium likelihood: Technical advancements may be necessary. Key issues are identified but no specific contingency plans have been made.
0.1	Low likelihood: Major technical breakthroughs are required. Adequate plans for meeting objectives or key problems have not been identified.

	Likelihood of Useful Results
1	High likelihood: Project has demonstrated that it can meet production requirements. There is a high confidence that implementation will not create unacceptable risks. Benefits outweigh the costs.
0.5	Medium likelihood: Project has not yet demonstrated that it can meet production requirements. There are reservations that implementation can be achieved without creating unacceptable risks. Benefits do not clearly outweigh the costs.
0.1	Low likelihood: The option is not capable of demonstrating that it can meet production requirements. Serious reservations are present that implementation can be achieved without creating unacceptable risks. Costs significantly outweigh the benefits.

Worksheet 10

Level III

Revision No.:______
Revision Date:______
Page _____ of _____

Pollution Prevention Opportunity Assessment

Final Report Check Sheet

PPOA Title or PPOA ID Code(s): ______________________________

Requirement	***Completed***
Title Page	_____
PPOA Title	
PPOA ID Code(s)	
Team members	
Issue date/revision date/revision no.	
Executive Summary	_____
Process description	
Process assessment	
Option summary and analysis	
Conclusions	
Recommendations	
Introduction	_____
Background of evaluation	
Process Description	_____
Associated equipment	
Process flow diagram	
Process Assessment	_____
Methodology	
Material Balance	
Unusual occurrences	
Option Summary and Analysis	_____
Option description and rank	
Upstream/Downstream impacts	
Material usage	
Anticipated reduction	
Estimated costs	
Estimated benefits	
Feasibility	
Waste streams affected	
Conclusion	_____
Concluding evaluation	
Option analysis decisions	
Concerns	
Options already implemented	
Lessons learned	
Recommendations	_____
Future work	
New equipment	
Implementation strategies	
Worksheets	_____
1-10	

Worksheet 10

A final report is required for each PPOA. The final report is a compilation of essential facts about the process, pollution prevention options, feasibility and impact of those options, and future implementation costs. The report documents the work performed and identifies funding requirements necessary to implement pollution prevention options. The length of the final report will depend on the complexity of the PPOA.

1. Revision No.: List the revision number for this worksheet.

2. Revision Date: List the most recent revision date for this worksheet.

3. Page____of____: Indicate the number of this page and the total number of pages for this worksheet.

4. PPOA Title or PPOA ID Code(s): List the PPOA Title or PPOA ID Code(s) given on Worksheet 1.

5. While writing the final report, check the blank next to each major **requirement** as all elements of that task are **completed**.

Title Page	Uniquely identify the PPOA, including team members and issue/revision date.
Executive Summary	This should be an overview of all of the elements of the final PPOA report. It should relate to the reader any information that is critical about this PPOA.
Introduction	Present background information and efforts taken to initiate the PPOA.
Process Description	Detail process flow and associated equipment. Include process flow diagram, if desired.
Process Assessment	Describe the approach used to complete the PPOA. Document any assumptions made. Include information on the material balance.
Option Summary & Analysis	Present the options generated, impacts if implemented, and their respective pollution prevention possibilities.
Conclusion	Provide closure to the report. The team's consensus on the benefits achieved from this PPOA or any concerns respective to the process should be included.
Recommendations	Describe any actions that will be taken to further advance the results of this PPOA.

Worksheet 1S

Level I

Date: ________

Page ______ of ______

Pollution Prevention Opportunity Assessment

Team & Process Description

Title:

PPOA ID Code:

Team Members (*Leader)	Job Classification	Phone
*		

Process Description:

Potential for Pollution Prevention or Recommendations:

Worksheet 1S

This worksheet provides the scope and identification of the pollution prevention opportunity assessment (PPOA) team. For the PPOA to be successful, employees involved with the activity being assessed should be members of the team. The assessment team needs a leader, members, and additional resources, as required.

The team leader should have technical knowledge of the area's operations and the personnel involved. The leader shall assemble the team to perform the assessment. Team members may include engineers, waste generators, waste management specialists, scientists, laboratory technicians, and other line personnel. Additional resources may be utilized to provide information not available within the team. The size of the team may be large for complicated operations, but should be kept to a minimum to maintain focus.

1. **Date:** List the initiation date for this PPOA.

2. **Title:** List the PPOA title selected by the team.

3. **PPOA ID Code:** List the PPOA ID Code selected by the team. This should be a unique identifier.

4. **Team Members, Job Classification, Phone:** To facilitate team meetings and for future reference, this information should be completed when the PPOA team is formed.

5. **Process Description:** This should detail important attributes of the operation. Equipment, summary of operations performed, controls, input materials, and operator training (qualification or certification) may be included.

6. **Potential for Pollution Prevention or Recommendations:** For this process, describe the potential for pollution prevention, source reduction, and/or waste minimization. (Is there any pollution prevention potential for the following changes: material substitution, procedures, process parameters, equipment, general practices, recycling, reuse, reclamation, etc.?) Are there any recommendations for this process?

Worksheet 2S

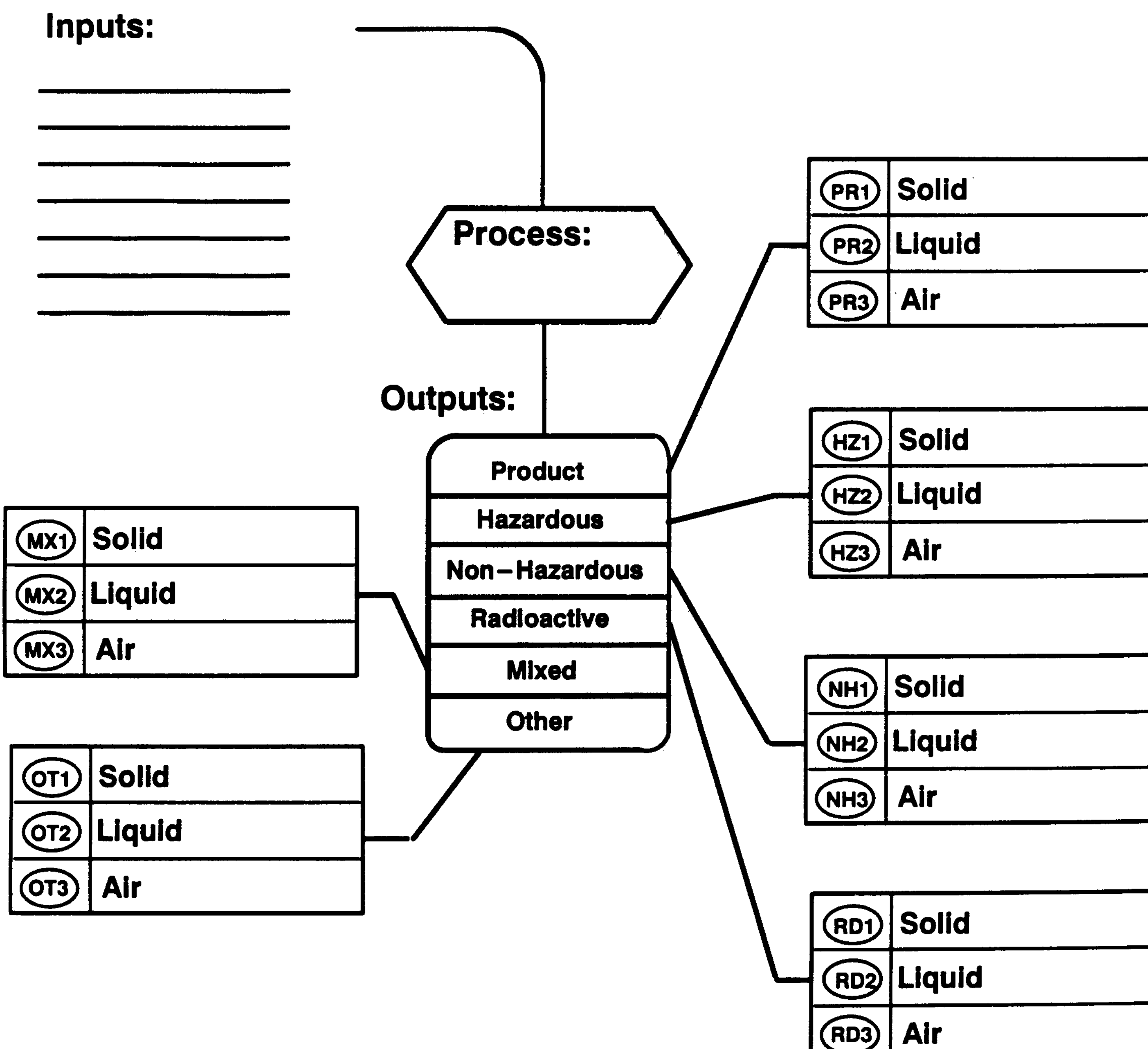
Level I

Date: ______

Pollution Prevention Opportunity Assessment

Process Flow Diagram

Title or Assessment ID Code: ______________________________



Worksheet 2S

This worksheet provides a method to document the process flow diagram for the assessment. The flow diagram should identify all Assessment Code(s) associated with the process, all input materials, and outputs (products/wastes). The flow diagram should track materials from the time they enter the process boundary until they leave. This diagram represents a very simplistic flow model; a more detailed diagram may be required to identify all waste streams, especially for complex, multi-step processes.

1. **Title or Assessment ID Code(s)**: List the PPOA Title or PPOA ID Code given on Worksheet 1S.

2. **Page ____of ____:** Indicate the page number for this worksheet and the number of pages for this worksheet.

3. **Inputs**: List the input materials on the lines provided. Fill in the Process Name box. Then highlight those outputs that are applicable to the process (e.g. Product, Hazardous, etc.). Then sub-categorize those outputs into solid, liquid, or air emission streams by highlighting the corresponding output stream. A **Stream ID Code** is provided for each sub-category of waste.

4. **Outputs:** The Stream ID Code provides a uniform coding scheme for the release information. A brief waste description may be recorded in the box to the right of the Stream ID Code. The code information is summarized in the table below:

Stream ID Codes

Designator	Code
Product	PR
Hazardous	HZ
Non-Hazardous	NH
Radioactive	RD
Mixed	MX
Other	OT

Solid Stream = 1, Liquid Stream = 2, Air Stream = 3

Worksheet 3S

Level I

Page ______ of ______

Pollution Prevention Opportunity Assessment

Material & Waste Stream Summary

Title: ______________________________

PPOA ID Code: ______________________________

Input Material	Annual Quantity Used	% Product	% Recycled	Total Releases		
				% Air	% Liquid	% Solid

Does the process require further analysis based on the site's Priority Material/Waste Stream List?

Yes ________ **No** ________

Level II ________ **Level III** ________

Worksheet 3S

This worksheet provides a brief summary of the input materials and output streams from the operation or activity being assessed. Its purpose is to provide the pollution prevention team an overview of the waste streams resulting from the PPOA.

1. **Title:** List the PPOA title given on Worksheet 1S.

2. **Assessment ID Code:** List the PPOA ID Code given on Worksheet 1S.

3. **Input Material:** List the material names which enter the operation.

4. **Annual Quantity Used:** Enter the annual quantity used for each material listed - include the unit of measure, e.g., lbs, curies, etc. For input material from another process, it may be helpful to also identify the release components of those materials.

5. **% Product:** For each input material, estimate the percent of the annual quantity used which goes to product.

6. **% Recycled:** For each input material, estimate the percent of the annual quantity used which is recycled.

7. **% Air:** For each input material, estimate the percent of the annual quantity used which is an air waste stream.

8. **% Liquid:** For each input material, estimate the percent of the annual quantity used which is a liquid waste stream.

9. **% Solid:** For each input material, estimate the percent of the annual quantity used which is a solid waste stream.

10. **Does the process require further analysis based on the site's Priority Material/Waste Stream List?** Using your site's Priority Material/Waste Stream List and the DOE Graded Approach Logic Diagram, determine if further assessment is necessary. If yes, indicate the level of assessment required.

Worksheet 4S

Level II

Pollution Prevention Opportunity Assessment

Option Summary

Title or PPOA ID Code(s) ____

____

Option No. __: ____

____

____

____

____

Type (*)	Consider?	Feasibility	Estimated Cost	Estimated Savings	Anticipated Reduction Qty

Option No. __: ____

____

____

____

____

Type (*)	Consider?	Feasibility	Estimated Cost	Estimated Savings	Anticipated Reduction Qty

Option No. __: ____

____

____

____

____

Type (*)	Consider?	Feasibility	Estimated Cost	Estimated Savings	Anticipated Reduction Qty

(*) Type = Source Reduction, Recycling, Treatment, or Disposal

Worksheet 4S

This summary sheet serves as a method to record and evaluate the options that have been identified during brainstorming sessions or other option generating techniques.

1. **Title or PPOA ID Code(s)**: List the PPOA Title or PPOA ID Code given on Worksheet 1S.

2. **Option :** Options generated should be numbered consecutively. Briefly describe each option, affected materials, waste streams, upstream/downstream impacts if implemented, and anticipated reduction quantity if implemented.

3. **Type:** Indicate whether the option is source reduction, recycling, treatment, or disposal.

4. **Consider?:** If the option is worth further consideration, enter YES. If not, enter NO and briefly indicate in the Option Description why not.

5. **Feasibility**: Provide a brief description. (Excellent, good, fair, poor)

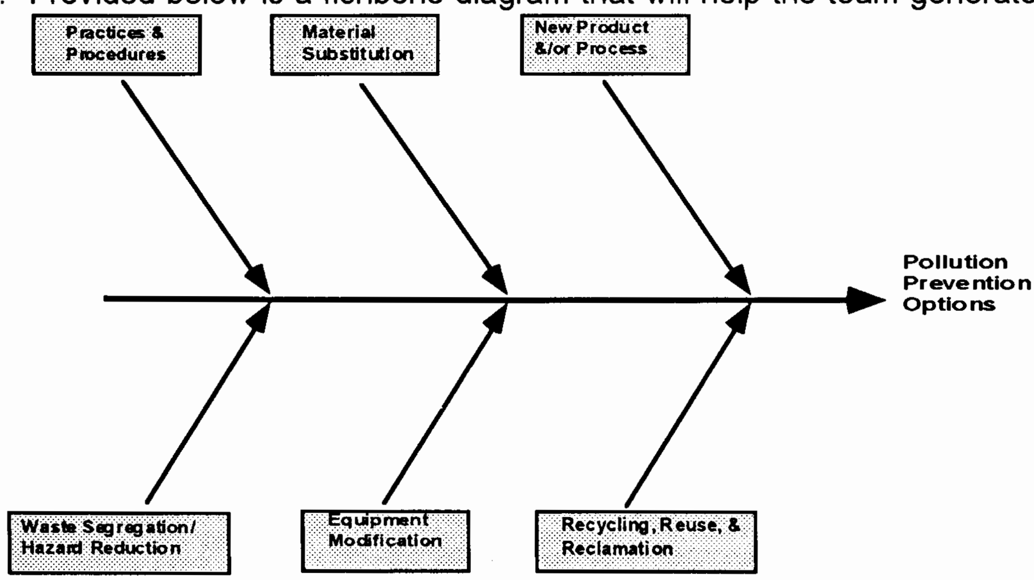
6. **Estimated Cost**: Estimate an implementation cost.

7. **Estimated Cost Savings**: Estimate the cost savings.

8. **Anticipated Reduction Qty.**: Estimate the weight or volume of the waste that will be reduced.

Note: Typically, it is difficult to estimate the anticipated waste reduction or cost avoidance in the initial phases of implementation because of many factors. However, for some options, especially in cases where the option provides complete elimination of a hazardous material or waste stream, these estimates can be accurately completed.

The process by which options are identified should occur in an environment that encourages creativity and independent thinking. Brainstorming sessions are effective ways for individuals to generate options. To make these sessions beneficial, research is often necessary. Provided below is a fishbone diagram that will help the team generate ideas.



Worksheet 5S

Level II

Date: __________
Page ______ **of** ______

Pollution Prevention Opportunity Assessment

Final Summary

Title: ______________________________

PPOA ID Code(s): ______________________________

Assessment: ______________________________

Conclusions: ______________________________

Recommendations: ______________________________

Worksheet 5S

This sheet provides a brief summary of other pertinent information about the activity being assessed. Its purpose is to document how this assessment was performed, the conclusions reached by the team, and the recommendations for further actions.

1. **Date:** List the date this sheet was completed.

2. **Title:** List the title given on Worksheet 1S.

3. **PPOA ID Code(s):** List the ID Code(s) given on Worksheet 1S.

4. **Assessment:** Briefly describe the approach (methodology) used to complete this assessment and any assumptions made.

5. **Conclusions:** Briefly describe the waste streams or input material to be minimized, benefits achieved from this assessment, and any concerns (environmental or health risks) associated with the material or operation.

6. **Recommendations:** Briefly describe any actions that should or will be taken in respect to this assessment.

APPENDIX H

REFERENCES

1. U.S. Department of Energy, *General Environmental Protection Program*, DOE Order 5400.1 (November 9, 1988).

2. U.S. Department of Energy, *Hazardous and Radioactive Mixed Waste Program*, DOE Order 5400.3 (February 22, 1989).

3. U.S. Department of Energy, *Radioactive Waste Management*, DOE Order 5820.2A (September 26, 1988).

4. U.S. Department of Energy, *Environmental Restoration and Waste Management Five-Year Plan*, DOE/S-0070 (1989).

5. U.S. Department of Energy, *Applied Research Development, Demonstration, Testing and Evaluation Plan* (Draft) (November 1989).

6. U.S. Department of Energy, *Model Waste Minimization and Pollution Prevention Awareness Plan* (1990).

7. U.S. Department of Energy, *Process Waste Assessment Guidance* (ISO).

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United States
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Agency

Office of Research and
Development
Washington, DC 20460

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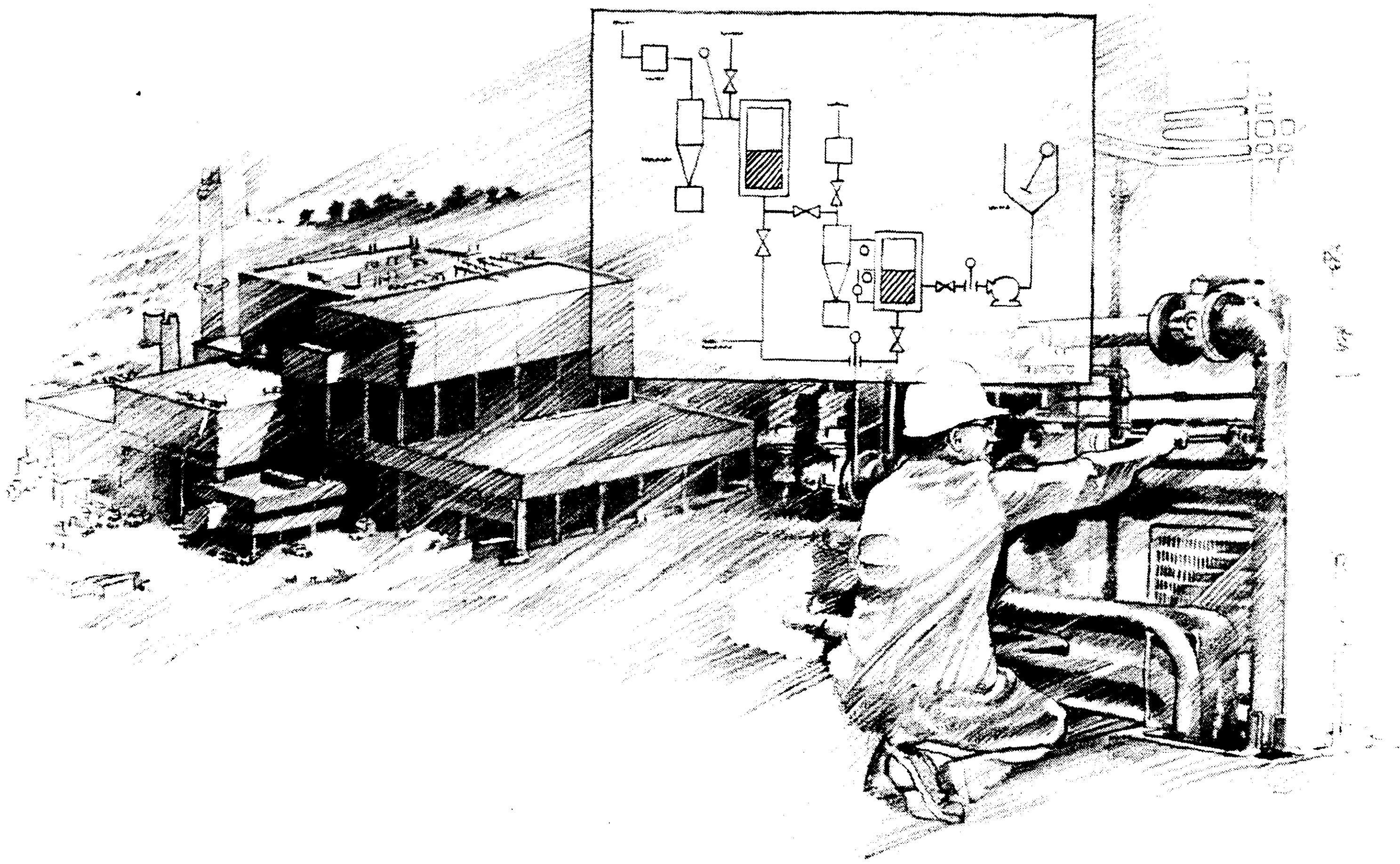
Facility Pollution Prevention Guide



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APPENDIX

FIGURES

LIST OF ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygienists
DOE	Department of Energy
EPA	Environmental Protection Agency
ES&H	Environmental, Safety, & Health
MNCAW	Materials Not Categorized As Waste
MSDS	Material Safety Data Sheet
NPDES	National Pollutant Discharge Elimination System
ODC	Ozone Depleting Compound
OSHA	Occupational Safety and Health Administration
PCB	Polychlorinated biphenyl
PM/WSL	Priority Material/Waste Stream List
POTW	Publicly Owned Treatment Works
PPOA	Pollution Prevention Opportunity Assessment
PWA	Process Waste Assessment
VOC	Volatile Organic Compound
WMin/PP	Waste Minimization/Pollution Prevention

ACKNOWLEDGMENT

In July, 1988, DOE Defense Programs recognized the need for a waste minimization program that would focus beyond pollution control and the traditional media-by-media approach to containment and treatment of environmental releases. Defense Programs was proactive in initiating a Waste Minimization Program that included the completion of process waste assessments as a means to identify opportunities which would reduce the generation of waste.

The Waste Minimization Program evolved to a Pollution Prevention Program through the auspices of the DOE Defense Programs' Pollution Prevention Strategic Plan issued in April, 1992. The Strategic Plan reiterated the hierarchy of preferred environmental practices outlined in the Pollution Prevention Act of 1990 (i.e. source reduction, recycling, treatment, and finally, disposal).

The first Model PWA Guidance was assembled by Defense Programs' contractors based on the published EPA guidance and previous work performed at the Y-12 Plant. The manual was originally issued in February 1990, and distributed throughout the Weapons Complex. This is the first revision to the document, and it replaces the term "PWA" with a more positive term, "Pollution Prevention Opportunity Assessment". The new term avoids the implication that assessments should be limited to process wastes, rather, they should address all releases.

The following DOE personnel and DOE contractors assisted in the suggestions for this revision. Their time and effort were greatly appreciated.

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I. INTRODUCTION

A. PURPOSE OF GUIDANCE

The purpose of this document is to provide a guide for DOE sites to conduct pollution prevention opportunity assessments (PPOAs), commonly known through the DOE as process waste assessments (PWAs). This will avoid the implication that assessments should be limited to process wastes - PPOAs address all releases. This guidance describes those activities and methods that can be employed to characterize all waste generating processes and identifies opportunities to reduce or eliminate waste generation. The document also includes a methodology to evaluate proposed modifications to site processes and other options to minimize waste and prevent pollution.

B. GUIDANCE SCOPE AND OBJECTIVES

PPOAs will be conducted as part of an ongoing program to identify opportunities to eliminate or reduce the generation of waste. A PPOA documents the amount of material that is disposed of as waste during operations. It provides a summary of material usage, process by-products, and waste generation; and it targets those processes and operations that need to be improved or replaced to promote waste minimization and pollution prevention. The assessment also establishes a basis to prioritize modifications to site processes or other pollution prevention options that are developed during the assessment.

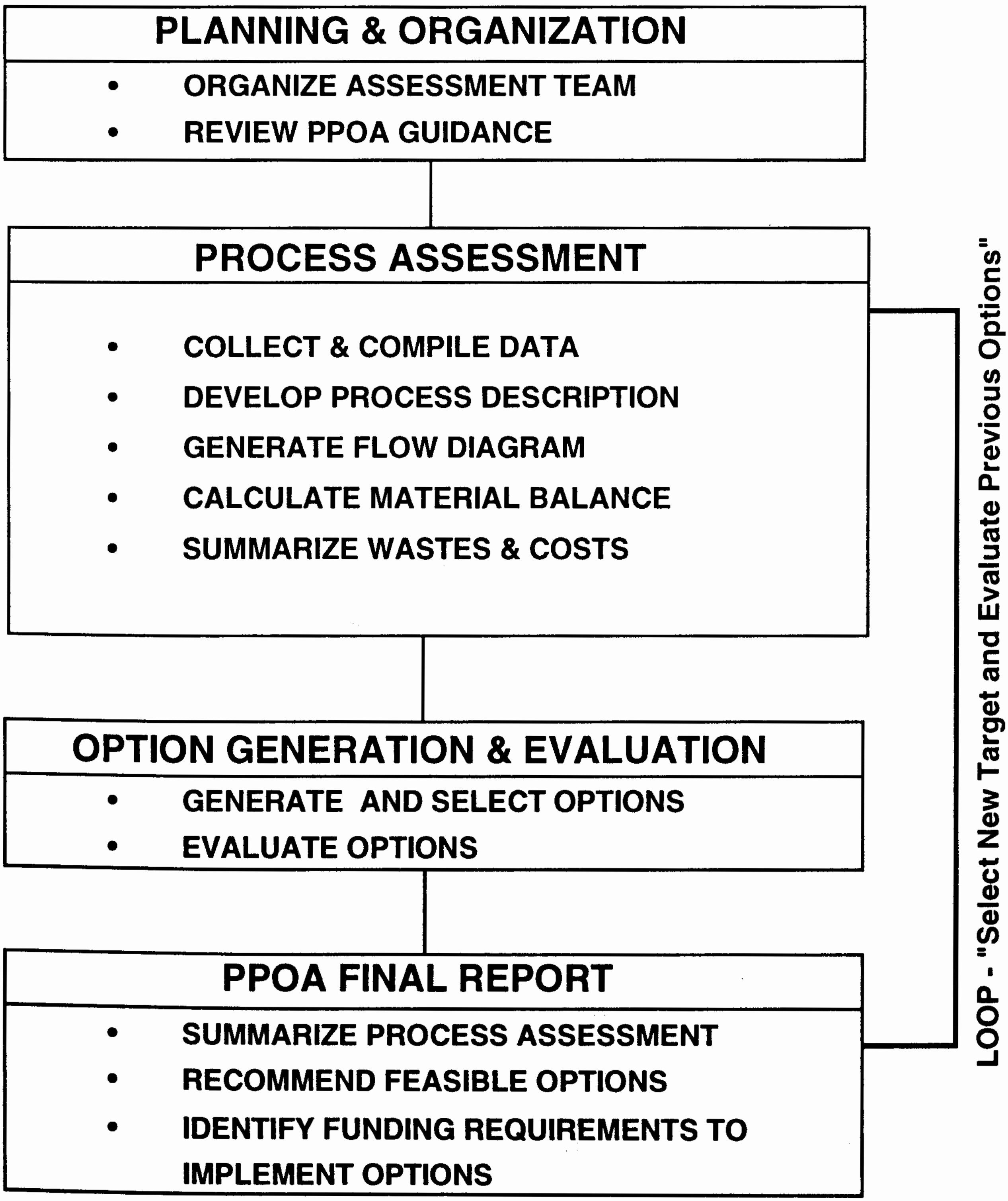
The objective of a PPOA is to document a facility's processes, operating procedures, and waste streams in a manner that will permit the identification of the best improvements to avoid or minimize waste generation. This guide shall not be used as an audit tool. The assessment consists of a systematic approach which may include the following:

- GRADED APPROACH LEVEL DETERMINATION
- ORGANIZATION OF PPOA TEAMS
- ASSESSMENT OF PROCESSES AND WASTE STREAMS
- DEVELOPMENT AND EVALUATION OF POLLUTION PREVENTION OPTIONS
- RECOMMENDATIONS OF POLLUTION PREVENTION OPTIONS & FINAL REPORT

A step-by-step process for completing a PPOA is shown in Figure 1. These steps are sequential and should be performed in that order for best results.

POLLUTION PREVENTION OPPORTUNITY ASSESSMENT FLOW CHART

FIGURE 1



II. GRADED APPROACH

A. INTRODUCTION

The DOE Complex is comprised of numerous sites located in many different states. These facilities range from single-mission to multiple-disciplinary facilities, and vary in size from quite small to very large. The facilities as a whole represent a tremendous diversity of technologies, processes and activities. Due to this diversity, there is also a wide variety and number of waste streams generated. Many of these waste streams are small and intermittent, and not of consistent composition. The value added of detailed analysis for individual, small waste streams is often not sufficient to justify the cost, nor is the analysis necessarily meaningful since many of these waste streams are constantly changing.

Although waste minimization activities have been implemented at DOE sites, these efforts are not being sufficiently documented. A DOE survey of PPOA activities across several sites indicated that these waste minimization practices need to be documented so that waste generation baselines can be more accurately established. Furthermore, the documentation can ensure that the site receives credit for accomplishing waste minimization.

The PPOA Graded Approach addresses these complexities and recognizes that processes vary in the quantity of pollution they generate, as well as in the perceived risk and hazards associated with an operation. It also recognizes the variance due to the cost and function of the final product. Therefore, the graded approach is intended to provide a **cost-effective** and **flexible** methodology which allows individual sites to prioritize their local concerns and align their efforts with the resources allocated, while also providing some consistency throughout the DOE to perform PPOAs. In order to achieve this, the approach has defined three levels of effort to satisfy the requirement of completing a PPOA. This section documents the minimum amount of effort required, Level I, Activity Characterization, and provides a systematic approach using the Weighted Sums Evaluation to determine if additional and more detailed analysis should be conducted for either a Level II, Informal Assessment, or a Level III, Formal Assessment.

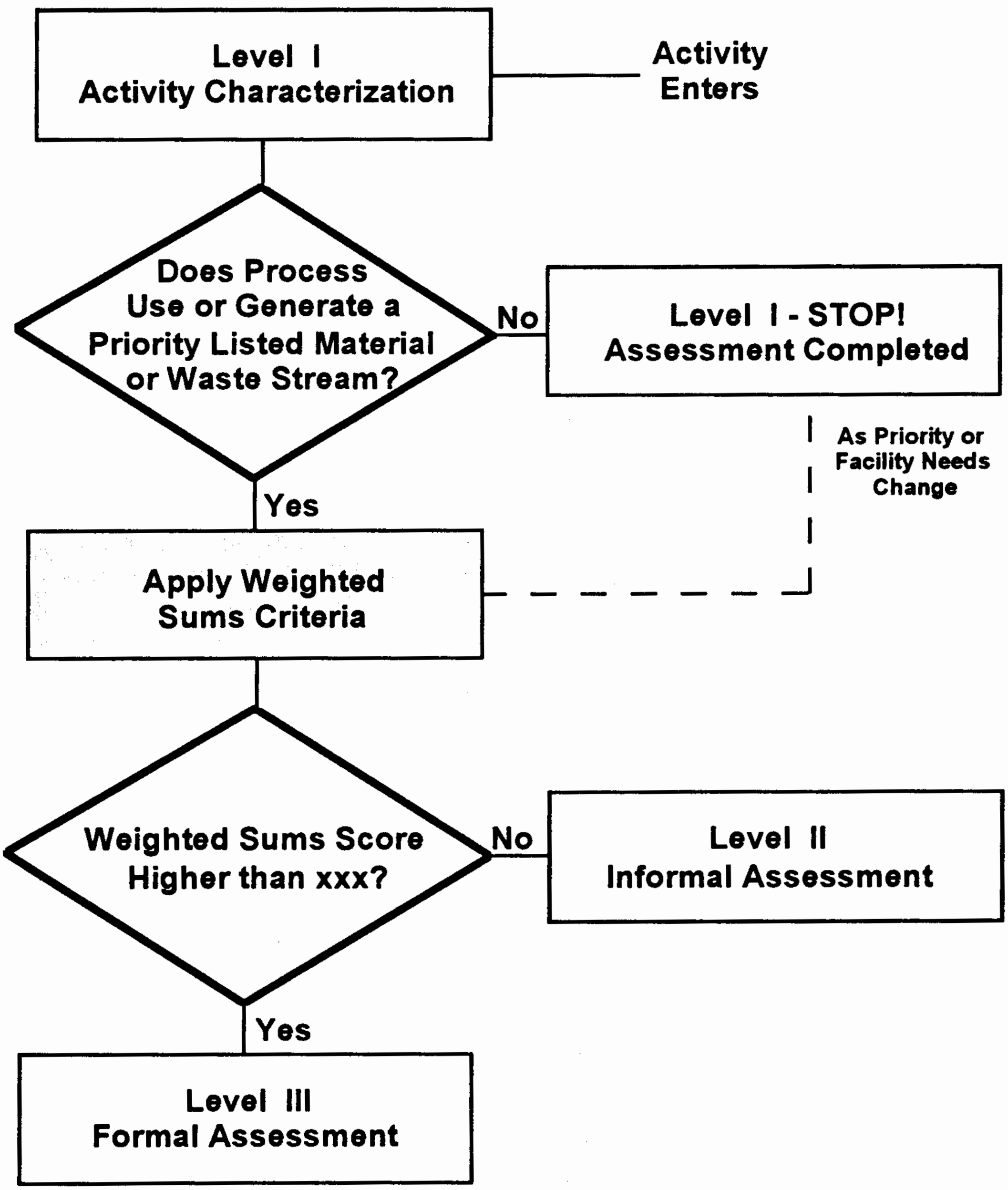
If used properly, the graded approach will allow a site to concentrate its shrinking resources on the most important waste problems first. While all of the site's waste streams and processes will be assessed, the most critical areas will be assessed first and to the greatest extent.

B. GRADED APPROACH LOGIC DIAGRAM & PRIORITY MATERIAL /WASTE STREAM LIST

Figure 2, the Graded Approach Logic Diagram, illustrates graphically how the graded approach methodology works. The diagram starts at the top with the Level I, minimum effort assessment and works down to an informal and/or formal assessment. The methodology shown in the logic diagram allows flexibility and provides a consistent

FIGURE 2

Pollution Prevention Graded Approach Logic Diagram



structure. A site must develop the priority material / waste stream list (PM/WSL) to use the graded approach. This list is not limited to the requirements specified below but can include any other additional concerns. (See Appendix A for an additional list of considerations.) The priority list provides the site an opportunity to identify their individual regulatory and/or prioritized needs to cost-effectively determine if additional, more detailed analysis is necessary. DOE has established requirements and suggestions for this list as follows.

PRIORITY MATERIAL / WASTE STREAM LIST

Required or Mandatory PM/WSL:

- Waste of any amount for which an approved disposal method does not exist (i.e., mixed wastes, classified waste, etc.)
- Waste which is equal to 5% or more of the facility's total waste stream (Total waste = Manifest records (Hazardous) + Radioactive + Mixed)
- Clean Air Act, Class I Materials (ODCs - Ozone Depleting Compounds)
- EPA's 33/50 Materials
- Known Human Carcinogens (ACGIH, Type 1)

Suggested Additions to PM/WSL:

- Federal, State, & Local Requirements
- Permitted Waste & Materials (e.g., VOCs, NPDES, POTW, etc.)
- Site Health Risks for Hazardous Materials & Hazardous Wastes (e.g., OSHA - Suspect carcinogens, teratogens, explosives, PCBs, Asbestos, etc.)
- Municipal Solid Waste
- Materials Not Categorized As Waste Inventory (MNCAW)

C. LEVEL I - ACTIVITY CHARACTERIZATION

Level I, Activity Characterization, requires a minimal amount of descriptive, quantitative, and qualitative information to document each of the facility's processes and activities which are defined as "Any existing or planned operation or activity (including remediation projects) which generates waste or pollution to the air, land, or water." In gathering this information, the facility begins the initial step to determine whether any waste reduction or pollution prevention opportunities exist. The collection of this information will also provide the basis to determine whether or not any of the facility's

processes/activities necessitate further analysis per the graded approach methodology. Therefore the principle objectives of Level I are to:

- define the process,
- document Waste Minimization / Pollution Prevention (WMin/PP) activities (past or current),
- determine the level of effort that should be performed for a cost-effective Pollution Prevention Opportunity Assessment Program, and
- provide information to determine if more analysis is necessary.

Level I Required Documentation

1. A brief process description / simple flow diagram;
2. A quantitative estimate of the material inputs, products, by-products, and wastes;
3. A preliminary evaluation of WMin/PP potential; and
4. A decision to determine if further analysis is necessary.

Level I process assessments will establish the site's baseline of operational information. These process/activity descriptions should include input materials, process products, by-products and/or waste generated. Identification of these elements and estimates of quantities is made using the best available information source, or combination of sources. Possible information sources are listed in Appendix B.

In addition to the descriptive information, the potential for WMin/PP can be initially evaluated based on the activity or process expert's knowledge. These recommendations should be included in the Level I documentation. If opportunities do exist and are easily implemented, then the actions taken or planned to be taken should be documented. Furthermore, for WMin/PP options identified and implemented, upstream / downstream impacts should also be included in the documentation.

After collecting the process/activity information, it is necessary to determine whether the process/activity continues to a Level II or III analysis as defined by the graded approach logic diagram and the site's priority material / waste stream list.

If the process does not contain any of the materials or waste streams on the priority list, then the Level I documentation satisfies the PPOA requirement. Conversely, those processes/activities which are captured by the site's priority list are included in the Weighted Sums Evaluation to determine the next level of effort to be performed.

A completed example Level I Activity Characterization is shown in Appendix C. PPOA Worksheets 1S-3S can be used to document the information required in a Level I assessment.

D. GRADED APPROACH WEIGHTED SUMS EVALUATION

The graded approach methodology continues when the site selects a core team to determine which processes require Level II and Level III assessments. The core team

should be cross-functional and consist of key site personnel with knowledge about the site's processes, waste management, and regulations. The team's objectives are to assign weights to the criteria, to determine the numeric value that distinguishes a Level II from a Level III, and to provide consistency in scoring across processes. The form to aid in this evaluation (weighted sums) is shown in Figure 3. (Appendix D contains the weighted sums form, criteria, and instructions.) First the site assigns a weight to each criteria listed in the first column of the weighted sums. Then, for each process being evaluated, the team determines a scale for the five listed criteria and a multiplier. From the products and sums, a total point value is assigned. Finally, the team determines the cut-off value for which Level II assessments will be completed versus Level III assessments. Processes identified by the Weighted Sums Evaluation which require a Level III, Formal Assessment, are those processes that are critical to the site's priorities and would benefit by the allocation of resources to examine how to best implement pollution prevention technologies to these critical areas.

E. LEVEL II - INFORMAL ASSESSMENT

After completing the Graded Approach Weighted Sums Evaluation, the facility has distinguished which processes/activities require the Level II, Informal Assessment. The principal objectives of Level II are to:

- develop and screen WMin/PP opportunities and
- recommend viable options for implementation.

This level of effort does not require the collection of new data. Much of the documentation has already been completed in the Level I assessment. However, due to some aspect of the process, the facility needs to further explore the WMin/PP opportunities available to reduce the quantity of waste or the risk/hazard associated with the operation.

<u>Level II Required Documentation</u>

{1.} Brief process description / simple flow diagram;
{2.} Quantitative estimate of the material inputs, products, by-products, and wastes;
{3.} Preliminary evaluation of WMin/PP potential;
4. WMin/PP options identification and evaluation;
5. Consideration of potential upstream / downstream impacts; and
6. Recommendations for option implementation.

{} - denotes those items already completed in Level I, Activity Characterization

Further suggested reading for Level II information can be found in sections IV: A-C and V: A-B. A completed example Level II, Informal Assessment, is shown in Appendix E. PPOA Worksheets 1S-5S can be used to complete the requirements of a Level II assessment.

Date: ________

Page ______ of ________

FIGURE 3
Pollution Prevention Opportunity Assessment Graded Approach

Weighted Sums Evaluation

Evaluation Criteria	Weight 'W'	Process: ____ Scale 'S'	'WxS'	Process: ____ Scale 'S'	'WxS'	Process: ____ Scale 'S'	'WxS'	Process: ____ Scale 'S'	'WxS'	Process: ____ Scale 'S'	'WxS'
Environmental, Safety, & Health Hazards	Site Assigns										
Quantity of Waste Generated	" "										
Site Liabilities	" "										
Economic Factors - Process & Waste Costs (Unit &/or Annual)	"										
Process By-Product Management	" "										
Other											
Subtotal											
WMin/PP Potential Multiplier		x		x		x		x		x	
Total											
PPOA Level											

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F. LEVEL III - FORMAL ASSESSMENT

In addition to the information completed in the Level I assessment, the Level III requires considerably more documentation to complete the PPOA. For example, both the process description and a corresponding block flow diagram are required to illustrate the basis of generation. The use of narratives, calculations, photographs, illustrations, figures and/or data sufficient to convey an understanding of the process are certainly recommended. The Level III assessment also requires collection of quantitative data for a material balance. A material balance should be completed to account for all waste generated. This information, if not already available, may need to be tracked to accurately establish the current process waste generation information necessary to complete the WMin/PP options analysis.

The primary objectives of the Level III Assessment are to:

- conduct a detailed analysis of the process for WMin/PP opportunities and
- document the results of the process evaluation in a written report.

Level III Required Documentation

{1.} Brief process description / simple flow diagram;
{2.} Quantitative estimate of the material inputs, products, by-products, and wastes;
{3.} Preliminary evaluation of WMin/PP potential;
4. Process description;
5. Flow diagram;
6. Material balance;
7. WMin/PP options identification;
8. Analysis of WMin/PP options generated: economic, technical, upstream / downstream impacts, and other benefits;
9. Prioritized list of options; and
10. Formal report with documentation and recommendations for option implementation.

{} - denotes those items already completed in Level I, Activity Characterization

A completed example Level III, Formal Assessment, is shown in Appendix F.

The following sections of this guidance describe the details necessary to achieve the requirements of a Level III, Formal Assessment. Each of these sections can also be used as a reference for the information required in the Informal Assessment and Activity Characterization, Levels II and I, respectively. Blank Model Worksheets have been included in Appendix G to help guide a team through the PPOA requirements. They are only suggested forms - they are not requirements. A site may prefer to modify them to fit their individual site needs. Model PPOA Worksheets 1-10 were developed for the Level III assessment, PPOA Worksheets 1S-3S were developed for Level I, and Worksheets 1S-5S were developed for a Level II.

III. POLLUTION PREVENTION OPPORTUNITY ASSESSMENT TEAMS

The Waste Minimization and Pollution Prevention Awareness Program Plan states that assessments of all waste-generating operations at the site will be conducted by PPOA teams. The team leader should have the authority to complete the assessment, line responsibility, familiarity with the site's process and waste management operations, and proven technical and problem-solving abilities (e.g. Value Engineering Specialist).

The remainder of each assessment team should be drawn from line staff, or subcontractor organizations that can furnish the type of specialized expertise that will be needed to conduct the assessment. Each PPOA team should consist of a small core of individuals familiar with the site's operations, who will direct the assessment efforts and guide the data gathering. The careful selection of personnel to conduct the assessment is essential. Experienced people familiar with the site's operations are crucial to completing an accurate and timely assessment. Subsets of this team are satisfactory for Levels I and II of the graded approach. Other personnel with specialized skills will be used on a part-time, as-needed basis. Each team may include members who have knowledge in the following areas:

- process operations;
- federal, state, and local hazardous waste statutes and regulations;
- operation and waste minimization principles and techniques;
- quality control requirements;
- purchasing procedures;
- material control/inventory procedures; and/or
- value engineering skills.

Model Worksheets 1 and 1S can be used to record the PPOA team members and the assessment title and identification (ID) code. The PPOA ID Code should be unique for each PPOA at the site. For uniformity, the site should determine the structure of this code.

PPOA team leaders should receive training on the procedures, methodologies, techniques and documentation requirements for PPOAs before the assessments are conducted. The team leader needs to have clear authority from the WMin/PP Coordinator or line management to select other team members, obtain support services, and to direct the efforts of the assessment team in its interaction with operating personnel. The team should be given unrestricted access to all facility personnel and information that may, in the team's estimation, be relevant to the assessment.

IV. ASSESSMENT OF PROCESSES AND WASTE STREAMS

A. INITIAL DATA GATHERING

For each assigned process, the PPOA team begins with gathering data about that process and associated waste streams. The boundaries of the process must be established. The team should consider the following process boundary criteria: (1) the process must have a distinct starting and ending point, (2) the process input materials must be accounted for, (3) the time frame must be considered, and (4) the process must be manageable - an appropriate size to collect information and provide focus. The team will collect information through interviews and the review of process documents that will permit a thorough understanding of the process to be assessed and the development of a written analysis on how that process generates waste (see Appendix B for sources of additional information). The team should also visit the process areas to witness how the process is conducted and to validate the written information that has been collected.

Each PPOA team should develop and/or collect information as defined in the graded approach level. The following assessment tools may be used:

- process descriptions,
- process flow diagrams,
- material balances, and/or
- waste stream characterizations for assessment area or process.

Additional guidance may be found in the EPA *Facility Pollution Prevention Guide* (Reference #8 of Appendix H) to complete the PPOA.

PPOA team members may identify ways to reduce waste during the data collection phase. It is at this point that observations about operations, schedules, and procedures can be noted which may easily be changed to prevent waste. These changes can have a wide impact. The knowledge and experience of team members and their colleagues will help to develop these ideas into potential options. The team members should also make effective use of technical literature from equipment vendors and trade associations; the experience of plant engineers, operators, and consultants; and the databases available from environmental agencies.

B. PROCESS DESCRIPTION

The PPOA will include a general description of each process step in the waste generating operation. The narrative should describe the following:

- purpose of the process;
- material and equipment used in the process;
- equipment layout;
- personnel and their experience / training level; and
- products, by-products, and waste streams generated.

Model Worksheets 2 and 2S can be used to complete the process description. Chemicals and other materials purchased or otherwise introduced into the process should be identified. The description should also include other information that adequately describes the process and may be relevant to WMin/PP planning. For example, process or product specifications, requirements, assumptions, and upstream and downstream impacts may have a critical bearing on waste generation and should be included in the description.

To further understand the process, the team may perform a function analysis as explained in the DOE/Defense Program's *Prioritization of Pollution Prevention Options Using Value Engineering* (Reference #13 of Appendix H). The principal objective of function analysis is to discover the basic purposes of a process in contrast to its secondary or support uses. It aids the team in determining the process' primary functions and in minimizing or eliminating secondary functions which, in turn, may produce unnecessary wastes. The function analysis can help answer the question as to whether this process is actually necessary.

C. PROCESS FLOW DIAGRAM

The analytical work of the waste assessment effort starts with the development of a simple process flow diagram for the operation being assessed. The requirement for this flow diagram is based on the maxim that a picture is worth a 1000 words. It is also the foundation upon which the material balance is built. The process flow diagram should identify the major steps within an operation and diagram the flow of materials into and out of each step during the process. The diagram should indicate the following:

- process steps,
- material inputs, and
- process outputs (e.g., product, by-products and waste streams).

The diagram should also characterize the streams according to the nature of the release and waste classification, including but not limited to the following:

- air,
- liquid,
- solid,
- radioactive,
- mixed,
- hazardous, and/or
- non-hazardous.

Model Worksheets 3 and 2S can be used for the completion of the process flow diagram. There are three styles to chose from for Model Worksheet 3 depending on the complexity of the analysis and whether radioactive materials and waste streams are involved.

D. MATERIAL BALANCE

The PPOA shall account for all input materials that enter the process which are either consumed, transferred, or disposed of as waste. This accounting, which is called a "material balance", will be indicated on the process flow diagram and transferred to a spreadsheet. A material balance is a tool which is used to provide an input/output summary of the process being assessed. Closing the balance on an unknown stream can help identify the constituents in that stream. The material balance should indicate the following:

- amount of input materials introduced into the process,
- amount of materials consumed,
- amount of materials withdrawn as a product or by-product, and
- amount of materials flowing out of a process as a waste stream.

Using the best available information, the material balance should be closed (i.e., all input materials and transfers should be accounted for in the product, by-product and waste streams). The purpose of closing the balance is to identify streams which are difficult to quantify, e.g. fugitive and point-source emission streams. The material balance should show the average material flows over a representative time period which is logical for the site's operations. For example, it may be appropriate to gather data for Operation A from monthly averages, while a longer time span may be more appropriate for Operation B. Material balances performed over the duration of a complete production run are typically the easiest to construct and are reasonably accurate.

In its simplest form, the material balance is represented by the mass conservation principle:

Mass in = Mass out + Mass Accumulated

That is, materials placed into a process can be accounted for through products, by-products, air emissions, water discharges, spills, recycling streams, waste streams, scrap, out-of-shelf life materials, or out-of-specification materials. All materials (hazardous and non hazardous) should be accounted for in the input and output streams. The quantification units for the material balance should be consistent, i.e. pounds. The Material Safety Data Sheet (MSDS) can be helpful in converting materials into a common unit.

Measurement of Feed Materials: All input materials that are introduced into a process must be identified. The amount and type of the input materials can be determined by examining the following:

- procurement and inventory records;
- processing logs; and/or
- other records that show purchase, transfer, donation, or other receipt of materials by production unit.

Other examples of information sources are found in Appendix B.

Products and By-products: The material balance should indicate the amount of materials leaving the work unit as a product or by-product.

Transfer of Materials: Some materials may be used in a process and then transferred to another area or process for further processing. The material balance should account for the transfer of the materials.

E. MEASUREMENT OF WASTE

Information about the quantity and character of the waste streams is a critical component of the PPOA. Waste stream information should be obtained from sources such as:

- site tracking system,
- permits and permit applications,
- monitoring reports,
- hazardous waste manifests,
- emission factors,
- experiments,
- emission or toxic substance release inventories,
- hazardous waste reports,
- waste analyses, and/or
- environmental audit reports.

If the waste data is not available from the above sources, it may be necessary to monitor the process and record the needed information. Model Worksheet 4 can be used to record material balance data. The completed material balance should be a database of process information that represents the process area over a time period long enough to characterize that operation. The suggested time period to record this data is an annual basis to coincide with other site reporting requirements. If data was taken over a shorter time period, extrapolation can be used. The material balance will show the source of waste streams and the contribution that different activities make to the waste streams. It will serve as a baseline for tracking WMin/PP efforts and will provide data needed for evaluation of WMin/PP options. The process data used to calculate a baseline of operations should be as representative of current operations as possible.

Monitoring waste stream flows and compositions is something that should be done periodically. By tracking waste streams, seasonal variations in waste flows or single, large waste streams can be distinguished from continual, constant flows. Changes in waste generation cannot be meaningfully measured unless the information is collected both before and after a pollution prevention option is implemented.

F. WASTE STREAM CHARACTERIZATION

Each waste stream identified in the process flow diagram will be characterized, including but not limited to the following:

- source of waste;
- composition;
- rate of generation from work unit operation; and
- costs associated with treatment, storage, or disposal of wastes.

The waste stream characterization information is also part of Model Worksheet 4. The cost information for the input materials and waste streams can be recorded on Model Worksheet 5. After characterization, consideration should be given to each waste stream to determine where WMin/PP is most needed.

V. DEVELOPMENT AND EVALUATION OF WASTE MINIMIZATION/ POLLUTION PREVENTION OPTIONS

A. IDENTIFICATION OF WMIN/PP OPTIONS

Once the process and causes of waste generation are understood, the PPOA enters the creative phase. Following the collection of data and site inspections, the members of the team will have begun to identify possible ways to minimize waste or prevent pollution in the assessment process. Identifying potential options relies both on the expertise and creativity of the team members. Much of the requisite knowledge may come from their education and on-the-job experience, however, the use of technical literature, contacts, and other sources may also be employed.

The process by which pollution prevention options are identified should occur in an environment that encourages creativity and independent thinking by the members of the assessment team. The key to successful results is the deferral of any critical judgments or comments which might inhibit any of the team members. While the individual team members will suggest many potential options on their own, the process can be enhanced by using some of the common group decision techniques. These techniques allow the assessment team to identify options that the individual members might not have come up with on their own. Employees having practical experience with the process may have given thought to the process' input and output efficiencies or alternative operating methods. Therefore, creativity and brainstorming is strongly encouraged.

To identify WMin/PP options, the PPOA teams will utilize the following priorities:

- source-reduction options:
  - material substitution,
  - process changes,
  - product reformulating,
  - equipment changes,
  - operational improvements,
  - schedule changes,
  - affirmative procurement, and/or
  - administrative controls (e.g., inventory control, employee training, polices, etc.).

- recycling/reuse options

Each of these different approaches may generate many options or none, i.e., while operational improvements are a very broad approach, input or process changes may be difficult to control. Are there any processes / products upstream and downstream which could be affected by changes to the process or product? As these different approaches are discussed several questions should be repeatedly asked:

- Is this operation necessary?
- Why is this waste generated?
- Why do we do this operation in this manner?
- Why must we use these chemicals?
- Are there any non-hazardous substitutions available?

In addition to using the process expert's knowledge, there are numerous outside references to assist in developing a list of options. These include EPA publications, databases, and technical references; state and local environmental agency's publications, bibliographies, and technical assistance; as well as, published literature in technical magazines, trade journals, research briefs, vendor equipment information and chemical supplier information.

Model Worksheet 6 can be used in a team brainstorming session to generate the pollution prevention opportunities. Model Worksheets 7 and 4S can be used to record the detailed description for each of the options generated. The description should include the basic idea behind the option, affected materials and product, any roadblocks to implementation, and the anticipated reduction quantity.

B. PRELIMINARY SCREENING OF WMIN/PP OPTIONS

Many pollution prevention options will be identified in a successful assessment. At this point, it is necessary to identify those options that offer real potential to minimize waste and reduce costs. Since detailed evaluation of technical and economic feasibility is usually costly, the proposed options should be screened to identify those that deserve further evaluation. The screening procedure serves to eliminate suggested options that appear marginal, impractical, or inferior without a detailed and more costly feasibility

study. The screening procedures may include any combination of the following methods:

- information reviews by program managers,
- ballots by team members, and/or
- quantitative tools (e.g. weighted sum method).

Whatever method is used, the preliminary screening procedure should consider the following questions:

- Is implementation of the option cost effective?
- What is the principal benefit of the option?
- What is the expected change in the type or amount of waste generated (toxicity, reactivity, etc.)?
- Does it use existing technology?
- What kind of development effort is required?
- Will implementation be constrained by time?
- Does the option have a dependable performance record?
- Will the option effect product, employee health, or safety?
- What are the upstream/downstream impacts if implemented?

The results of the screening process will be a list of options that are candidates for more detailed technical and economic evaluation. It is important to document the decisions made in the screening process for future reference. Model Worksheet 7 can also be used to record the results from the initial screening process.

C. EVALUATION OF WMIN/PP OPTIONS

The PPOA team should perform an in-depth evaluation on the potential economic and technical feasibility of each option using Model PPOA Worksheets 8 and 9. The options will then be ranked in order of preferred implementation. The highest priority normally should be given to source-reduction projects, after which projects that recycle/reuse all or part of a waste stream or by-product will be considered.

Model Worksheet 8 evaluates each option from a cost perspective. The three major cost categories for weighing options are: Implementation Costs, Incremental Operating Costs, and Incremental Intangible Costs. EPA's *Pollution Prevention Benefits Manual* (Reference #12 of Appendix H) provides more detail on cost analysis and contains examples of each of these cost categories.

The following considerations must be fully evaluated to determine the recommended WMin/PP options. These include: economic evaluation including capital cost, operating cost, waste management costs and return on investment; expected change in the type or amount of waste generated (toxicity, reactivity, etc.); technical feasibility; avoided costs; effect on product, employee health and safety; permits, variances, and compliance schedule of applicable agencies; releases and discharges to all media; previous successes; implementation period; and/or ease of implementation.

This evaluation is most easily accomplished and documented by the use of a simple matrix for scoring and ranking - the suggested evaluation is the weighted sums method shown on Model Worksheet 9. The DOE/DP *Prioritization of Pollution Prevention Options Using Value Engineering* (Reference #13 in Appendix H) also demonstrates how options can be evaluated and prioritized using this method. The evaluation matrix provides a means to quantify the important criteria that affect the site and is a quick visual representation of the factors affecting various WMin/PP options. The scoring system for each criteria, used in the matrix and some rational for selection or weighting of scores should be included in the formal report. Evaluation of this matrix would complete the final requirement for prioritizing the list of options for implementation. The formal report should provide sufficient detail to allow transfer of the measure to other generators with similar processes or operations.

VI. FINAL REPORT

A final report is required for each PPOA. The final report is a compilation of essential facts about the process, pollution prevention options, feasibility of those options, upstream/downstream impacts of those options, and future implementation costs. The final report documents the work performed, assumptions made during the assessment, and identifies funding requirements necessary to implement pollution prevention options. The length of the final report will depend on the complexity of the PPOA. For Level II assessments, Model Worksheet 5S can be used to complete the requirements of the final report.

For a Formal Assessment, Level III, each option will be ranked by the PPOA team according to its economic and technical feasibility using Model Worksheets 8 & 9. Economic feasibility will be a factor, but not the determining factor, in judging the relative merit of each WMin/PP option. The PPOA team will report the results of its evaluation, including final rankings and ranking criteria, to the Waste Minimization Committee or line management. The PPOA team will indicate its preferred options in the report.

Easily implemented options will be completed and documented in the final report. Options that require additional analysis and/or approval shall be addressed via the site's Waste Minimization and Pollution Prevention Program Plan.

Documentation of the WMin/PP options and recommendations should demonstrate a good faith effort undertaken to identify alternatives and should provide a narrative description of these factors in sufficient detail to allow transfer of the measure to other generators with similar processes or operations.

The final report and associated data will be maintained as permanent records for later reference and tracking information. PPOAs should be reviewed on an annual basis after the initial PPOA is completed and should be revised if significant process changes are made.

VII. APPENDIX

APPENDIX A

GENERAL CONSIDERATIONS FOR PRIORITIZING THE ASSESSMENT OF WASTE STREAMS

- Costs savings (direct and indirect)
- Potential for (or ease of) minimization
- Potential recovery of valuable by-products
- Reduced quantity of waste
- Compliance with current and future regulations
- Hazardous properties of the waste (including toxicity, flammability, corrosivity, and reactivity)
- Other safety hazards to employees
- Potential environmental and safety liability/improvements
- Potential for removing bottlenecks in production or waste treatment

APPENDIX B

SOURCES OF MATERIAL BALANCE INFORMATION

Listed below are potential sources of information for preparing a process description, flow diagram or material balance inventory. The list is not meant to be exclusive.

- Process Expert Knowledge
- Operating Logs
- On-site Tracking Systems
- Purchasing Records
- Vendor Information
- Process Design Information
- Batch Makeup Records
- Emission Inventories
- Equipment Cleaning and Validation Procedures
- Material & Chemical Inventories
- Operating Procedures and Manuals
- Production Records
- Product Specifications
- Samples, Analyses, and Flow Measurements
- Waste Disposal Records
- Waste Manifests
- E S & H reports
- Permitting Applications
- Experiments
- Laboratory Notebooks

APPENDIX C

LEVEL I EXAMPLE PPOA

SNL/NM Organization: 7813-5 Process Name: Asbestos Brakes & Clutch Removal

DATA FORM 1

DESCRIPTION OF PROCESS/OPERATIONS

Process Location Area I,II,III,IV,V & Remote Area SNL-Albuquerque NM/SNL-Livermore CA./TTR-Las Vagas NV./KTF-Kauai
(include site, TA, building, room, as appropriate)

Describe the general operations or activities of the organization performing the process. Continue on the back of this sheet, if necessary.

The Crane and Hoist section is responsible for performing annual Inspections, Repairs, and Preventative Maintenance on Cranes and Hoists.

Describe the particular process that generates wastes and/or other pollutants, or uses hazardous materials. Describe how the hazardous materials are used, and how the wastes or pollutants are generated. (See Chapter 2 of the PWA Guidance Manual for guidelines on defining a process.) Continue on the back of this sheet, if necessary.

Asbestos Brakes and Clutches are generated waste in this process.

Asbestos Brakes and Clutches becomes a generated waste when the Asbestos Brakes and Clutches are removed and replaced with Non-Asbestos Brakes and Clutches.

Date: 7/22/93 Prepared by (MinNet Rep): Bernard Alexander Phone: 4-1365
PWA #: Process Contact: Bernard Alexander Phone: 4-1365
(to be completed by WMSC)

PROCESS DEFINITION

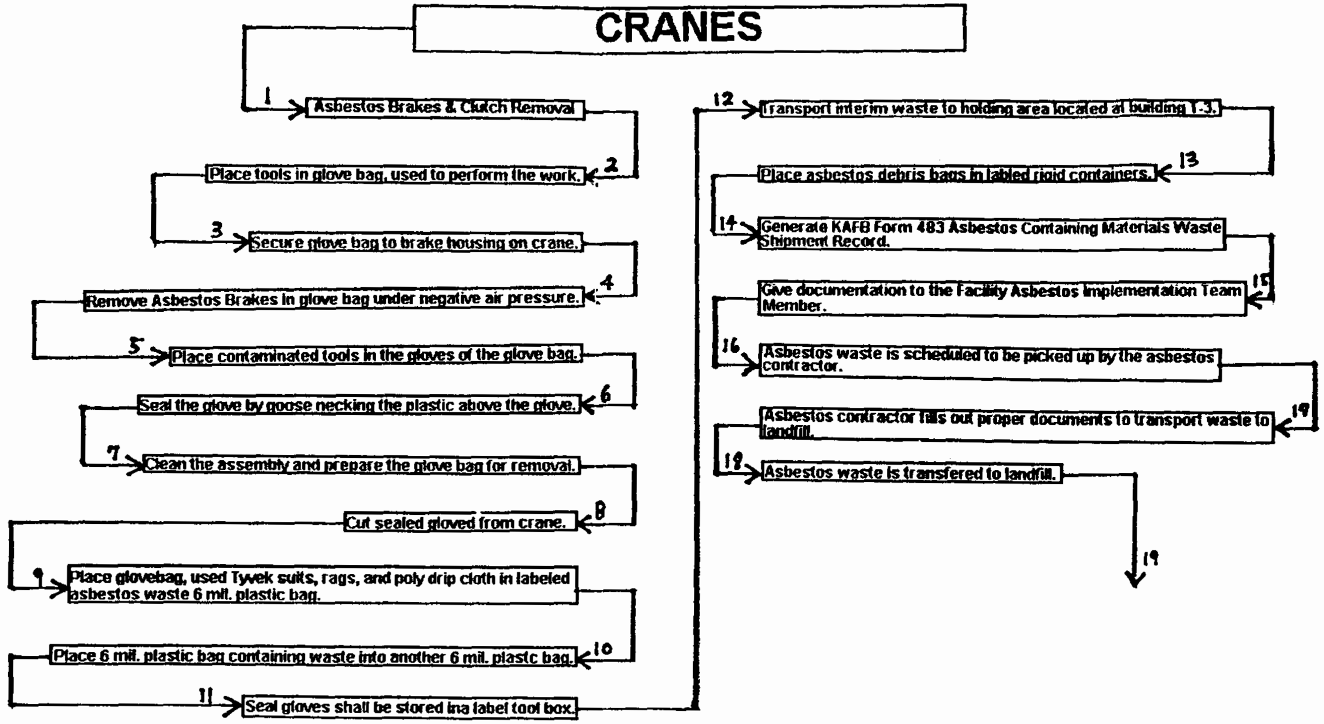
SNL/NM Organization: 7813-5 Process Name: Asbestos Brakes & Clutch Removal

Process Location: Remote Areas Area I,II,III,IV,V/TTR-Las Vegas NV./KTF-Kauai SNL-Albuquerque NM/SNL-Livermore CA.
(include site, TA, building, room, as appropriate)

DATA FORM 2

PROCESS FLOW DIAGRAM

Sketch a flow diagram of the process. Show subprocesses with materials entering the process, as well as products, materials, wastes, and other pollutants generated by the process. Show the sources of the input and destinations of the output materials.



Use additional sheets if necessary.

Date: 7/22/93
PWA #:
(to be completed by WMSC)

Prepared by (MinNet Rep): Bernard Alexander Phone: 4-1365
Process Contact: Bernard Alexander Phone: 4-1365

SNL/NM Organization: 7813-5 Process Name: Asbestos Brakes and Clutches Removal

DATA FORM 3

CALENDAR YEAR 1992 WASTE MINIMIZATION ACTIVITIES

Process Location: Area I,II,III,IV,V, & Remote Areas SNL-Albuquerque NM/SNL-Livermore CA./TTR-Las Vegas NV./KTF-Kauai
(include site, TA, building, room, as appropriate)

Have waste minimization (WM) activities been undertaken in CY92? ☒ Yes ☐ No

If No, briefly discuss factors that have prevented waste minimization activities: ______

If Yes, short name of WM activity (e.g., Increase Input Purity, Improve Rinse Process) (use other sheets if more than one activity taken): Removing and disposing of a hazardous material.

Type of WM activity (check best one that applies):

Source Reduction
- ☒ Good Operating Practice
- ☐ Inventory Control
- ☐ Spill and Leaks Prevention
- ☐ Raw Material Modification
- ☐ Production Modification
- ☐ Process Modification (Clean and Degreasing)
- ☐ Process Modification (Surface Prep and Finish)
- ☐ Process Modification (Other)
- ☐ Other (specify below)

Recycling
- ☐ Began Onsite Recycling
- ☐ Began Offsite Recycling
- ☐ Reuse in Original Process
- ☐ Reuse in Another Process

Energy Recovery
- ☐ Began Onsite Energy Recovery
- ☐ Began Offsite Energy Recovery

Treatment
- ☐ Began Onsite Treatment
- ☐ Began Offsite Treatment

Briefly describe WM activity: Removal of Asbestos Brakes and Clutches to be replace with a non-asbestos material.

Date: 7/22/93 Prepared by (MinNet Rep): Bernard Alexander Phone: 4-1365
PWA #: ______ Process Contact: Bernard Alexander Phone: 4-1365
(to be completed by WMSC)

SNL/NM Organization: 7813-5 Process Name: Asbestos Brakes and Clutches Removal

DATA FORM 3

FISCAL YEAR 1992 WASTE MINIMIZATION ACTIVITIES

Waste stream type affected: ☒ Hazardous (Chemical) Solid Waste ☐ Radioactive/Mixed Solid Waste ☐ Waste Water Discharge ☐ Air Emission

Waste stream name affected (see corresponding Data Form 2): Asbestos Brakes and Clutches

Did WM activity increase the toxicity of waste generated? ☐ Yes ☒ No

Did WM activity increase the quantity or toxicity of wastes emitted to other media (air, waste, land)? ☐ Yes ☒ No

Did WM activity reduce toxicity but not quantity? ☒ Yes ☐ No

Indicate the quantity impact of the WM activity (use most appropriate measure):

Mass before WM activity (kg/yr): ______ Mass after WM activity (kg/yr): ______
Volume before WM activity (ℓ/yr): ______ Volume after WM activity (ℓ/yr): ______
Specific activity before WM activity (Ci/kg/yr): ______ Specific activity after WM activity (Ci/kg/yr): ______

Basis of quantities (e.g., direct measurement, material balance calculation, published emission factors, engineering calculations, engineering/scientific judgment): ______

Has the WM activity been successful? ☒ Yes ☐ No
Is the activity still being used? ☒ Yes ☐ No

If unsuccessful or otherwise not being used, describe why: ______

Date: 7/22/93 Prepared by (MinNet Rep): Bernard Alexander Phone: 4-1365
PWA #: ______ Process Contact: Bernard Alexander Phone: 4-1365
(to be completed by WMSC)

SNL/NM Organization: 7813-5 Process Name: Asbestos Brakes and Clutches

DATA FORM 4

HAZARDOUS/RADIOACTIVE MATERIAL INPUTS

Name of Hazardous/Radioactive Material	Input Stream Number	Predicted Frequency of Usage[1]	Average Annual Usage Rate (kg/yr)
Asbestos	1		
Glove Bag	2		
Tyvek Suits,Rags,Drip Cloth	9		

[1] Indicate usage as Continuously (C), Daily (D), Weekly (W), Monthly (M), Quarterly (Q), or Annually (A)

Date: 7/22/93 Prepared by (MinNet Rep): Bernard Alexander Phone: 4-1365

PWA #: Process Contact: Bernard Alexander Phone: 4-1365

(to be completed by WMSC)

SNL/NM Organization: 7813-5 Process Name: Asbestos Brakes and Clutches

DATA FORM 5

HAZARDOUS (CHEMICAL) SOLID WASTE

Waste Stream Number (from Worksheet 1): 1,2,9,10

Waste Stream Name (from Data Form 2/Worksheet 1): Asbestos,tyvk suits,rags,drip cloth, plastic bag

Location of waste generation (TA, building, room): SNL-Alb/SNL-CA/TTR-NV/KTF-Kauai

Inside RMMA? ☐ Yes ☒ No

Briefly describe how waste is generated: Asbestos Brakes and Clutches are removed and replaced with non-asbestos material. Glove bages,tyvek suits rags, and drip cloth are used in th removal process to remove the generated waste.

Frequency of waste generation: ☐ Continuously ☐ Daily ☐ Weekly ☒ Monthly ☐ Quarterly ☐ Annually

Which description fits the process step that generates the waste (check best one):

☒ A regularly scheduled process step that is likely to be repeated several times during the upcoming year.
☐ A one-time activity that is not likely to be repeated during the upcoming year.

Predicted average quantity of waste generated annually – normal operations (kg): 200 lbs.

Predicted min/max quantity generated annually – normal operations (kg): Min _____ Max _____

List (describe) all hazardous constituents (e.g., mercury inside switches, benzene-tainted glassware) or brand names (e.g., WD-40) that could be in the waste:

Asbestos

Do the hazardous constituents of the waste stream listed above vary (e.g., sometimes contains lead, sometimes contains lead and cadmium)? ☐ Yes ☒ No If yes, describe how the waste varies:

Describe physical characteristics of wastes (e.g., aqueous solution, solid, sludge, oil, containerized compressed gas - include % of solids or % moisture, if applicable): Solid

Date: 7/22/92 Prepared by (MinNet Rep): Bernard Alexander Phone: 4-1365

PWA #: _____ Process Contact: Bernard Alexander Phone: 4-1365

(to be completed by WMSC)

SNL/NM Organization: 7813-5 Process Name: Asbestos Brakes and Clutches

DATA FORM 5

HAZARDOUS (CHEMICAL) SOLID WASTE

The pH of the waste stream may range from N/A to N/A (answer if appropriate)

Is the waste ignitable? (see Guidance Manual for clarification) ☐ Yes ☒ No ☐ Unknown
Is the waste corrosive? (see Guidance Manual for clarification) ☐ Yes ☒ No ☐ Unknown
Is the waste reactive? (see Guidance Manual for clarification) ☐ Yes ☒ No ☐ Unknown

Does the waste stream contain any of the following toxic metals: ☐ Yes ☒ No (check all that apply)

☐ Arsenic ☐ Barium ☐ Cadmium ☐ Chromium
☐ Lead ☐ Mercury ☐ Selenium ☐ Silver

Does the waste stream contain a toxic volatile, semi-volatile, or pesticide listed in Table 3-2?
☐ Yes ☒ No If yes, list: ______

Does the waste stream contain any of the spent solvents listed in Table 3-3? ☐ Yes ☒ No
If yes, list: ______

Does the waste stream contain, or is it generated from the production of, any of the following benzene derivatives? ☐ Yes ☒ No (check all that apply)

☐ trichlorophenol ☐ tetrachlorobenzene
☐ tetrachlorophenol ☐ pentachlorobenzene
☐ pentachlorophenol ☐ hexachlorobenzene

Is the waste any of the following? ☐ Yes ☒ No (check all that apply)

☐ waste water treatment sludge ☐ wood preserving process waste
☐ petroleum refining waste ☐ leachate from treatment, storage, or disposal of waste

Does the waste contain cyanide or is cyanide used in the process? ☐ Yes ☒ No

Is the waste any of the following? ☐ Yes ☒ No (check all that apply)

☐ waste from the production of inorganic pigments ☐ waste from the production of pesticides
☐ waste from the production of inorganic chemicals ☐ waste from the production of metals
☐ waste from the production of organic chemicals ☐ waste from the production of pharmaceuticals
☐ waste from the production of explosives ☐ coking waste
☐ waste from the production of ink formulations ☐ petroleum refining waste

Date: 7/22/93 Prepared by (MinNet Rep): Bernard Alexander Phone: 4-1365
PWA #: ______ Process Contact: Bernard Alexander Phone: 4-1365
(to be completed by WMSC)

SNL/NM Organization: 7813-5 Process Name: Asbestos Brakesand Clutches

DATA FORM 5

HAZARDOUS (CHEMICAL) SOLID WASTE

Based on the above description of how the waste is generated, select the single best summary of the waste-generating process step.

CLEANING AND DEGREASING

- ☐ Stripping (A01)
- ☐ Acid cleaning ((A02)
- ☐ Caustic (Alkali) cleaning (A03)
- ☐ Flush rinsing (A04)
- ☐ Dip rinsing (A05)
- ☐ Spray rinsing (A06)
- ☐ Vapor degreasing (A07)
- ☐ Physical scraping and removal (A08)
- ☐ Clean out process equipment (A09)
- ☐ Other cleaning and degreasing (A19)

SURFACE PREPARATION AND FINISHING

- ☐ Painting (A21)
- ☐ Electroplating (A22)
- ☐ Electroless plating (A23)
- ☐ Phosphating (A24)
- ☐ Heat treating (A25)
- ☐ Pickling (A26)
- ☐ Etching (A27)
- ☐ Other surface coating/preparation (A29)

PROCESSES OTHER THAN SURFACE PREPARATION

- ☐ Product rinsing (A31)
- ☐ Product filtering (A32)
- ☐ Product distillation (A33)
- ☐ Product solvent extraction (A34)
- ☐ By-product processing (A35)
- ☐ Spent catalyst removal (A36)
- ☐ Spent process liquids removal (A38)
- ☐ Tank sludge removal (A38)
- ☐ Slag removal (A39)
- ☐ Metal forming (A40)
- ☐ Plastics forming (A41)

PRODUCTION OR SERVICE DERIVED ONE-TIME AND INTERMITTENT PROCESSES

- ☐ Leak collection (A51)
- ☐ Cleanup of spill residues (A53)
- ☐ Oil changes (A54)
- ☐ Filter/battery replacement (A55)
- ☐ Discontinue use of process equipment (A56)
- ☒ Discarding off-spec material (A57)
- ☐ Discarding out-of-date products or chemicals (A58)
- ☐ Other production-derived on-time and intermittent processes (A59)
- ☐ Sludge removal (A60)

REMEDIATION DERIVED WASTE

- ☐ Superfund Remedial Action (A61)
- ☐ Superfund Emergency Response (A62)
- ☐ RCRA Corrective Action at solid waste management unit (A63)
- ☐ RCRA closure of hazardous waste management unit (A64)
- ☐ Underground storage tank cleanup (A65)
- ☐ Other remediation (A69)

POLLUTION CONTROL OR WASTE TREATMENT PROCESSES

- ☐ Filtering/screening (A71)
- ☐ Metals recovery (A72)
- ☐ Solvents recovery (A73)
- ☐ Incineration/thermal treatment (A74)
- ☐ Wastewater treatment (A75)
- ☐ Sludge dewatering (A76)
- ☐ Stabilization (A77)
- ☐ Air pollution control devices (A78)
- ☐ Leachate collection (A79)
- ☐ Other pollution control or waste treatment (A89)

OTHER PROCESSES

- ☒ Clothing and personal protective equipment (A91)
- ☒ Routine cleanup wastes (e.g., floor sweepings) (A92)
- ☐ Closure of hazardous waste management unit(s) or equipment other than by remediation (A93)
- ☐ Laboratory wastes (A94)
- ☐ Other (A99)

Date: 7/22/93
PWA #: ______
(to be completed by WMSC)

Prepared by (MinNet Rep): Bernard Alexander Phone: 4-1365
Process Contact: Bernard Alexander Phone: 4-1365

APPENDIX D

PPOA GRADED APPROACH WEIGHTED SUMS FORM, CRITERIA, AND INSTRUCTIONS

Date: ________

Page ______ of ________

Pollution Prevention Opportunity Assessment Graded Approach

Weighted Sums Evaluation

Evaluation Criteria	Weight 'W'	Process:		Process:		Process:		Process:		Process:	
		Scale 'S'	'WxS'	Scale 'S'	'WxS'	Scale 'S'	'WxS'	Scale 'S'	'WxS'	Scale 'S'	'WxS'
Environmental, Safety, & Health Hazards	Site Assigns										
Quantity of Waste Generated	" "										
Site Liabilities	" "										
Economic Factors - Process & Waste Costs (Unit &/or Annual)	"										
Process By-Product Management	" "										
Other											
Subtotal											
WMin/PP Potential Multiplier		x		x		x		x		x	
Total											
PPOA Level											

8/93

Date: ________
Page ______ of ________

Pollution Prevention Opportunity Assessment Graded Approach

Weighted Sums Evaluation

Evaluation Criteria	Weight 'W'	Process: ______ Scale 'S'	'WxS'	Process: ______ Scale 'S'	'WxS'	Process: ______ Scale 'S'	'WxS'	Process: ______ Scale 'S'	'WxS'	Process: ______ Scale 'S'	'WxS'
Environmental, Safety, & Health Hazards	Site Assigns										
Quantity of Waste Generated	" "										
Site Liabilities	" "										
Economic Factors - Process & Waste Costs (Unit &/or Annual)	"										
Process By-Product Management	" "										
Other											
Subtotal											
WMin/PP Potential Multiplier		X		X		X		X		X	
Total											
PPOA Level											

Graded Approach Worksheet

The purpose of this worksheet is to determine the PPOA level for each of the facility processes. To begin, a list of these processes or areas should be generated for each facility. Then for each item listed, complete one column on this worksheet. For consistency, each facility should establish site-specific weights for each of the criteria. Once each item has received a weighted sum value, then each facility should establish the dividing line from which to require informal (Level II) or formal PPOAs (Level III).

Weighted Sums Instructions:

a. The values in the Weight column (designated by 'W') represent the facility's priority for the criteria.

b. In the Scale column for each process (designated by 'S'), rate each criteria by assigning a value from 0-10 (lowest to highest).

c. In the 'W x S' column for each process, enter the product of the weight and scale.

d. Sum the 'W x S' column for each process to obtain a subtotal.

e. Calculate the process ratio for waste generated/input material used (0 - 1). This is the multiplier.

f. Multiply the subtotal by the multiplier and enter the product in the Total column for each process.

g. Determine the level of PPOA required by comparing the Total weighted sums value with the site guidelines in the following table.

Weighted Sums Total	PPOA Level Required
If 0 to (?)	Level II Informal PPOA
If ≥ (?)	Level III Formal PPOA

APPENDIX E

LEVEL II EXAMPLE PPOA

PPOA-1

Original Issue Date: 8/31/91
Revision No.:
Revision Date:

Pollution Prevention Opportunity Assessment

Team & Scope

Assessment ID Code: SNL/CA MS001

Assessment Title: Machine and Fabrication Shop

Name	Job Classification	Phone
* Alice Johnson-Duarte	WMin Coordinator	4-3266
Andy Cardiel	Shop Supervisor	4-2544
Charlie Schmitz	Machinist	4-2315
Kim Shepodd	Waste Manager	4-1475

* Team Leader

Assessment Scope:

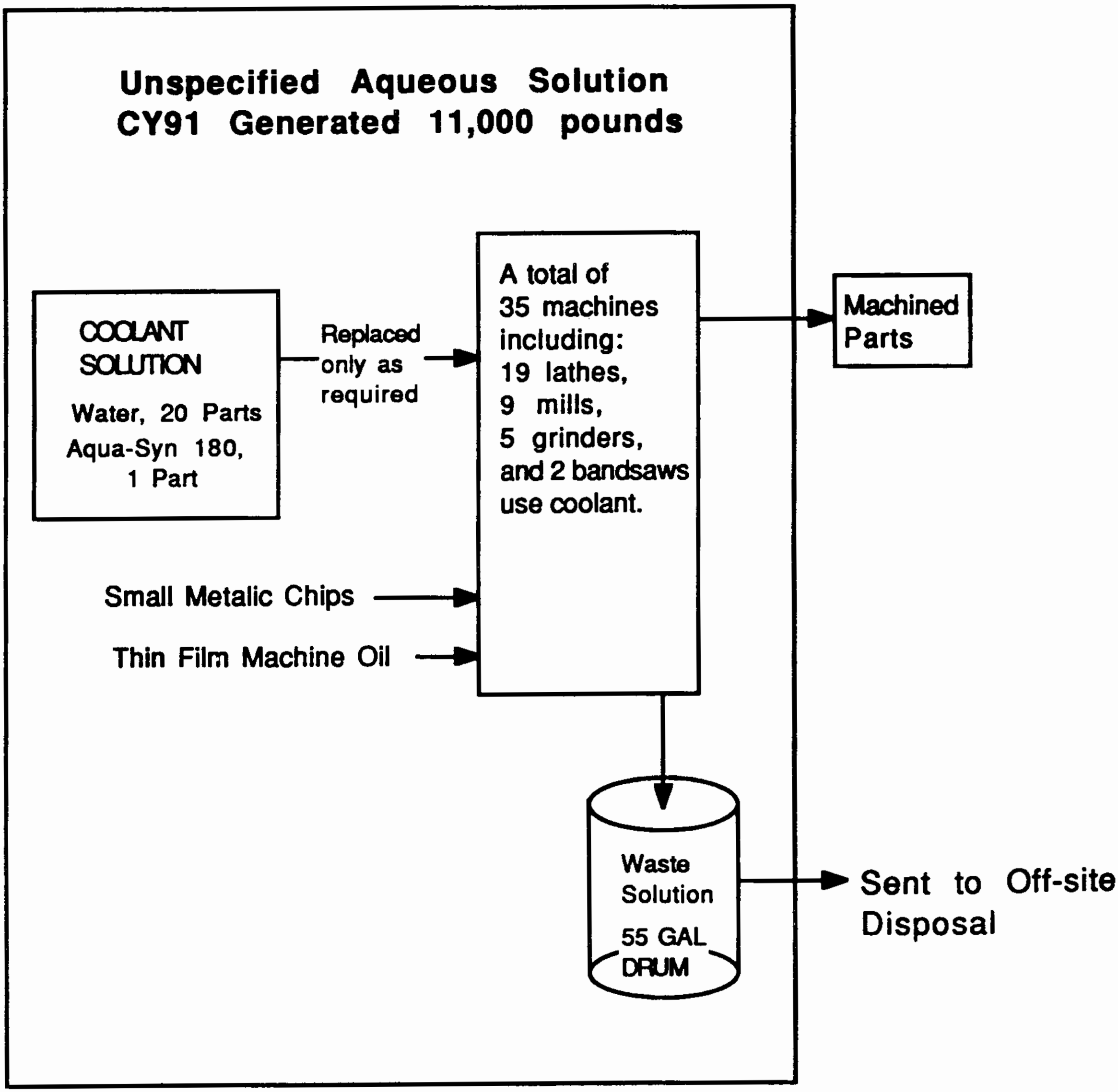
The Machining and Fabrication Shop is a support function whose principal purpose is machining parts requiring a quick turn-around, restriction of access due to classification, and/or close liaison with the designer and engineer. The shop maintains equipment suitable to perform turning, milling and grinding operations. The major hazardous waste stream generated by this facility is the spent coolant used in the machining process. The diluted Aqua-Syn 180 itself is a non-hazardous material per 29CFR 1910.1200(c); however, in the machining process it is mixed with small amounts of machine oil and metal shavings. The coolant is routinely changed after 3 to 4 months of service except as noted in the shop's operating procedures.

Potential for Pollution Prevention / Waste Minimization or Recommendations:

There are limited operational and administrative pollution prevention opportunities to reduce the spent coolant waste.

POLLUTION PREVENTION OPPORTUNITY ASSESSMENT
PROCESS FLOW DIAGRAM

PWA ASSESSMENT ID CODE: SNL/CA MS001
TITLE: Machine and Fabrication Shop



PPOA-2

Pollution Prevention Opportunity Assessment

Material & Waste Stream Summary

Assessment ID Code: SNL/CA MS001

Title: Machine and Fabrication Shop

Input Material Name/No.	Annual Quantity Used	% Product	% Recycled	Total Releases % Air	Total Releases % Liquid	Total Releases % Solid
Water	10400.0			5	95	
Aqua-Syn	520.0			1	99	
Metalic chips	65.0					100
Machine oil	15.0				100	

Totals/Page: 11000.0

Total Annual Quantity 11000.0

Does the process require further analysis based on the site's Priority Material/Waste Stream List?

● Yes ○ No

☒ Level II ☐ Level II

9/16/93

PPOA-3

Pollution Prevention Opportunity Assessment

Option Summary

Assessment ID Code: SNL/CA MS001

Title: Machine and Fabrication Shop

Option No. 1

Description

One consideration for an operational improvement would be to recycle the spent coolant. According to industrial sources, a reduction of approximately 50% in the present amount of coolant disposed of.

Type	Consider?	Feasibility	Estimated Cost	Estimated Savings	Anticipated Reduction Qty
Recycling	● Yes ○ No	Fair	$25,000.00	$100.00	5,000.00

Option No. 2

Description

Analyze the spent coolant solution for contaiminants and determine if it is indeed hazardous.

Type	Consider?	Feasibility	Estimated Cost	Estimated Savings	Anticipated Reduction Qty
Disposal	○ Yes ● No	Poor	$5,000.00	$100.00	1,0000

PPOA-4

Date
8/31/91

Pollution Prevention Opportunity Assessment

Final Summary

Assessment ID Code SNL/CA MS001

Title: Machine and Fabrication Shop

Assessment:
A Level I and Level II PWA were completed on the Machining and Fabrication Shop coolant waste stream. The machinist responsible for the operational maintenance of the machine shop equipment had limited suggestions for reducing the amount of spent coolant generated. Recycling and treatment options were generated and evaluated. Assumptions made during this assessment were: the level of activity of the machine shop is relatively stable; the coolant must be changed on a periodic basis which is dependent on use and/or time and; disposal costs are relatively stable.

Conclusions:
The PWA team concluded the options are not economically feasible at this time since: 1) option one would require a considerable investment with the possibility of increasing the actual amount of coolant waste caused by contamination; 2) the recycling equipment presently available is not designed to treat the small quantity of spent coolant generated; 3) a conservative approach regarding waste management is consistent with the site's policy.

Recommendations:
The Line Management will continue monitoring the amount of waste generated and the availability of recycling equipment for improvement in the economical feasibility of implementation.

APPENDIX F

LEVEL III EXAMPLE PPOA

Worksheet 1

Level III

Original Issue Date: 01-Dec-1993
Revision No.: 0
Revision Date:

Pollution Prevention Opportunity Assessment

PPOA Team

PPOA Title: Polyurethane Foam Mixing and Curing

PPOA ID Code(s): G517-034-Machine_Mix

Name	Job Classification	Phone
*Bill Harrison	Process Engineer	X1234
John Taylor	Area Supervisor	X1235
Albert Green	Foam Machine Operator	X1235
Mary White	Foam Machine Operator	X1235
Violet Jones	Area Production Planner	X1236

*Team Leader

Additional Resources	Name	Phone
PPOA Coordinator	Nancy Notrebmep	X5432
Waste Management	Hakim Senoj	X5433
Industrial Hygiene		
Environmental Protection	Tim Sregge	X5434
Safety		
Fire Protection		
Process Engineering		
Materials Engineering		
Utilities Engineering		
Facilities Engineering		
Maintenance (Equipment)		
Analytical Lab Testing	Dottie Muldune	X5431
Scheduling		
Purchasing		

Worksheet 2

Level III

Revision No.: _____
Revision Date: _____

Pollution Prevention Opportunity Assessment

Process Description

PPOA Title: Polyurethane Foam Mixing and Curing

PPOA ID Code(s): G517-034-Machine_Mix

Process Location: Main Building #105, Post FN33

Process Description:

The foam mixing process is a process in which the required material components are metered and mixed at a defined ratio. The ratio of the two component streams is set and calibrated by production personnel. The materials are then mixed during the dispense cycle by the action of a motorized impeller. The mixed material "foam" is transferred manually to a mold and cured at temperatures from 165 to 350 deg. F. for four to six hours. Input materials include polyol resins, isocyanates, cleaning solvent and processing supplies. Five foam dispensing units are used. They range in age from four to fifteen years. The cure ovens are ventilated as is the foam pouring area. The foam machine operators have sufficient training to operate the dispensing units. Their previous training did not emphasize pollution prevention.
Waste streams include solid and liquid waste from the foaming operations as well as air emissions from the foam pouring and curing activities.

Description of Major Product(s) of Process:

Molded Polyurethane Foam Products

Worksheet 3
Style 1
Level III

Revision No. : 0
Revision Date: ____________

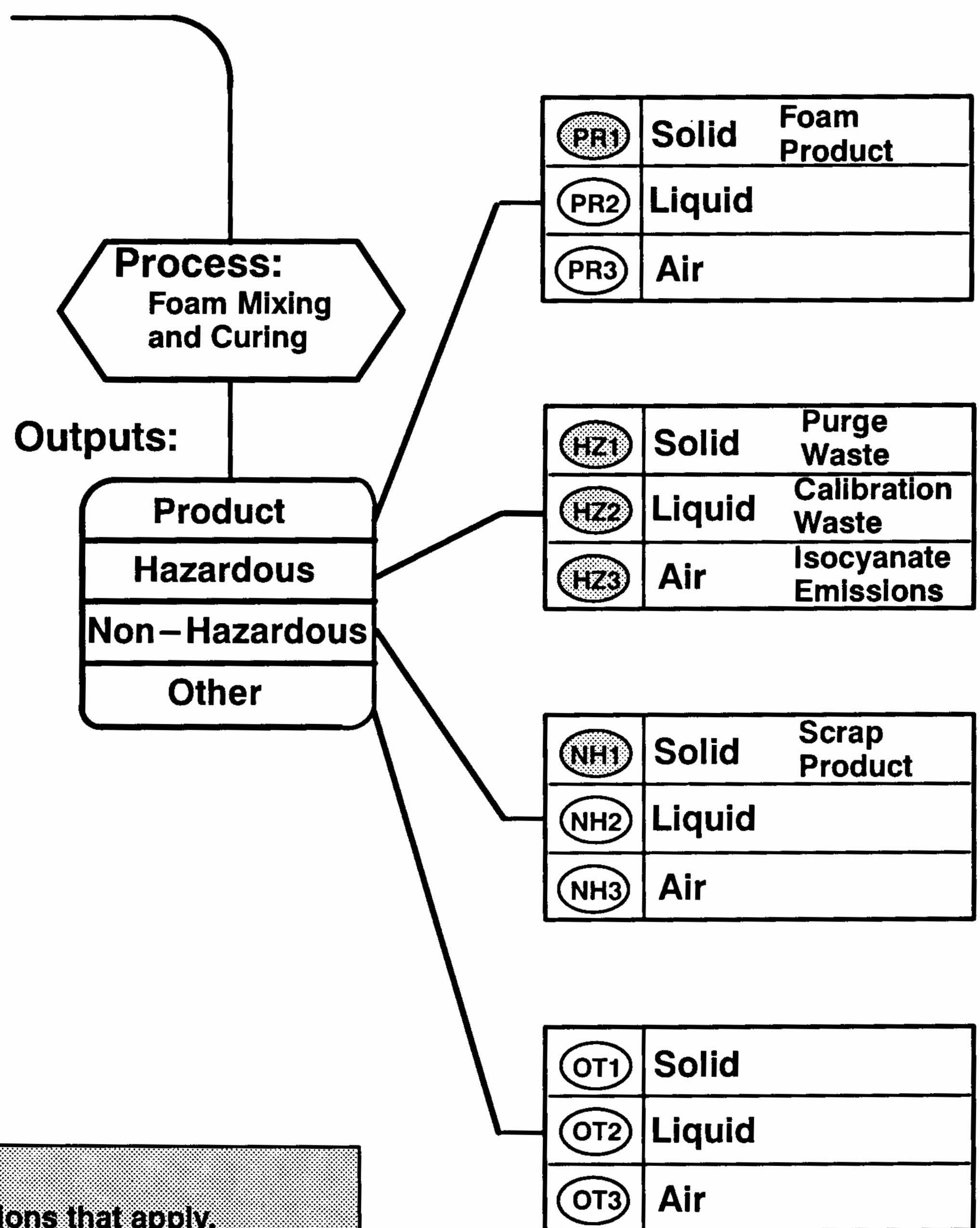
Pollution Prevention Opportunity Assessment

Process Flow Diagram

PPOA Title or PPOA ID Code(s): G517–034–Machine_Mix

Inputs:

- Isocyanate Comp.
- Resin Component
- Solvent
- Supplies



Highlight those sections that apply.
Use Worksheet 4 to identify and quantify the appropriate stream.

Worksheet 4
Level III

Pollution Prevention Opportunity Assessment

Material Balance Summary

Revision No.: 0
Revision Date:

Time frame
From: 01-Jan-92
To: 31-Dec-92

PPOA Title or PPOA ID Code(s): G517-034-Machine_Mix

Material Description	Total Input	Total Output	OUTPUT QUANTITY (Units: lbs.)								
			Stream ID Code Foam Product PR1	Stream ID Code Purge Waste HZ1	Stream ID Code Calibration Waste HZ2	Stream ID Code Isocyanate Emissions HZ3	Stream ID Code Scrap Product NH1	Stream ID Code	Stream ID Code	Stream ID Code	Stream ID Code
Isocyanate	313.6	124.5		98.3	24.4	1.8					
Resin	186.4	73.5		58.9	14.6						
Solvent	80.0	80.0		80.0							
Supplies	94.0	94.0		94.0							
Foam	0.0	302.0	237.0				65.0				
Totals/Subtotals	674.0	674.0	237.0	331.2	39.0	1.8	65.0				

Worksheet 5

Level III

Revision No.: 0
Revision Date: ______
Page 1 of 1

Pollution Prevention Opportunity Assessment

Material Cost

PPOA Title or PPOA ID Code(s): G517-034-Machine_Mix

Material	Stock Number (if applicable)	Cost Per Unit	Annual Cost
Isocyanate Component		$1.96/lb	$614.65
Resin Component		$2.25/lb	$419.40
Solvent		$0.27/lb	$ 21.60
Supplies (paper cups, etc.)		$0.57/lb	$ 53.60
		Total / Subtotal	$1109.25

Waste Disposal Cost:

Material / Waste Stream	Waste Stream Category	Cost Per Unit	Annual Cost
Waste Liquid	Haz. Liquid	$4.60/lb	$179.40
Waste Solid	Haz. Solid	$2.97/lb	$983.66
Scrap Product	Non Haz. Solid	$0.69/lb	$ 44.85
		Total / Subtotal	$1207.91

Worksheet 6

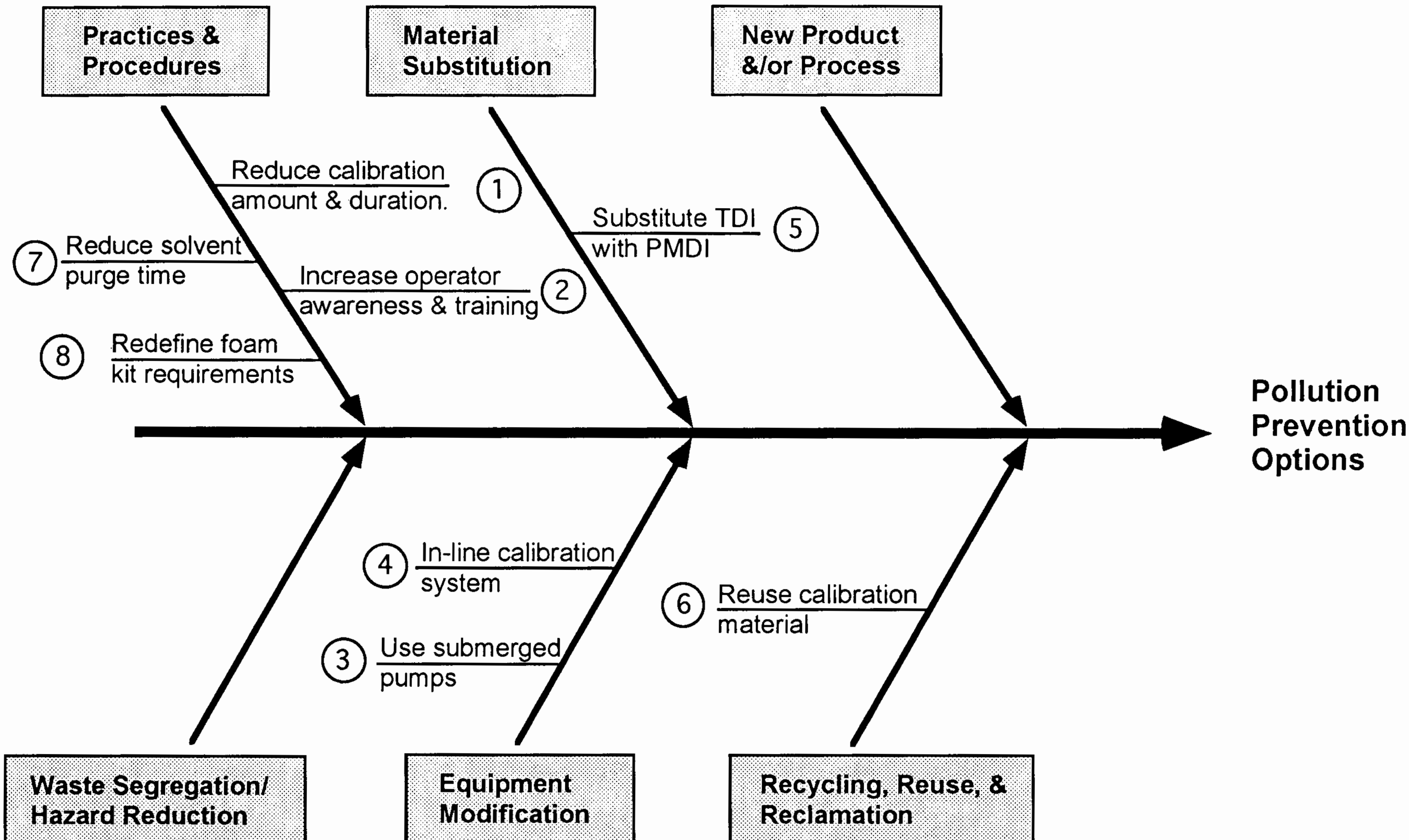
Level III

Revision No.: 0
Revision Date:

Pollution Prevention Opportunity Assessment

Option Generation

PPOA Title or PPOA ID Code(s): G517-034-Machine-Mix



Worksheet 7

Level III

Pollution Prevention Opportunity Assessment

Option Description

PPOA Title or PPOA ID Code(s): G517-034-Machine_Mix

Option Name and Description
(Include input materials, products affected, and anticipated reduction quantity.)

Option No. 1 : Calibration Reduction. Reduce the amount and duration of the calibration shots for the foam dispensers. Use new analytical methods "nitrogen testing" to justify the reduced level.

Consider: Yes X No__

Practices & Procedures X
Material Substitution ____
New Product &/or Process ____
Waste Segregation/Hazard Reduction ____
Equipment Modification ____
Recycling, Reuse, & Reclamation ____

Option No. 2 : Increase Awareness and Training. Conduct training session to increase pollution prevention awareness. Instruct in the importance of the individual in the waste generation process.

Consider: Yes X No__

Practices & Procedures X
Material Substitution ____
New Product &/or Process ____
Waste Segregation/Hazard Reduction ____
Equipment Modification ____
Recycling, Reuse, & Reclamation ____

Option No. 3 : Use Submerged Pumps. Replace gear pumps on foam machines with in-tank pumps. Leakage will be into material tanks. This will eliminate material waste and exposure as the result of clean-up

Consider: Yes X No__

Practices & Procedures ____
Material Substitution ____
New Product &/or Process X
Waste Segregation/Hazard Reduction ____
Equipment Modification ____
Recycling, Reuse, & Reclamation ____

Option No. 4 : In-Line Calibration System. Purchase new foam equipment with "in-line" calibration capability. This would replace the open cup method and would reduce the liquid and solid waste streams

Consider: Yes X No__

Practices & Procedures ____
Material Substitution ____
New Product &/or Process ____
Waste Segregation/Hazard Reduction ____
Equipment Modification X
Recycling, Reuse, & Reclamation ____

Worksheet 7

Level III

Pollution Prevention Opportunity Assessment

Option Description

PPOA Title or PPOA ID Code(s): G517-034-Machine_Mix

Option Name and Description
(Include input materials, products affected, and anticipated reduction quantity.)

Option No. 5 : Substitute for TDI. Lessen the toxicity of the waste stream by replacing TDI isocyanate with a PMDI based foam system. PMDI is not a carcinogen and is not a RCRC Hazardous waste.

Consider: Yes X No__

Practices & Procedures ______ Waste Segregation/Hazard Reduction ______
Material Substitution X Equipment Modification ______
New Product &/or Process ______ Recycling, Reuse, & Reclamation ______

Option No. 6 : Reuse Calibration Material. Retain spent calibration material for use on low end product requirements. This could include machine tryout parts, or foam billets used as base material for holding fixtures.

Consider: Yes X No__

Practices & Procedures ______ Waste Segregation/Hazard Reduction ______
Material Substitution ______ Equipment Modification ______
New Product &/or Process ______ Recycling, Reuse, & Reclamation X

Option No. 7 : Reduce Solvent Purge Time. Reset the solvent timers on the foam machine to the absolute minimum to flush the mix head. Subsequent soaking of mixer blade and housing can also reduce the required amount.

Consider: Yes X No__

Practices & Procedures X Waste Segregation/Hazard Reduction ______
Material Substitution ______ Equipment Modification ______
New Product &/or Process ______ Recycling, Reuse, & Reclamation ______

Option No. 8 : Redefine Foam Kit Requirements. Set-up separate material numbers for resin and isocyanate components so ratio/usage of material will be balanced. Current "matched set" distribution result in waste of excess component.

Consider: Yes X No__

Practices & Procedures X Waste Segregation/Hazard Reduction ______
Material Substitution ______ Equipment Modification ______
New Product &/or Process ______ Recycling, Reuse, & Reclamation ______

Worksheet 8

Level III

Revision No.: 0
Revision Date: ______
Page 1 **of** 2

Pollution Prevention Opportunity Assessment

Options Cost Evaluation

PPOA Title or PPOA ID Code(s): G517-034-Machine_Mix

	Option No.: 1	Option No.: 2	Option No.: 3	Option No.: 4	Option No.: 5
Implementation Costs					
Purchased Equipment			$500	$75,000	
Installation			$100	$10,000	
Materials					
Utility Connections				$2000	
Engineering	$250	$100	$150	$3000	$1000
Development					$500
Start up / Training	$100	$100	$150	$5000	
Administrative	$50	$50			
Other					
Total Implementation Cost	$400	$250	$900	$95,000	$1500
Incremental Operating Costs					
Change in Raw Materials	$215	$100	$150	$750	$500
Change in Maintenance			($150)		
Change in Labor	$500			$500	
Change in Disposal	$50	$50	$100	$600	$500
Other					
Annual Operating Savings/(Cost)	$765	$150	$100	$1850	$1000
Incremental Intangible Costs					
Penalties and Fines					
Future Liabilities					
Other					
Annual Intangible Savings/(Cost)	$0	$0	$0	$0	$0
Total Annual Savings/(Cost)	$765	$150	$100	$1850	$1000
Payback Period	0.5 yrs	1.6 yrs	9.0 yrs	51 yrs	1.5 yrs

Worksheet 8

Level III

Revision No.: 0
Revision Date: ______
Page 2 of 2

Pollution Prevention Opportunity Assessment

Options Cost Evaluation

PPOA Title or PPOA ID Code(s): G517-034-Machine_Mix

	Option No.: 6	Option No.: 7	Option No.: 8	Option No.:	Option No.:
Implementation Costs					
Purchased Equipment					
Installation					
Materials					
Utility Connections					
Engineering	$200	$150	$150		
Development					
Start up / Training		$150			
Administrative			$150		
Other					
Total Implementation Cost	$200	$300	$300		
Incremental Operating Costs					
Change in Raw Materials		$15			
Change in Maintenance					
Change in Labor					
Change in Disposal	$180	$125	$350		
Other					
Annual Operating Savings/(Cost)	$180	$140	$350		
Incremental Intangible Costs					
Penalties and Fines					
Future Liabilities					
Other					
Annual Intangible Savings/(Cost)	$0	$0	$0		
Total Annual Savings/(Cost)	$180	$140	$350		
Payback Period	1.1 yrs	2.1 yrs	0.9 yrs		

Worksheet 9

Level III

Revision No.: 0
Revision Date: ______
Page 1 of 2

Pollution Prevention Opportunity Assessment

Weighted Sums Option Evaluation

PPOA Title or PPOA ID Code(s): G517-034-Machine_Mix

Criteria	Weight 'W'	Option No.: 1 Scale 'S'	'WxS'	Option No.: 2 Scale 'S'	'WxS'	Option No.: 3 Scale 'S'	'WxS'	Option No.: 4 Scale 'S'	'WxS'	Option No.: 5 Scale 'S'	'WxS'
Public Health, Safety, & Environment	10	8	80	6	60	6	60	7	70	8	80
Employee Health & Safety	10	8	80	7	70	5	50	8	80	9	90
Regulatory Compliance	8	7	56	7	56	8	64	7	56	9	72
Economic	6	8	48	9	54	7	42	5	30	8	48
Implementation Period	4	7	28	9	36	6	24	6	24	7	28
Improved Operation / Product	2	5	10	8	16	7	14	8	16	8	16
Other											
Subtotal			302		292		254		276		334
Likelihood of Technical Success (Multiplier)		X	0.8	X	1.0	X	0.9	X	0.9	X	1.0
Likelihood of Useful Results (Multiplier)		X	0.9	X	0.9	X	0.9	X	0.9	X	1.0
Total			217		262		205		224		339
Rank			7		4		8		5		1

Worksheet 9

Level III

Revision No.: 0
Revision Date: ______

Pollution Prevention Opportunity Assessment

Weighted Sums Option Evaluation

PPOA Title or PPOA ID Code(s): G517-034-Machine_Mix

Criteria	Weight 'W'	Option No.: 6 Scale 'S'	'WxS'	Option No.: 7 Scale 'S'	'WxS'	Option No.: 8 Scale 'S'	'WxS'	Option No.: ___ Scale 'S'	'WxS'	Option No.: ___ Scale 'S'	'WxS'
Public Health, Safety, & Environment	10	6	60	8	80	6	60				
Employee Health & Safety	10	7	70	8	80	7	70				
Regulatory Compliance	8	6	48	7	56	7	56				
Economic	6	7	42	9	54	8	48				
Implementation Period	4	7	28	9	36	8	32				
Improved Operation / Product	2	7	14	6	12	9	18				
Other											
Subtotal			262		318		284				
Likelihood of Technical Success (Multiplier)		X	0.9	X	1.0	X	1.0	X		X	
Likelihood of Useful Results (Multiplier)		X	0.9	X	0.9	X	1.0	X		X	
Total			212		286		284				
Rank			6		2		3				

Worksheet 10

Level III

Revision No.: 0 .
Revision Date: ______
Page 1 of 1

Pollution Prevention Opportunity Assessment

Final Report Check Sheet

PPOA Title or PPOA ID Code(s): G517-034-Machine_Mix

Requirement	***Completed***
Title Page	X
PPOA Title	
PPOA ID Code(s)	
Team members	
Issue date/revision date/revision no.	
Executive Summary	X
Process description	
Process assessment	
Option summary and analysis	
Conclusions	
Recommendations	
Introduction	X
Background of evaluation	
Process Description	X
Associated equipment	
Process flow diagram	
Process Assessment	X
Methodology	
Material Balance	
Unusual occurrences	
Option Summary and Analysis	X
Option description and rank	
Upstream/Downstream impacts	
Material usage	
Anticipated reduction	
Estimated costs	
Estimated benefits	
Feasibility	
Waste streams affected	
Conclusion	X
Concluding evaluation	
Option analysis decisions	
Concerns	
Options already implemented	
Lessons learned	
Recommendations	X
Future work	
New equipment	
Implementation strategies	
Worksheets	X
1-10	

APPENDIX G

MODEL PPOA WORKSHEETS

Worksheet 1

Level III

Original Issue Date: ________
Revision No.: ________
Revision Date: ________

Pollution Prevention Opportunity Assessment

PPOA Team

PPOA Title: ____________________

PPOA ID Code(s): ____________________

Name	Job Classification	Phone
*		

*Team Leader

Additional Resources	Name	Phone
PPOA Coordinator		
Waste Management		
Industrial Hygiene		
Environmental Protection		
Safety		
Fire Protection		
Process Engineering		
Materials Engineering		
Utilities Engineering		
Facilities Engineering		
Maintenance (Equipment)		
Analytical Lab Testing		
Scheduling		
Purchasing		

Worksheet 1

Worksheet 1 provides the identification of the PPOA assessment team. For the PPOA to be successful, employees involved with the process should be members of the team. The assessment team needs a leader, members, and additional resources, as required.

The team leader should have technical knowledge of the process, knowledge of the current production operations, and the personnel involved. The leader shall assemble the team to perform the assessment. Team members may include process engineers, product engineers, knowledgeable department personnel such as production operator(s), and material experts. Additional resources may be called in to provide information not available within the team. The size of the team may be large for complicated processes, but should be kept to a minimum to maintain focus.

1. **Original Issue Date:** List the original issue date of the PPOA.

2. **Revision No.:** List the revision number for this worksheet. {Original issue = 0.}

3. **Revision Date:** List the most recent revision date for this worksheet.

4. **PPOA Title:** List the PPOA title selected by the team.

5. **PPOA ID Code(s):** List the PPOA ID Code(s) selected by the team.

6. **Name, Job Classification, Phone:** To facilitate team meetings and for future reference, this information should be completed when the PPOA team is formed.

Worksheet 2

Level III

Revision No.: ________

Revision Date: ________

Pollution Prevention Opportunity Assessment

Process Description

PPOA Title: ____________________

PPOA ID Code(s): ____________________

Process Location: ____________________

Process Description: ____________________

Description of Major Product(s) of Process: ____________________

Worksheet 2

Worksheet 2 provides a brief description of the process. The main elements of the process description are the process location, input materials, equipment, summary of operations performed, process controls, operator training, major products, and the waste streams affected.

1. **Revision No.:** List the revision number for this worksheet.

2. **Revision Date:** List the most recent revision date for this worksheet.

3. **PPOA Title:** List the PPOA Title given on Worksheet 1.

4. **PPOA ID Code(s):** List the PPOA ID Code(s) given on Worksheet 1.

5. **Process Location:** List the best descriptor of the process location. It may be a department, building, room, etc..

6. **Process Description:** The process description should detail important attributes of the process. Equipment, summary of operations performed, process controls, input materials, and operator training (qualification or certification) should be included.

7. **Description of Major Product(s) of Process:** Describe the major products which result from this process or the reason the process is being perfromed.

Worksheet 3
Style 1
Level III

Revision No. : ____________
Revision Date: ____________

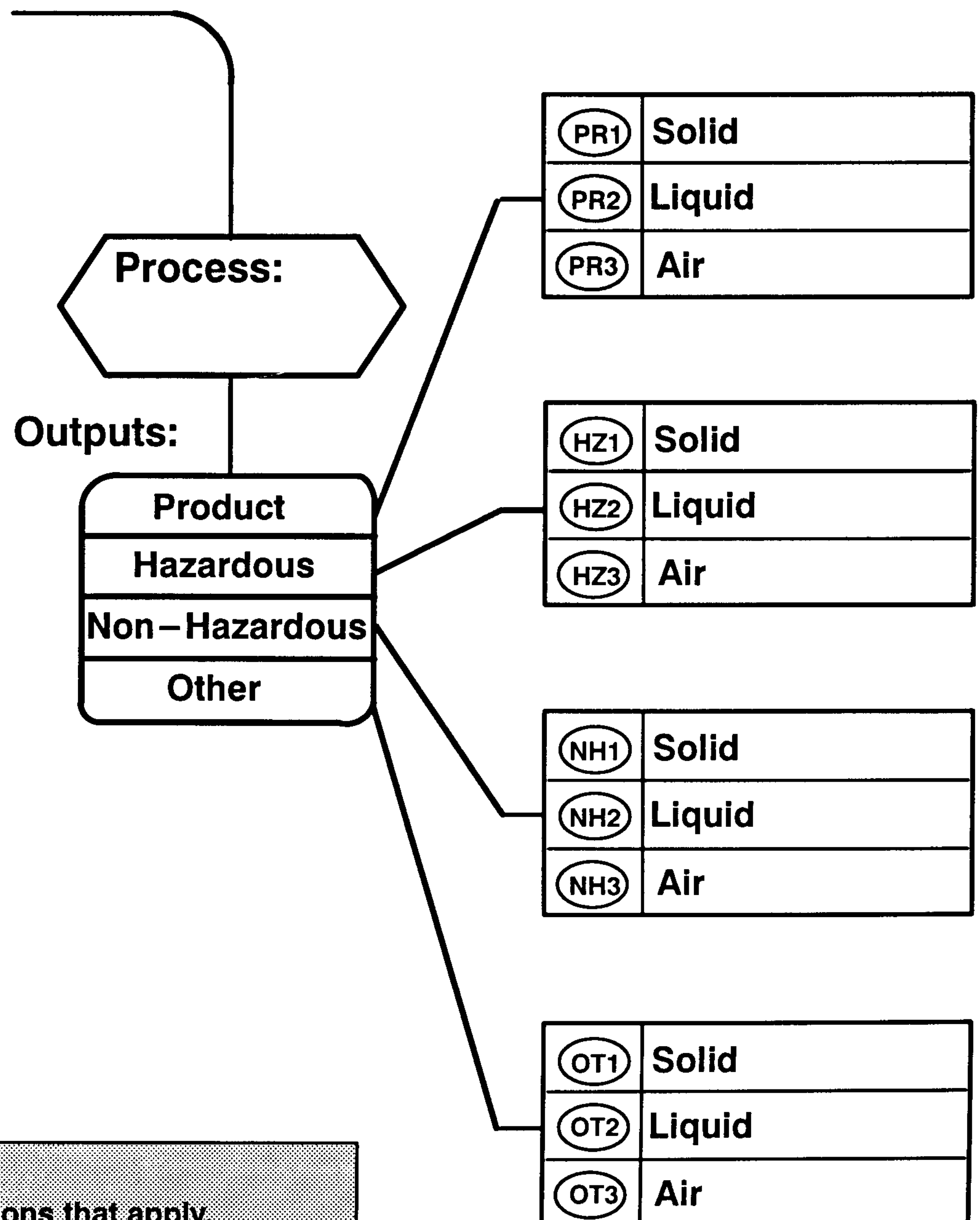
Pollution Prevention Opportunity Assessment

Process Flow Diagram

PPOA Title or PPOA ID Code(s): ____

Inputs:

____
____
____
____
____
____
____



Highlight those sections that apply. Use Worksheet 4 to identify and quantify the appropriate stream.

Worksheet 3

Worksheet 3 provides a process flow diagram for the PPOA. The flow diagram should identify all PPOA ID Code(s) associated with the process, all input materials, and outputs (products/wastes). The flow diagram should track materials from the time they enter the process boundary until they leave. This diagram represents a very simplistic flow model; a more detailed diagram may be required to identify all waste streams, especially for complex, multi-step processes.

1. **Revision No.:** List the revision number for this worksheet.

2. **Revision Date:** List the most recent revision date for this worksheet.

3. **PPOA Title or PPOA ID Code(s)**: List the PPOA Title or PPOA ID Code(s) given on Worksheet 1.

4. **Process Flow Diagram**: List the input materials on the lines provided. Fill in the Process Name box. Then highlight those outputs that are applicable to the process (e.g. Product, Hazardous, etc.). Then sub-categorize those outputs into solid, liquid, or air emission streams by highlighting the corresponding output stream. A **Stream ID Code** is provided for each sub-category of waste.

5. **Outputs:** The Stream ID Code provides a uniform coding scheme for the release information requested on Worksheet 4. A brief waste description may be recorded in the box to the right of the Stream ID Code.

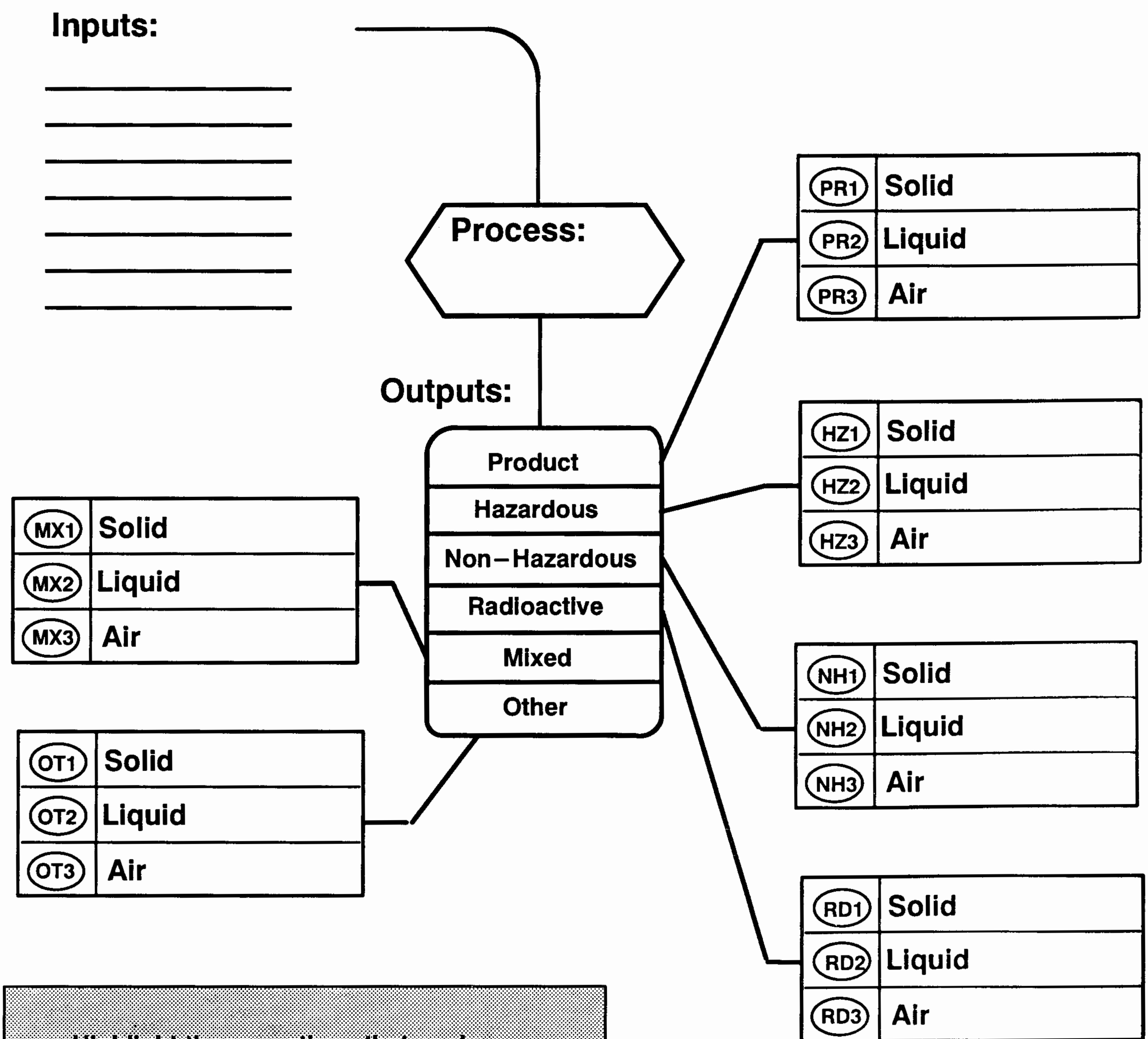
Worksheet 3
Style 2
Level III

Revision No.: ____________
Revision Date: ____________

Pollution Prevention Opportunity Assessment

Process Flow Diagram

PPOA Title or PPOA ID Code(s): ____



Highlight those sections that apply.
Use Worksheet 4 to identify and
quantify the appropriate stream.

Worksheet 3

Worksheet 3 provides a process flow diagram for the PPOA. The flow diagram should identify all PPOA ID Code(s) associated with the process, all input materials, and outputs (products/wastes). The flow diagram should track materials from the time they enter the process boundary until they leave. This diagram represents a very simplistic flow model; a more detailed diagram may be required to identify all waste streams, especially for complex, multi-step processes.

1. **Revision No.:** List the revision number for this worksheet.

2. **Revision Date:** List the most recent revision date for this worksheet.

3. **PPOA Title or PPOA ID Code(s)**: List the PPOA Title or PPOA ID Code(s) given on Worksheet 1.

4. **Process Flow Diagram**: List the input materials on the lines provided. Fill in the Process Name box. Then highlight those outputs that are applicable to the process (e.g. Product, Hazardous, etc.). Then sub-categorize those outputs into solid, liquid, or air emission streams by highlighting the corresponding output stream. A **Stream ID Code** is provided for each sub-category of waste.

5. **Outputs:** The Stream ID Code provides a uniform coding scheme for the release information requested on Worksheet 4. A brief waste description may be recorded in the box to the right of the Stream ID Code.

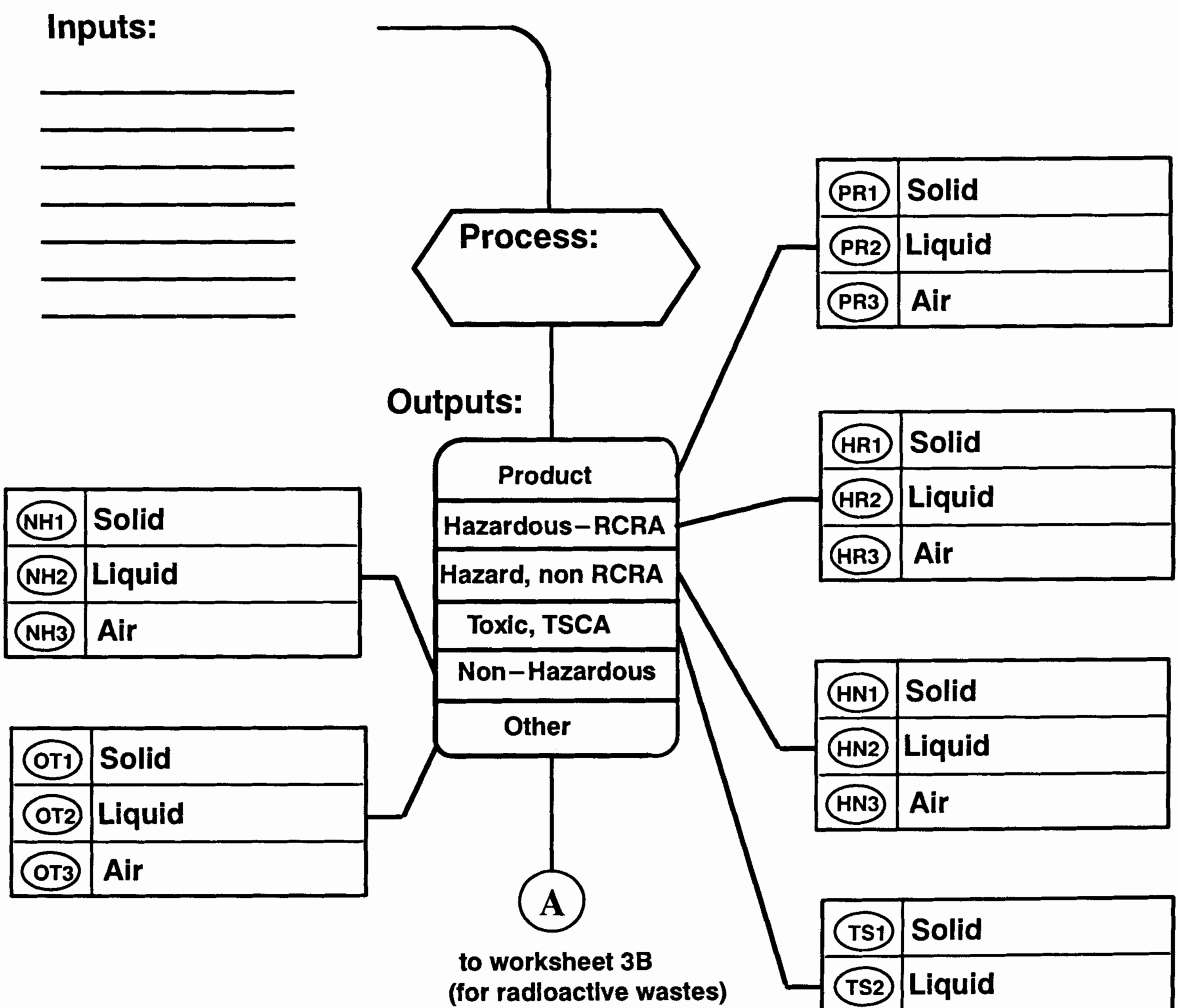
Worksheet 3A
Style 3
Level III

Revision No.: ______
Revision Date: ______

Pollution Prevention Opportunity Assessment

Process Flow Diagram

PPOA Title or PPOA ID Code(s): ____________________



**Highlight those sections that apply.
Use Worksheet 4 to identify and
quantify the appropriate stream.**

11/93

Worksheet 3A

Worksheet 3 provides a process flow diagram for the PPOA. The flow diagram should represent all PPOA ID Code(s) associated with the process, all input materials, and outputs (products/wastes). The flow diagram should track materials from the time they enter the process boundary until they leave. This diagram represents a very simplistic flow model; a more detailed diagram may be required to identify all waste streams, especially for complex, multi-step processes.

1. **Revision No.:** List the revision number for this worksheet.

2. **Revision Date:** List the most recent revision date for this worksheet.

3. **PPOA Title or PPOA ID Code(s)**: List the PPOA Title or PPOA ID Code(s) given on Worksheet 1.

4. **Process Flow Diagram**: List the input materials on the lines provided. Fill in the Process Name box. Then highlight those outputs that are applicable to the process (e.g. Product, Hazardous, etc.). Then categorize those outputs into solid, liquid, or air emission streams by highlighting the corresponding output stream. A **Stream ID Code** is provided for each category of waste.

5. **Outputs:** The Stream ID Code provides a uniform coding scheme for the release information requested on Worksheet 4. A brief waste description may be recorded in the box to the right of the Stream ID Code.

DOE Definitions:

Hazardous Waste - Waste, which because of its quantitiy, concentration, or physical, chemical or infectious nature may (a) cause or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible illness, or (b) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, disposed of, or otherwise managed. Hazardous waste can be further defined as:

RCRA-regulated - solid waste not specifically excluded from regulation under 40 CFR 261.4, or delisted by petition, that is either a listed hazardous waste (40 CFR 261.30 - 261.33) or exhibits the characteristics of a hazardous waste (40 CFR 261.20 - 261.24).

Non RCRA-regulated - any other hazardous waste not specifically regulated under TSCA or RCRA, which may be regulated by the state or local authorities, such as used oil.

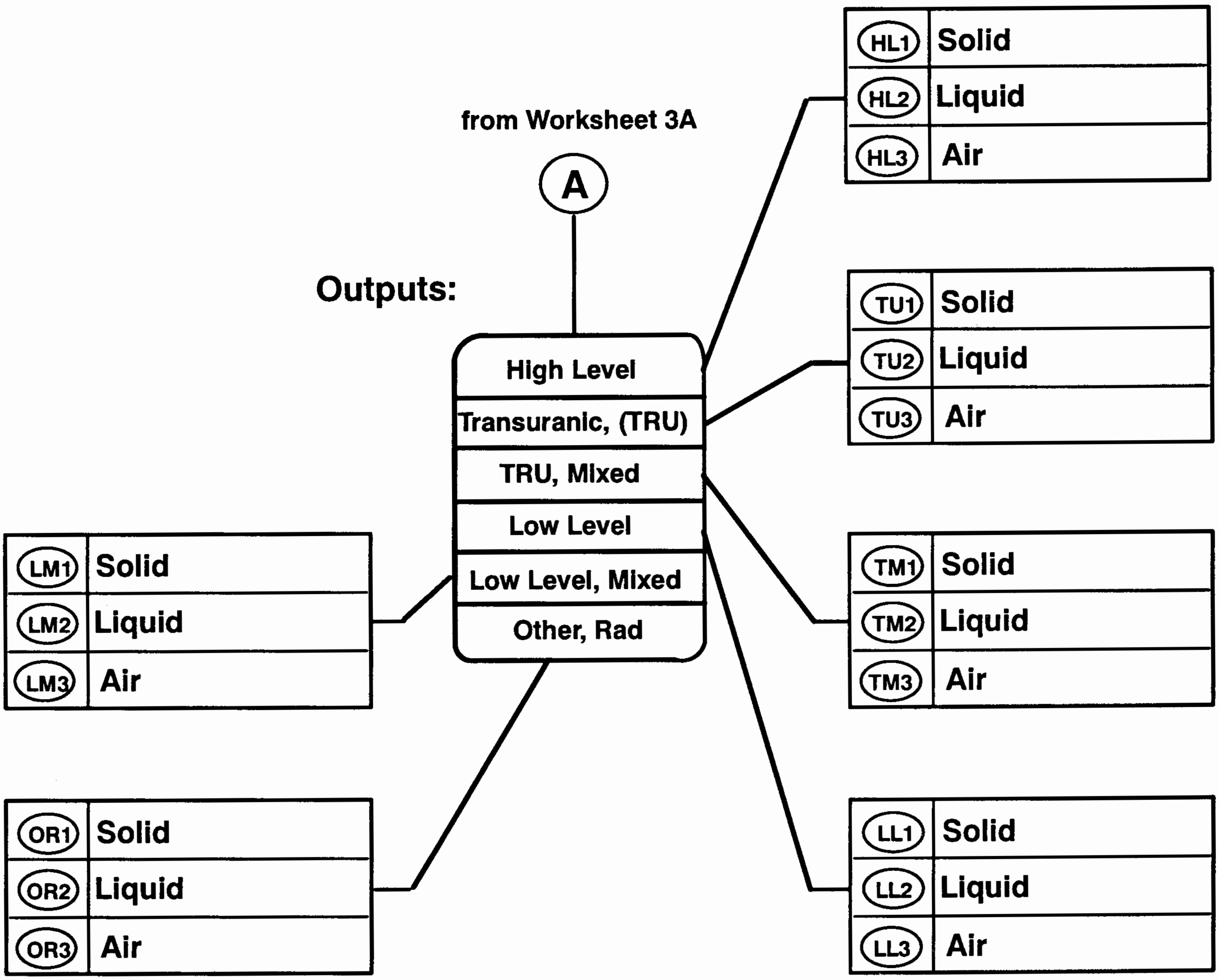
TSCA Waste - Individual chemical wastes (both liquid and solid), such as polychlorinated biphenyls (PCBs).

Worksheet 3B
Style 3
Level III

Revision No. : ____________
Revision Date: ____________

Pollution Prevention Opportunity Assessment
Process Flow Diagram

PPOA Title or PPOA ID Code(s): ____



Highlight those sections that apply.
Use Worksheet 4 to identify and quantify the appropriate stream.

Worksheet 3B

Worksheet 3 provides a process flow diagram for the PPOA. The flow diagram should represent all PPOA ID Code(s) associated with the process, all input materials, and outputs (products/wastes). The flow diagram should track materials from the time they enter the process boundary until they leave. This diagram represents a very simplistic flow model; a more detailed diagram may be required to identify all waste streams, especially for complex, multi-step processes.

1. **Revision No.:** List the revision number for this worksheet.

2. **Revision Date:** List the most recent revision date for this worksheet.

3. **PPOA Title or PPOA ID Code(s)**: List the PPOA Title or PPOA ID Code(s) given on Worksheet 1.

4. **Process Flow Diagram**: List the input materials on the lines provided. Fill in the Process Name box. Then highlight those outputs that are applicable to the process (e.g. Product, Hazardous, etc.). Then categorize those outputs into solid, liquid, or air emission streams by highlighting the corresponding output stream. A **Stream ID Code** is provided for each category of waste.

5. **Outputs:** The Stream ID Code provides a uniform coding scheme for the release information requested on Worksheet 4. A brief waste description may be recorded in the box to the right of the Stream ID Code.

DOE Definitions:

High Level Waste- Irradiated reactor fuel, liquid wastes resulting from operation of the first cycle solvent extraction system, or equivalent, and the concentrated wastes from subsequent extraction cycles, or equivalent, in a facility for reprocessing irradiated reactor fuel, and solids into which such liquid wastes have been converted. (10 CFR 60.2)

Transuranic Waste - Waste that is contaminated with alpha-emitting radionuclides with (1) an atomic number greater than 92 (heavier than uranium); (2) half-lives greater than 20 years; and (3) concentrations greater than 100 nanocuries per gram of waste.

Transuranic Mixed Waste: - Waste which contains both transuranic waste and hazardous components, as defined by the Atomic Energy Act and RCRA, respectively.

Low Level Waste: - Radioactive Waste not classified as high level waste, transuranic waste, spent nuclear fuel, or by-product material [specified as uranium or thorium tailings and waste in accordance with DOE Order 5820.2A].

Low Level Mixed Waste: - Waste which contains both low level waste and hazardous components, as defined by the Atomic Energy Act and RCRA, respectively.

Worksheet 4

Level III

Pollution Prevention Opportunity Assessment

Mass Balance Summary

Revision No.: ____________
Revision Date: ____________
Page ________ of ________

Time frame
From: ________
To: ________

PPOA Title or PPOA ID Code(s): ____________________

Material Description	Total Input	OUTPUT QUANTITY (Units: _____)									
		Total Output	Stream ID Code ◯	Stream ID Code ◯	Stream ID Code ◯	Stream ID Code ◯	Stream ID Code ◯	Stream ID Code ◯	Stream ID Code ◯	Stream ID Code ◯	Stream ID Code ◯
Totals/Subtotals											

Worksheet 4

A material balance is a summation of the total quantity of input material to a process and the releases to the environment, another process, or made into product. The purpose of Worksheet 4 is to tabulate this information and total the inputs and outputs for all streams.

1. **Revision No.:** List the revision number of the PPOA.

2. **Revision Date**: List the most recent revision date for the PPOA worksheet.

3. **PPOA Title/PPOA ID Code(s)**: List the PPOA Title or ID Code(s) given on Worksheet 1.

4. **Page ____of ____:** Indicate the page number for this worksheet and the number of pages for this worksheet.

5. **From/To**: Report the dates (month and year) for the time period covered. An annual period is suggested for purposes of averaging and documenting performance toward facility goals.

6. **Material Description:** List the material name and stock number (optional) or the output product if different than originating material.

7. **Units ____:** Enter the unit of measure for the input/output summary. A consistent unit of measurement is suggested. If requirements dictate mixing units, designate the units for a particular column under the Stream ID Code heading.

8. **Total Input:** For the material described in the far left column enter the weight of material used in the process during the time frame specified.

9. **Total Output:** For the material specified in the Material Description column enter the weight of the output. This is the sum of all waste streams and any product generated. For processes where chemical reactions take place, input materials are consumed or changed to different compounds, a separate entry in the Material Description column is required to adequately define the output. In these cases, the input and output quantities will not balance for the listed material in that row.

10. **Output Quantity:** Use these columns to break down the total output into output categories. Refer to Worksheet 3 for the appropriate Stream ID Code for the output type. Enter the Stream ID Code at the top of the column (e.g., HZ1 for a hazardous solid waste stream), then enter the discharge amount for the material described in the Material Description column that relates to that Stream ID Code. Continue across the worksheet for all Stream ID Code(s) utilized in Worksheet 3.

11. **Totals/Subtotals:** Sum the Total Input, Total Output, and Output columns. Record the sum at the bottom row of the last worksheet. Subtotals are recorded at the bottom row for other pages of the worksheet. The Total Input column should equal the Total Output column unless there is system accumulation. The Total Output column should also be the sum of all the Stream ID Code output streams.

Stream ID Codes:

Designator	Style 1	Style 2	Style 3
Product	PR	PR	PR
Hazardous	HZ	HZ	
Non-Hazardous	NH	NH	NH
Radioactive		RD	
Mixed		MX	
Other	OT	OT	OT
Hazardous, RCRA			HR
Hazardous, Non-RCRA			HN
Toxic, TSCA			TS
High Level			HL
Transuranic, TRU			TU
TRU, Mixed			TM
Low Level			LL
Low Level, Mixed			LM
Other, Radioactive			OR

Solid Stream = 1, Liquid Stream = 2, Air Stream = 3

Style refers to the version of Worksheet 3 used.

Worksheet 5

Level III

Revision No.: ______
Revision Date: ______
Page _____of ______

Pollution Prevention Opportunity Assessment

Material Cost

PPOA Title or PPOA ID Code(s): ____

Input Material Cost:

Material	Stock Number (if applicable)	Cost Per Unit	Annual Cost
		Total / Subtotal	

Waste Disposal Cost:

Material / Waste Stream	Waste Stream Category	Cost Per Unit	Annual Cost
		Total / Subtotal	

Worksheet 5

Worksheet 5 details the cost of the PPOA input materials (use the quantities from Worksheet 4) and the cost of disposal for these materials. The material cost may be obtained from Purchasing or Stores. The cost of disposal may be obtained from Waste Management or Accounting. Annual Cost is calculated from the amount of material placed in the process or from the amount of disposed material, multiplied by the cost per unit.

1. Revision No.: List the revision number for this worksheet.

2. Revision Date: List the most recent revision date for this worksheet.

3. Page_____of_____: Indicate the number of this page and the total number of pages for this worksheet.

4. PPOA Title or PPOA ID Code(s): List the PPOA Title or PPOA ID Code(s) given on Worksheet 1.

5. Input Material Cost: List the material, stock number (if applicable), cost per unit ($/lb., $/gal, etc.), and the annual cost for this process.

6. Waste Disposal Cost: List the material or waste stream, waste stream category, (e.g., hazardous liquid), stock number if applicable, the cost per unit ($/lb., $/gal, etc.) , and annual cost.

7. Totals / Subtotals: Record the sum of the annual costs for the materials or waste streams listed. There will be a total for both the input material cost and waste disposal cost.

Worksheet 6

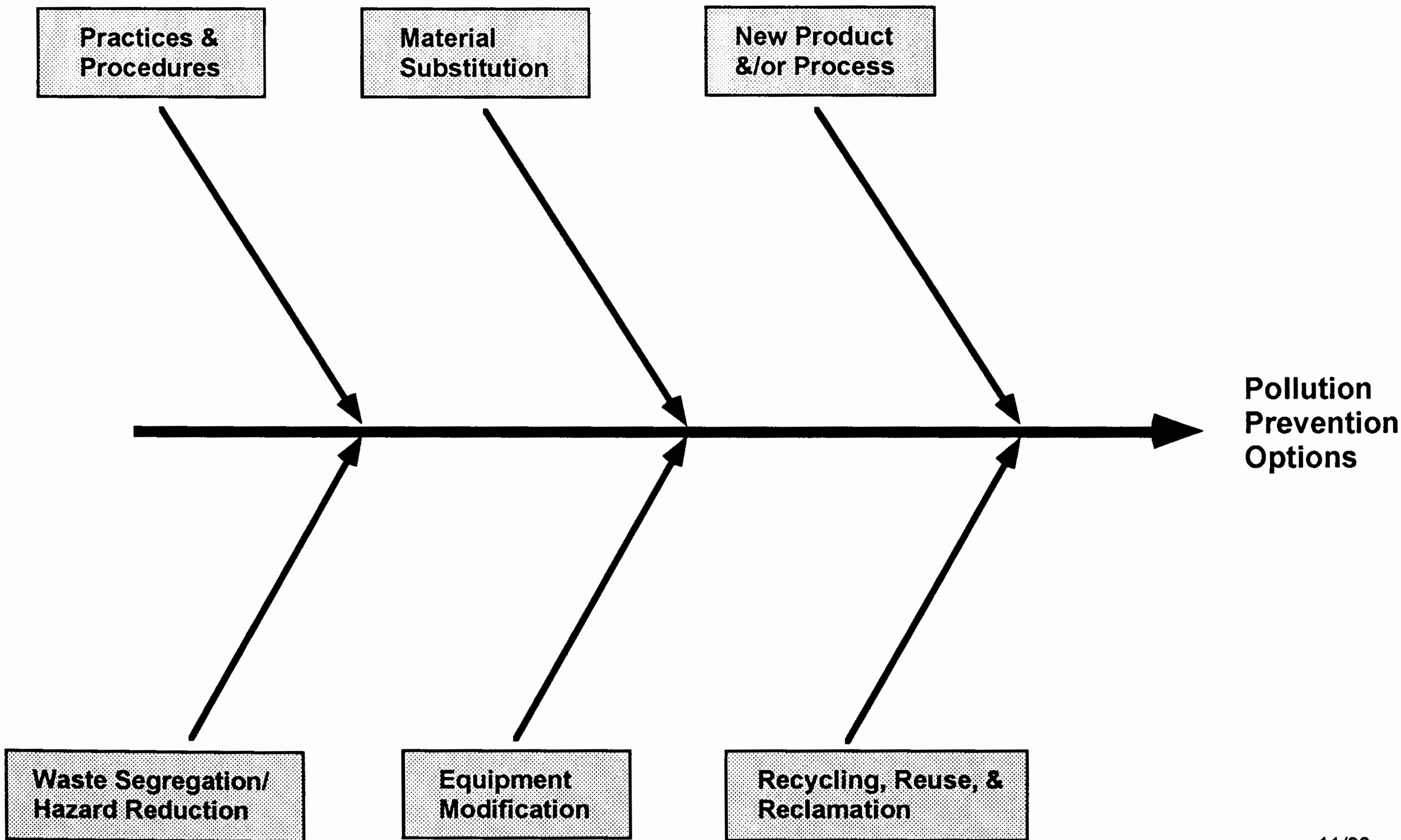
Level III

Pollution Prevention Opportunity Assessment

Revision No.: ____________
Revision Date: ____________

Option Generation

PPOA Title or PPOA ID Code(s): ______________________________



Worksheet 6

Worksheet 6 provides a tool for option generation. The purpose of this diagram (sometimes referred to as a Fishbone Diagram) is to help generate pollution prevention ideas. It is especially useful in a brainstorming session to group ideas undersimilar pollution prevention categories. It also helps insure that all of the pollution prevention categories are considered.

1. **Revision No.:** List the revision number for this worksheet.

2. **Revision Date:** List the most recent revision date for this worksheet.

3. **PPOA Title or PPOA ID Code(s):** List the PPOA title or PPOA ID Code(s) given on Worksheet 1.

4. **Brainstorming ideas:** Using the Fishbone Diagram, briefly document ideas for pollution prevention.

The following definitions clarify each of the major categories.

Practices & Procedures -- Good operating practices and procedures apply to the human aspect of operations. They are largely efficiency improvements. Examples are: Pollution Prevention Programs, personnel training, material handling & inventory practices, material loss prevention, scrap reduction, cost accounting, production scheduling, etc.

Material Substitution -- Changes to the input materials of the process. The result is a reduction or elimination of a pollutant or hazard.

New Product &/or Process -- Product changes which result in the reduction or elimination of waste. In addition, a different process can be used to create the same product with the intent of minimizing waste.

Waste Segregation/Hazard Reduction -- Actions taken to segregate waste streams to prevent nonhazardous waste from being designated and handled as hazardous. Hazard reduction can result from changes to the physical, chemical, or biological character or composition of the waste. These include neutralization, toxicity reduction, or volume reduction.

Equipment Modification -- Changes that occur to the equipment used in a process. These could include minor adjustments, additions, or complete replacements.

Recycling -- A material is recycled if it is used, reused, or reclaimed: (1) if it is used for something other than its original purpose, (2) if it goes back into the original process, or (3) if it is chemically or physically treated for use or reuse.

Worksheet 7

Level III

Revision No.: _____
Revision Date:_____
Page _____**of**_____

Pollution Prevention Opportunity Assessment

Option Description

PPOA Title or PPOA ID Code(s): ____________________

Option Name and Description
(Include input materials, products affected, and anticipated reduction quantity.)

Option No. _____ **:** ____________________

____

____

____

Consider: Yes__No__

Practices & Procedures _______ Waste Segregation/Hazard Reduction _____
Material Substitution _________ Equipment Modification _____
New Product &/or Process _____ Recycling, Reuse, & Reclamation _____

Option No. _____ **:** ____________________

____

____

____

Consider: Yes__No__

Practices & Procedures _______ Waste Segregation/Hazard Reduction _____
Material Substitution _________ Equipment Modification _____
New Product &/or Process _____ Recycling, Reuse, & Reclamation _____

Option No. _____ **:** ____________________

____

____

____

Consider: Yes__No__

Practices & Procedures _______ Waste Segregation/Hazard Reduction _____
Material Substitution _________ Equipment Modification _____
New Product &/or Process _____ Recycling, Reuse, & Reclamation _____

Option No. _____ **:** ____________________

____

____

____

Consider: Yes__No__

Practices & Procedures _______ Waste Segregation/Hazard Reduction _____
Material Substitution _________ Equipment Modification _____
New Product &/or Process _____ Recycling, Reuse, & Reclamation _____

Worksheet 7

The purpose of this worksheet is to further document the pollution prevention options identified on Worksheet 6. The process by which options are identified should occur in an environment that encourages creativity and independent thinking. Brainstorming sessions are effective ways for individuals to generate options. Consideration of the options generated in a brainstorming session can lead to questions. Answering these questions may require additional research. Listed below are some of the sources that can help to answer questions and/or generate additional options.

- Literature searches
- Technical conferences
- Equipment exhibitions
- Trips to other plants
- Vendor surveys
- Contact with design engineers
- Contact with personnel in other departments who have participated in similar PPOAs
- Materials engineers
- Benchmarking

1.Revision No.: List the revision number for this worksheet.

2. Revision Date: List the most recent revision date for this worksheet.

3. PPOA Title or PPOA ID Code: List the PPOA Title or PPOA ID Code given on Worksheet 1.

4. Page ___ of ___: Indicate the number of this page and the total number of pages for this worksheet.

5. Option: Options generated should be numbered consecutively and placed on this worksheet (reference Worksheet 6). They may or may not be evaluated. Briefly describe each option, affected materials and product, any roadblocks to implementation, upstream and downstream impacts if implemented, and anticipated reduction quantity.

6. Consider Yes/No: If the suggestion is worth further consideration, check 'Yes'. If the suggestion will not be pursued, check 'No' and indicate briefly in the Option Description why not.

7. Practices & Procedures, Material Substitution, New Product &/or Process, Waste Segregation/ Hazard Reduction, Equipment Modification, and Recycling, Reuse, & Reclamation: Check the appropriate descriptions. See Worksheet 6 for definitions.

Worksheet 8
Level III

Revision No.: ________
Revision Date: ________
Page ________of ________

Pollution Prevention Opportunity Assessment

Options Cost Evaluation

PPOA Title or PPOA ID Code(s): ____________________

	Option No.:	Option No.:	Option No.:	Option No.:	Option No.:
Implementation Costs					
Purchased Equipment					
Installation					
Materials					
Utility Connections					
Engineering					
Development					
Start up / Training					
Administrative					
Other					
Total Implementation Cost					
Incremental Operating Costs					
Change in Raw Materials					
Change in Maintenance					
Change in Labor					
Change in Disposal					
Other					
Annual Operating Savings/(Cost)					
Incremental Intangible Costs					
Penalties and Fines					
Future Liabilities					
Other					
Annual Intangible Savings/(Cost)					
Total Annual Savings/(Cost)					
Payback Period					

Worksheet 8

This worksheet provides a method to compare and contrast the pollution prevention options generated on Worksheet 6 from a cost perspective. The three major cost categories for weighing options are: Implementation Costs, Incremental Operating Costs, and Incremental Intangible Costs. These costs are totaled for each option considered from Worksheet 7. This worksheet will aid in completing the economic evaluation portion of Worksheet 9.

1. **Revision No.:** List the revision for this worksheet.

2. **Revision Date:** List the most recent revision date for this worksheet.

3. **Page ____of____:** Indicate the number of this page and the total number of pages for this worksheet.

4. **PPOA Title or PPOA ID Code(s):** List the PPOA Title or PPOA ID Code(s) given on Worksheet 1.

5. **Implementation Cost:** These are the one-time, first-year costs associated with the implementation of each option. Installation costs should be reported as an estimate. Implementation Cost may include materials, utility connections, site preparation, installation, engineering, procurement, start-up, training, permitting, initial catalysts and chemicals, and working capital; minus the salvage value of any existing equipment.

6. **Annual Operating Savings/(Costs):** These are the costs associated with day-to-day operations. List the incremental costs compared to the current process costs (positive for savings or negative for increased costs) that would be incurred if this option is implemented. Incremental operating costs could include waste disposal, raw material consumption, ancillary catalysts and chemicals, labor, maintenance and supplies, insurance, incremental revenues from increased / decreased production, and incremental revenues from marketable by-products.

7. **Annual Intangible Savings/(Cost):** These include hidden, liability, and other costs not immediately obvious for each option. List the incremental costs compared to the current process costs (positive for savings or negative for increased costs) that would be incurred if this option is implemented. These costs could include penalties and fines, future liabilities (storage, transportation, and disposal of hazardous waste), reporting, consulting fees, monitoring/testing, record keeping, preparedness and protective equipment, medical surveillance, manifesting, inspections, and corporate/public image.

8. **Total Annual Cost/Savings:** This is the sum of the **Annual Operating Savings/(Cost)** and the **Annual Intangible Savings/(Cost)**.

9. **Payback Period:** Divide the **Total Implementation Cost** by the **Total Annual Savings/(Cost)**.

Worksheet 9

Level III

Revision No.: ________
Revision Date: ________
Page ______ of ________

Pollution Prevention Opportunity Assessment

Weighted Sums Option Evaluation

PPOA Title or PPOA ID Code(s): ______________________________

Criteria	Weight 'W'	Option No.: ____ Scale 'S'	'WxS'	Option No.: ____ Scale 'S'	'WxS'	Option No.: ____ Scale 'S'	'WxS'	Option No.: ____ Scale 'S'	'WxS'	Option No.: ____ Scale 'S'	'WxS'
Public Health, Safety, & Environment	10										
Employee Health & Safety	10										
Regulatory Compliance	8										
Economic	6										
Implementation Period	4										
Improved Operation / Product	2										
Other											
Subtotal											
Likelihood of Technical Success (Multiplier)		x		x		x		x		x	
Likelihood of Useful Results (Multiplier)		x		x		x		x		x	
Total											
Rank											

Many pollution prevention options will be identified in a successful assessment. At this point, it is necessary to identify those options that offer real potential to minimize waste and reduce costs. Worksheet 9 serves as a screening tool to prioritize or eliminate suggested options.

1. **Revision No.:** List the revision number for this worksheet.

2. **Revision Date:** List the most recent revision date for this worksheet.

3. **Page ____ of ____:** Indicate the number of this page and the total number of pages for this worksheet.

4. **PPOA Title or PPOA ID Code(s):** List the PPOA Title or PPOA ID Code(s) given on Worksheet 1.

Additional Instructions:

a. The values in the Weight column (designated by 'W') represent the facility's priority for the criteria.

b. In the Scale column for each option (designated by 'S'), rate each criteria by assigning a value from 0-10 (lowest to highest). Use the definitions which follow to help determine a value.

c. In the 'W x S' column for each option, enter the product of the weight and scale.

d. Sum the 'W x S' column for each option to obtain a subtotal.

e. Multiply the subtotal for each option by the Likelihood of Technical Success.

f. Multiply the value in step e. above for each option by the Likelihood of Useful Results.

g. Enter the product found in step f. in the Total column for each option.

h. Assign a priority rank for each option; #1 for the highest score, #2 for the next highest, and so on.

Worksheet 9 -- (Scale & Multiplier Definitions)

Scale Factor Definitions (0-10)

	Public Health, Safety, & Environment -- Health or safety risk to the general public or damage to the environment.
10	Reduce the risk of loss of life or long-term environmental damage. High concentrations of hazardous materials.
8	Reduce the risk of long-term disability or moderate environmental damage. Moderate concentrations of hazardous materials.
6	Reduce the risk of short-term disability or unplanned releases to the environment. Low concentrations of hazardous materials.
4	No effect.
0	Negative effect.

	Employee Health & Safety -- Health or safety risk to an employee, contractor, or visitor.
10	Reduce the risk of loss of life through an accident or long-term exposure.
8	Reduce the risk of permanent or long-term disability through an accident or long-term exposure.
6	Reduce the risk of short-term disability or lost-time through an accident or long-term exposure.
4	No effect.
0	Negative effect.

	Regulatory Compliance -- Risk of non-compliance to regulatory laws with respect to employees or managers.
10	Reduce the risk and avoid criminal penalties.
8	Reduce the risk and avoid civil penalties.
6	Reduce the risk.
4	No effect.
0	Negative impact.

	Economic -- Potential for cost savings and payback period.
10	Large savings and short payback.
8	Moderate savings and moderate payback.
6	Positive cost savings and extented payback.
4	No cost savings and no possibility of payback.
0	Negative cost savings.

	Implementation Period -- Potential for rapid implementation of pollution prevention options.
10	Immediate (e.g., within 1 month).
8	Short-term (e.g., within 1 year).
6	Intermediate (e.g., within 2 years).
4	Long-term (e.g., within 3 years).
0	Greater than 3 years.

	Improved Operation / Product -- Quality improvement to process or product.
10	Significant improvement.
8	Moderate improvement.
6	Positive improvement.
4	No improvement.
0	Negative effect.

Worksheet 9 -- (Scale & Multiplier Definitions)

Multiplier Definitions (0-1)

Likelihood of Technical Success	
1	High likelihood: No major technical breakthrough required. Well-designed plans to meet objectives and successful track record exists.
0.5	Medium likelihood: Technical advancements may be necessary. Key issues are identified but no specific contingency plans have been made.
0.1	Low likelihood: Major technical breakthroughs are required. Adequate plans for meeting objectives or key problems have not been identified.

Likelihood of Useful Results	
1	High likelihood: Project has demonstrated that it can meet production requirements. There is a high confidence that implementation will not create unacceptable risks. Benefits outweigh the costs.
0.5	Medium likelihood: Project has not yet demonstrated that it can meet production requirements. There are reservations that implementation can be achieved without creating unacceptable risks. Benefits do not clearly outweigh the costs.
0.1	Low likelihood: The option is not capable of demonstrating that it can meet production requirements. Serious reservations are present that implementation can be achieved without creating unacceptable risks. Costs significantly outweigh the benefits.

Worksheet 10
Level III

Revision No.:______
Revision Date:______
Page _____ of _____

Pollution Prevention Opportunity Assessment
Final Report Check Sheet

PPOA Title or PPOA ID Code(s): ____________________

Requirement	*Completed*
Title Page	____
PPOA Title	
PPOA ID Code(s)	
Team members	
Issue date/revision date/revision no.	
Executive Summary	____
Process description	
Process assessment	
Option summary and analysis	
Conclusions	
Recommendations	
Introduction	____
Background of evaluation	
Process Description	____
Associated equipment	
Process flow diagram	
Process Assessment	____
Methodology	
Material Balance	
Unusual occurrences	
Option Summary and Analysis	____
Option description and rank	
Upstream/Downstream impacts	
Material usage	
Anticipated reduction	
Estimated costs	
Estimated benefits	
Feasibility	
Waste streams affected	
Conclusion	____
Concluding evaluation	
Option analysis decisions	
Concerns	
Options already implemented	
Lessons learned	
Recommendations	____
Future work	
New equipment	
Implementation strategies	
Worksheets	____
1-10	

Worksheet 10

A final report is required for each PPOA. The final report is a compilation of essential facts about the process, pollution prevention options, feasibility and impact of those options, and future implementation costs. The report documents the work performed and identifies funding requirements necessary to implement pollution prevention options. The length of the final report will depend on the complexity of the PPOA.

1. Revision No.: List the revision number for this worksheet.

2. Revision Date: List the most recent revision date for this worksheet.

3. Page____of____: Indicate the number of this page and the total number of pages for this worksheet.

4. PPOA Title or PPOA ID Code(s): List the PPOA Title or PPOA ID Code(s) given on Worksheet 1.

5. While writing the final report, check the blank next to each major **requirement** as all elements of that task are **completed**.

Title Page	Uniquely identify the PPOA, including team members and issue/revision date.
Executive Summary	This should be an overview of all of the elements of the final PPOA report. It should relate to the reader any information that is critical about this PPOA.
Introduction	Present background information and efforts taken to initiate the PPOA.
Process Description	Detail process flow and associated equipment. Include process flow diagram, if desired.
Process Assessment	Describe the approach used to complete the PPOA. Document any assumptions made. Include information on the material balance.
Option Summary & Analysis	Present the options generated, impacts if implemented, and their respective pollution prevention possibilities.
Conclusion	Provide closure to the report. The team's consensus on the benefits achieved from this PPOA or any concerns respective to the process should be included.
Recommendations	Describe any actions that will be taken to further advance the results of this PPOA.

Worksheet 1S

Level I

Date: ________

Page ______ of ______

Pollution Prevention Opportunity Assessment

Team & Process Description

Title:

PPOA ID Code:

Team Members (*Leader)	Job Classification	Phone
*		

Process Description:

Potential for Pollution Prevention or Recommendations:

Worksheet 1S

This worksheet provides the scope and identification of the pollution prevention opportunity assessment (PPOA) team. For the PPOA to be successful, employees involved with the activity being assessed should be members of the team. The assessment team needs a leader, members, and additional resources, as required.

The team leader should have technical knowledge of the area's operations and the personnel involved. The leader shall assemble the team to perform the assessment. Team members may include engineers, waste generators, waste management specialists, scientists, laboratory technicians, and other line personnel. Additional resources may be utilized to provide information not available within the team. The size of the team may be large for complicated operations, but should be kept to a minimum to maintain focus.

1. **Date:** List the initiation date for this PPOA.

2. **Title:** List the PPOA title selected by the team.

3. **PPOA ID Code:** List the PPOA ID Code selected by the team. This should be a unique identifier.

4. **Team Members, Job Classification, Phone:** To facilitate team meetings and for future reference, this information should be completed when the PPOA team is formed.

5. **Process Description:** This should detail important attributes of the operation. Equipment, summary of operations performed, controls, input materials, and operator training (qualification or certification) may be included.

6. **Potential for Pollution Prevention or Recommendations:** For this process, describe the potential for pollution prevention, source reduction, and/or waste minimization. (Is there any pollution prevention potential for the following changes: material substitution, procedures, process parameters, equipment, general practices, recycling, reuse, reclamation, etc.?) Are there any recommendations for this process?

Worksheet 2S

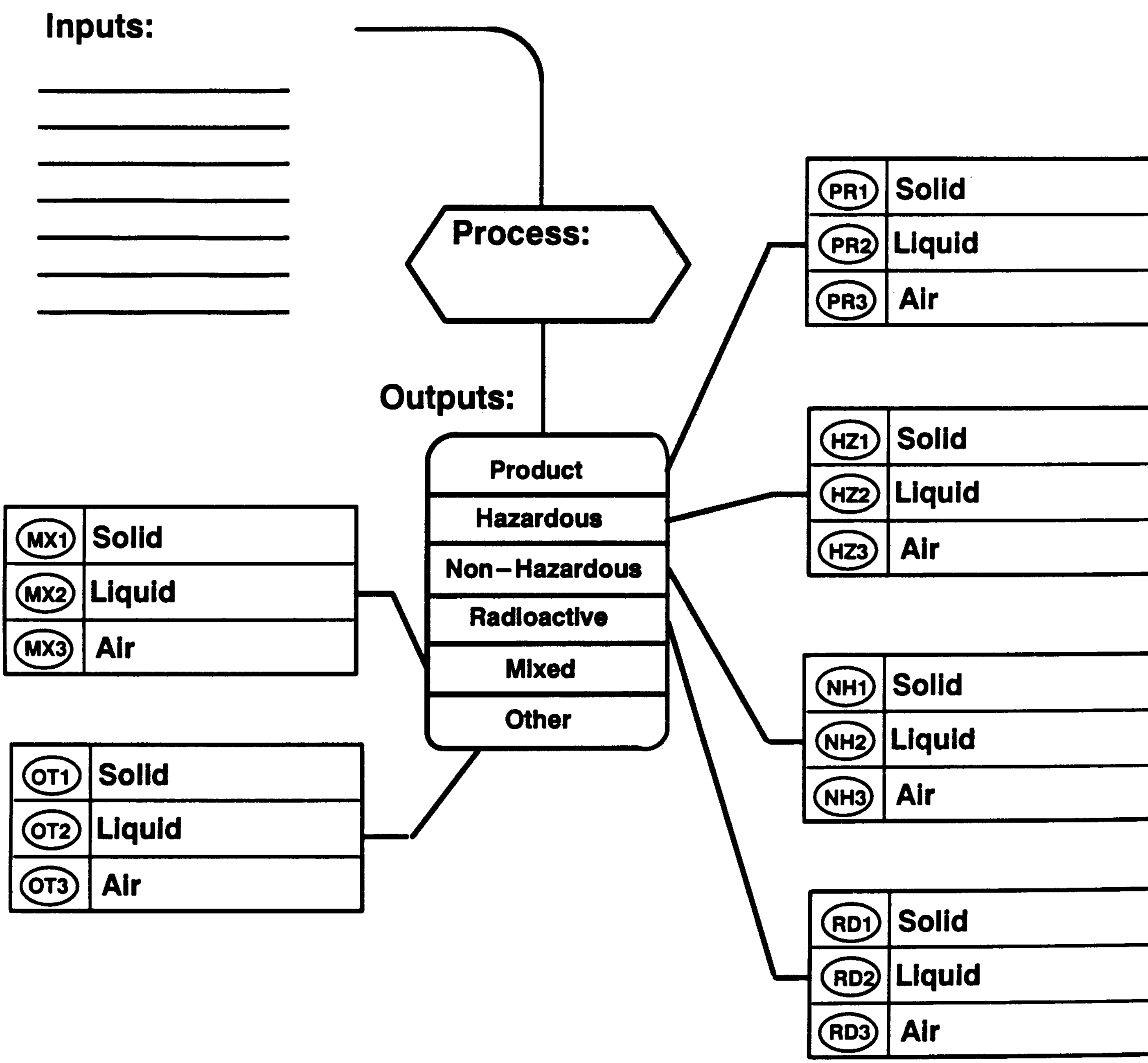
Level I

Date: ______

Pollution Prevention Opportunity Assessment

Process Flow Diagram

Title or Assessment ID Code: ____



Worksheet 2S

This worksheet provides a method to document the process flow diagram for the assessment. The flow diagram should identify all Assessment Code(s) associated with the process, all input materials, and outputs (products/wastes). The flow diagram should track materials from the time they enter the process boundary until they leave. This diagram represents a very simplistic flow model; a more detailed diagram may be required to identify all waste streams, especially for complex, multi-step processes.

1. **Title or Assessment ID Code(s)**: List the PPOA Title or PPOA ID Code given on Worksheet 1S.

2. **Page ____of ____:** Indicate the page number for this worksheet and the number of pages for this worksheet.

3. **Inputs**: List the input materials on the lines provided. Fill in the Process Name box. Then highlight those outputs that are applicable to the process (e.g. Product, Hazardous, etc.). Then sub-categorize those outputs into solid, liquid, or air emission streams by highlighting the corresponding output stream. A **Stream ID Code** is provided for each sub-category of waste.

4. **Outputs:** The Stream ID Code provides a uniform coding scheme for the release information. A brief waste description may be recorded in the box to the right of the Stream ID Code. The code information is summarized in the table below:

Stream ID Codes

Designator	Code
Product	PR
Hazardous	HZ
Non-Hazardous	NH
Radioactive	RD
Mixed	MX
Other	OT

Solid Stream = 1, Liquid Stream = 2, Air Stream = 3

Worksheet 3S

Level I

Page ______ of ______

Pollution Prevention Opportunity Assessment

Material & Waste Stream Summary

Title: ______

PPOA ID Code: ______

Input Material	Annual Quantity Used	% Product	% Recycled	Total Releases		
				% Air	% Liquid	% Solid

Does the process require further analysis based on the site's Priority Material/Waste Stream List?

Yes ______ No ______

Level II ______ Level III ______

Worksheet 3S

This worksheet provides a brief summary of the input materials and output streams from the operation or activity being assessed. Its purpose is to provide the pollution prevention team an overview of the waste streams resulting from the PPOA.

1. **Title:** List the PPOA title given on Worksheet 1S.

2. **Assessment ID Code:** List the PPOA ID Code given on Worksheet 1S.

3. **Input Material:** List the material names which enter the operation.

4. **Annual Quantity Used:** Enter the annual quantity used for each material listed - include the unit of measure, e.g., lbs, curies, etc. For input material from another process, it may be helpful to also identify the release components of those materials.

5. **% Product:** For each input material, estimate the percent of the annual quantity used which goes to product.

6. **% Recycled:** For each input material, estimate the percent of the annual quantity used which is recycled.

7. **% Air:** For each input material, estimate the percent of the annual quantity used which is an air waste stream.

8. **% Liquid:** For each input material, estimate the percent of the annual quantity used which is a liquid waste stream.

9. **% Solid:** For each input material, estimate the percent of the annual quantity used which is a solid waste stream.

10. **Does the process require further analysis based on the site's Priority Material/Waste Stream List?** Using your site's Priority Material/Waste Stream List and the DOE Graded Approach Logic Diagram, determine if further assessment is necessary. If yes, indicate the level of assessment required.

Worksheet 4S

Level II

Page ______ of ______

Pollution Prevention Opportunity Assessment

Option Summary

Title or PPOA ID Code(s) ______________________________

____

Option No. __: ______________________________

____

____

____

____

Type (*)	Consider?	Feasibility	Estimated Cost	Estimated Savings	Anticipated Reduction Qty

Option No. __: ______________________________

____

____

____

____

Type (*)	Consider?	Feasibility	Estimated Cost	Estimated Savings	Anticipated Reduction Qty

Option No. __: ______________________________

____

____

____

____

Type (*)	Consider?	Feasibility	Estimated Cost	Estimated Savings	Anticipated Reduction Qty

(*) Type = Source Reduction, Recycling, Treatment, or Disposal

Worksheet 4S

This summary sheet serves as a method to record and evaluate the options that have been identified during brainstorming sessions or other option generating techniques.

1. **Title or PPOA ID Code(s)**: List the PPOA Title or PPOA ID Code given on Worksheet 1S.

2. **Option :** Options generated should be numbered consecutively. Briefly describe each option, affected materials, waste streams, upstream/downstream impacts if implemented, and anticipated reduction quantity if implemented.

3. **Type:** Indicate whether the option is source reduction, recycling, treatment, or disposal.

4. **Consider?:** If the option is worth further consideration, enter YES. If not, enter NO and briefly indicate in the Option Description why not.

5. **Feasibility**: Provide a brief description. (Excellent, good, fair, poor)

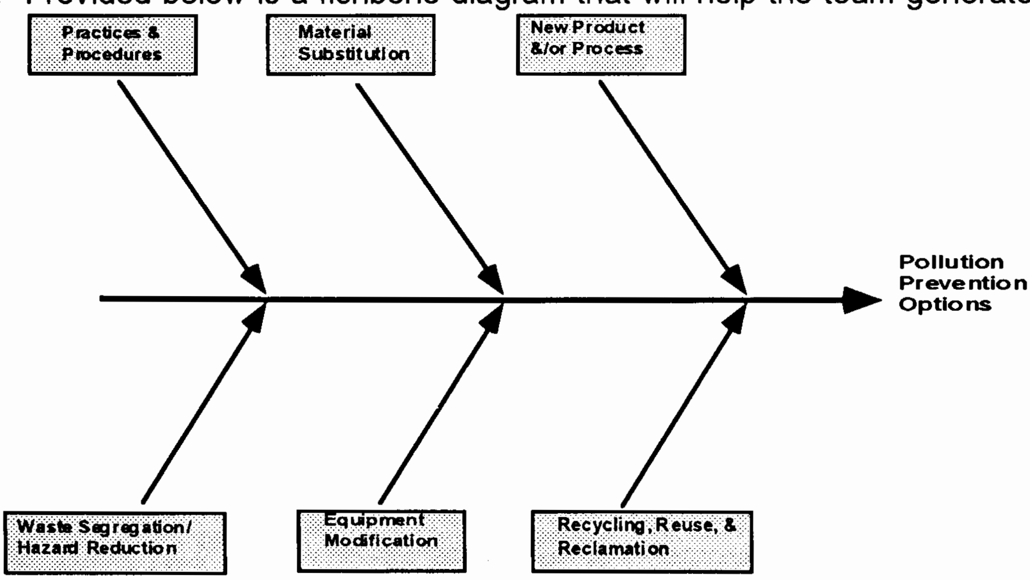
6. **Estimated Cost**: Estimate an implementation cost.

7. **Estimated Cost Savings**: Estimate the cost savings.

8. **Anticipated Reduction Qty.**: Estimate the weight or volume of the waste that will be reduced.

Note: Typically, it is difficult to estimate the anticipated waste reduction or cost avoidance in the initial phases of implementation because of many factors. However, for some options, especially in cases where the option provides complete elimination of a hazardous material or waste stream, these estimates can be accurately completed.

The process by which options are identified should occur in an environment that encourages creativity and independent thinking. Brainstorming sessions are effective ways for individuals to generate options. To make these sessions beneficial, research is often necessary. Provided below is a fishbone diagram that will help the team generate ideas.



Worksheet 5S

Level II

Date: ________

Page ______ of ______

Pollution Prevention Opportunity Assessment

Final Summary

Title:

PPOA ID Code(s):

Assessment:

Conclusions:

Recommendations:

Worksheet 5S

This sheet provides a brief summary of other pertinent information about the activity being assessed. Its purpose is to document how this assessment was performed, the conclusions reached by the team, and the recommendations for further actions.

1. **Date:** List the date this sheet was completed.

2. **Title:** List the title given on Worksheet 1S.

3. **PPOA ID Code(s):** List the ID Code(s) given on Worksheet 1S.

4. **Assessment:** Briefly describe the approach (methodology) used to complete this assessment and any assumptions made.

5. **Conclusions:** Briefly describe the waste streams or input material to be minimized, benefits achieved from this assessment, and any concerns (environmental or health risks) associated with the material or operation.

6. **Recommendations:** Briefly describe any actions that should or will be taken in respect to this assessment.

APPENDIX H

REFERENCES

1. U.S. Department of Energy, *General Environmental Protection Program*, DOE Order 5400.1 (November 9, 1988).

2. U.S. Department of Energy, *Hazardous and Radioactive Mixed Waste Program*, DOE Order 5400.3 (February 22, 1989).

3. U.S. Department of Energy, *Radioactive Waste Management*, DOE Order 5820.2A (September 26, 1988).

4. U.S. Department of Energy, *Environmental Restoration and Waste Management Five-Year Plan*, DOE/S-0070 (1989).

5. U.S. Department of Energy, *Applied Research Development, Demonstration, Testing and Evaluation Plan* (Draft) (November 1989).

6. U.S. Department of Energy, *Model Waste Minimization and Pollution Prevention Awareness Plan* (1990).

7. U.S. Department of Energy, *Process Waste Assessment Guidance* (ISO).

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