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Waste Minimization Manual:
A 10-Step Program for Success

Acknowledgment

The United States Agency for International Development (USAID) and the World Environment Center (WEC) have a Cooperative Agreement to provide U.S. expertise for technology and skills transfer to Central and Eastern European industry and government.

The objectives are:

Effective environmental pollution reduction;

Improved worker health and safety;

Efficient energy management; and

increased social awareness.

One of the WEC programs which is helping to achieve these objectives is waste minimization. This manual is part of that program.

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Introduction

When the WEC began this project of introducing waste minimization to the industries in Central and Eastern Europe, it intentionally targeted the chemical, petrochemical, pharmaceutical, and related activities for the first tier of programs. This paralleled the development of waste minimization in the US where companies such as Du Pont, Dow, and 3M were quite successful and willing to share their experiences with others.

Now the WEC program is entering a new phase of industrial involvement that extends this simple but highly effective program to a wider cross section of industries, both small and large. Moreover, like the US, industries and businesses in every sector can recognize the value and usefulness of this program as a means of increased profits and environmental improvements.

The original WEC waste minimization manual and training materials were prepared for the chemical industries in particular. This revised manual has been expanded to cover a broader industrial scope. The same principles and concepts apply, but many of the examples and applications have been added that represent situations encountered in general manufacturing, food processing, electrical and metals industries, paper and printing, as well as many others. With these additions, the WEC waste minimization program should be effective in any industrial situation.

WEC acknowledges the significant contribution of Mr. William Beck who prepared this waste minimization manual. Also, his clear and concise presentations at the waste minimization workshops and his follow-up guidance to companies implementing the WEC waste minimization program are a major contribution to the success of the program.

Bill is presently providing senior engineering and management consulting services for a number of companies and environmental organizations. This work built on his previous experiences, having worked for 36 years with the Du Pont Company in various engineering, supervision, and environmental assignments. Prior to his retirement, he was involved in starting up the company's highly successful pollution prevention program on a world-wide basis.

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This program was modeled on the program he started earlier at one of Du Pont's largest basic chemical plant in Texas. Bill guided Du Pont toward the integration of R&D, project engineering, product stewardship, and plant level small project activities into a coordinated pollution prevention program. This led to the implementation of longer range strategic environmental planning on a global basis.

As a chemical engineer, Bill's experience and expertise in the practical aspects of pollution prevention and environmental planning has generated numerous opportunities for consulting worldwide.

Also, WEC acknowledges the contribution of Dr. Paul Wilkinson who is a consultant and instructor for the Du Pont's Safety and Environmental Services Business. Dr. Wilkinson is retired from the Du Pont Company, having served 33 years in various research and development, marketing, and customer service management positions. His last seven years were spent in the environment division of Du Pont Legal as a consultant, working on right-to-know, hazard communications, and hazardous waste. In this capacity, he chaired the Chemical Manufacturers Association's Right-to-Know committee for several years.

Dr. Wilkinson helped structure the waste minimization workshops. The instruction team of Wilkinson and Beck demonstrated that waste minimization can be implemented at essentially no cost to a company which helped spread the adoption of the WEC waste minimization program throughout the entire industry of a country.

The funding for the WEC waste minimization program is provided by the United States Agency for International Development (USAID) through a USAID cooperative agreement with WEC. The waste minimization program is successful because USAID and WEC have truly cooperated in developing and implementing the program.

Executive Summary

To be successful in Central and Eastern European countries, waste minimization must provide cost savings and other economic benefits, environmental improvements, and improvements in the safety and conditions of the workplace. The WEC recognizes this fact and has developed a waste minimization program and this manual to incorporate these concepts. The WEC 10-step implementation program is built on the following ideas and experiences:

Management and Responsibility

Management's misunderstanding of the proper role of waste minimization is the largest barrier to a successful waste minimization program. Unfortunately, because of this misunderstanding and the confusion with waste minimization, management usually assigns the environmental department with implementing waste minimization.

- Waste minimization is not waste management. There is a big difference between these two. Waste minimization is a collection of activities that increases the efficiency of business to use its resources to produce goods. In doing so it also reduces or eliminates the generation of wastes. This is a production role. Waste management focuses on how to dispose or treat the waste after it is formed. This may involve the environmental staff.

- Waste minimization is not an "environmental" program or the responsibility of the environmental department. It is a "business" program. It is management's responsibility, along with the operations or production department, to use ingredients, other resources, and supplies more completely to make products and profit—not wastes.

- Waste minimization should be the responsibility of the production department—the operations group. They should, with assistance from other support groups, take the lead in setting up and implementing the waste minimization program for the plant or factory. Moreover, production/operations should be held accountable for tracking the progress of the program and reporting on the results.

Culture

In the WEC program, waste minimization should become a part of the everyday workers' attitude.

- Waste minimization is not a single idea or action, but usually a collection of ideas or actions that progressively reduces wastes and emissions. It is an ongoing process similar to safety and quality improvement.

- To be successful over a sustained period of years, waste minimization programs must become a part of everyone's job and a part of everyday activities.

- Waste minimization must be believed and embraced by the organization as an indispensable tool that will help the factory successfully meet its environmental responsibilities and economic objectives to compete effectively in the market place.

Organization

A waste minimization program involves many activities and people and so it must be logically organized.

- Successful waste minimization programs are the result of a collection of everyday actions by the workers and management throughout the plant or factory. It is not limited to just a few engineers in the Technical department or dependent on costly projects and technical programs or major process changes. Everyone can contribute to success and therefore everyone should have an assignment.

- The short coming with most of industries' waste reduction programs is that they involve too few people, focus on end-of-pipe solutions, and view waste reduction as a one-time project. Waste reduction programs must focus more on people's actions or decisions which make things unusable and not solely on the wastes. Waste is regarded by many as things (nouns) that have no value — however, it is also an activity (verb) that describes people's disregard for resources.

Approach—Based on Knowledge

Waste minimization programs that are systematic in waste and cost identification are the most successful.

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- Wastes and their management costs should be clearly identified as one or more items on the products' cost sheets. Most companies do not usually know their waste costs or the value of resources lost in wastes and this is one of the largest and most common barriers to effective waste minimization.

- Waste minimization is usually the result of applying common sense logic to a problem by using a combination of techniques that include brain storming and a systematic approach. The critical ingredient is to collect the correct information about the waste and its causes before applying a solution. This process also requires that the correct people are involved in identifying both the waste and its causes and as well as the development of possible solutions. This process of analysis and problem solving is helped by the involvement of "teams."

- Waste minimization programs must recognize that everything cannot be done at once. The program should be divided into phases that correspond with the time necessary and the resources available to start and complete a solution. For example, changes in job practices or the procedures for cleaning a equipment can be done immediately, literally today; whereas changing the service on equipment to reduce wastes may require design, procurement of the materials, fabrication, and waiting for installation. This is in the future—tomorrow or next month. Finally, a major production change or the use of a new ingredient or design may require considerable advance planning and funds. Such long range plans are beyond the "tomorrow" time frame and are well into the future. These three time periods (today, tomorrow, and beyond tomorrow) are logical divisions that WEC recommends companies adopt as a part of their waste minimization program.

With these ideas and points as the foundation, the WEC waste minimization program has been designed to assist companies to adopt this approach to their individual situations. WEC recognizes that a significant amount of waste in plants and factories is caused by outdated practices and procedures that are not recognized as such. With a careful evaluation of these outdated actions, changes can be implemented to reduce waste for little or no costs.

The WEC waste minimization program focuses on how to evaluate waste and waste generating activities with respect to practices and procedures. However attention will also be directed toward looking beyond the "today" opportunities of changing procedures and practices. These "tomorrow" opportunities are where simple

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and cost effective process or equipment changes, small and low cost projects, may be made in the near future.

Developing a waste minimization plan for each waste that combines today's opportunities with the potential reductions for the future and is aligned with the business plans for the product involved is critical for success. The WEC program can guarantee this success if it is solidly endorsed by management and supported in its implementation in the plants and factories through the involvement of everyone in the workplace. Fully implemented, waste minimization becomes a "routine way of doing business," a mind set that is very similar to the attitude about safety in many organizations

Results

The WEC Waste Minimization program can provide benefits beyond cost savings and environmental improvements. This approach of the 10-step program can be as effective in helping the enterprise strengthen its economics as it can in waste reduction.

The many success stories that have already resulted from this approach clearly demonstrate that it works and can work for you.

Chapter 1: Overview

The WEC Waste Minimization manual has been prepared to help industry, large and small, succeed in reducing wastes by presenting the best ideas gained from hundreds of programs worldwide. However, just the listing of the best ideas and examples will not guarantee success. Following these examples a company might realize a few successes. This is because in every factory usually a few opportunities for improvements can be found quite easily. But real and sustained success can only come from the understanding of the basic concepts and principles of waste minimization. Therefore the primary objective of this program is to identify and present concepts and principles that help a company to establish a system, an ongoing program to accomplish waste reduction with little or no costs where possible. This waste minimization program will also provide a cleaner and safer workplace and environmental improvements at the same time. It will develop a culture that implements cost saving projects that will reduce pollution.

WEC Approach to Waste Reduction

While a number of excellent manuals, books, and guides have been prepared to assist in waste minimization and pollution prevention [a United States Environmental Protection Agency (US EPA) term] these are primarily focused on what is considered as the "capital" or the "new investment" project approach. It assumes that a process or equipment change is central to waste reduction and that such changes can be accomplished by an economically justified project. Moreover, many of the books and training manuals stress technical solutions that are usually complex, difficult to implement, and require extensive engineering/technical resources.

Maximize Worker Involvement

These "large projects" options are not always available to companies such as those in Central and Eastern Europe who need immediate results and are limited in capital and engineering resources due to major economic turnarounds. In contrast, the WEC program develops the concept of small, less costly or 'no cost' activities that produce economic and environmental benefits associated with reduced wastes. Much of this can be accomplished by a more systematic approach to the everyday activities in the plant or factory.

This manual emphasizes such points as the importance of worker involvement and the value of proper maintenance to waste reduction as two factors that can be utilized readily and without

capital or engineering resources by even the smallest plant or factory.

Change Procedures and Practices

This program stresses that most companies can realize considerable waste reduction through changes in procedures and practices, both in operations and maintenance actions that are a part of the daily routine. The challenge is to fashion a program that involves all segments of the work force and provides the training necessary to identify potential waste reductions in these everyday activities. This must be reinforced with the motivation necessary for success. Such efforts require a management that understands what the waste reduction program is, where the responsibility rests to implement it, how to get it started, and most important of all, how to make it a part of the culture of the work force.

Practical experience over the years has shown that in many jobs the first and largest percentage of progress or success comes with only modest efforts. This has been described in various expressions such as picking the low hanging fruit or the 80/20 rule where 80% of the goal is achieved with only 20% of the expected total effort or cost. These concepts apply to waste reduction as well. This manual will try to help companies to recognize where and for what waste streams the 80/20 rule might apply.

Quick Success

In waste minimization it is important that success, even modest success, comes quickly to a new program. The WEC waste minimization program is structured for quick successes and the manual stresses this. One technique the WEC program uses to accomplish quick success is the early involvement of workers and the value of simple small "projects." Both of these elements are by their nature likely to produce quick results. In contrast, a large complicated technical project to reduce a difficult waste might require a year or longer to design, obtain management approval and funding, and then more time to install and startup. Waiting for a long term project to be implemented has frustrated many waste minimization programs and caused them to fail.

Finally this manual and this program are only "blueprints" or maps to follow. You and your organization will have to make the commitment and you will have to make it work.

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Chapter 2: Understanding Waste Minimization

Understanding waste minimization may appear to be so obvious as to be unnecessary to a first time reader - and yet the **key to a successful program is understanding the what, how, who, and why of waste minimization** and then **putting this understanding into a systematic program.**

What is Waste Minimization?

When the question, "What is waste minimization?" is asked of any group of industrial workers, environmental workers, or government workers, the number of different answers is surprising. In the United States (US), the term waste minimization was replaced several years ago by the US Environmental Protection Agency (EPA) with the term pollution prevention, which only added more confusion.

Waste Minimization in the context of the WEC Waste Minimization Program is any activity that reduces the amount of wastes generated or produced in a business or commercial enterprise. It is not waste management — disposing or treating the waste after it has already been generated.

These kinds of activities are shown in Figure 2-1 and include recycling, reuse, or recovery. They are included because they have the same over all benefit of reducing the amount of waste exiting a process or factory that might pollute the environment if not safely managed.

For comparison, only that part of waste minimization that involves source reduction or elimination and "inprocess" recycling corresponds to the US EPA's pollution prevention definition.

The WEC program prefers to focus on the job of getting results in a sound environmental and economical way, leaving the debate of definitions to others.

What is Waste ?

This is an easy question to answer but many answers are incomplete because they fail to include all wastes. Here again, the WEC program, benefiting from years of experience, recognizes that wastes can be more than just the solids and liquids that are typically considered as wastes.

For some businesses, wastes are vapors or gases that leak invisibly from pipes or open top vessels. For other businesses, wastes are the unnecessary energy used in generating excess amounts of steam or hot water for a factory. Wastes can also be water that is not used wisely but discharged into an already overloaded treatment system. Waste are ingredients or other supplies that are discarded because of overordering, under utilizing, poor handling, or a number of other reasons. For a service company, poorly used time is a waste. Waste is any resource that is not fully utilized in making a product or providing a service. The WEC program expands the horizon of waste minimization activities to include those listed in Figure 2.2.

Traditional
Waste Minimization Activities

- **Ingredient Substitution**
- **Source Reduction**
- **Recycle**
- **Other Uses — Alternate Fuels**
- **Sell as Co-products**

Figure 2-1 Traditional Waste Minimization Activities

WEC
Waste Minimization Activities

- **Energy Conservation**
- **Water Use Conservation**
- **Packaging Reuse**
- **Time Management**
- **Land Resource Recovery**

Figure 2-2 WEC Waste Minimization Activities

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Why Is It Important To Industry?

Simply stated, wastes represent lost profits and a potential threat to the environment and workplace safety. Wastes, by definition, are materials and gases that are judged to be no longer useful and therefore represent unrecovered costs that reduce the profits of an organization. This should be an important reason to reduce wastes but it is often overlooked because the total cost of waste is not known and is often understated.

In many countries where waste disposal, land fills, or incineration is limited, the cost of disposal, along with transportation costs, is usually a major factor. These costs are important but should not overshadow the value of lost ingredients or the value of lost "wasted" product and other waste resources.

Cost Savings Examples

There are numerous examples of cost savings related to waste minimization, such as 3M's $540 million USD savings in the first ten years of their program. Du Pont's experiences of savings well over $100 million USD per year in disposal costs alone and Dow's claim of some $40 million USD in savings at just one large plant in the US are impressive. Closer to home there have been some impressive savings as a result of the WEC workshops and company programs in the participating countries. We have included some examples in Appendix B.

Other Reasons

Other reasons waste minimization is, or should be, important to industry include those listed in Figure 2-3 and Figure 2-4 on the following pages. Worker and workplace safety is another important benefit of waste reduction which is sometimes overlooked. However, the relative importance of these reasons depends on each company's individual situation. For the company that is having problems with the nearby community because it is using an existing dump, waste reduction that lessens the used of that dump can be a positive sign to the community that the company is concerned and is doing something positive.

For a company with older plants, which often tend to make more wastes, a reduction program can help in housekeeping, safety, and worker morale and pride. Still another plant may use its waste reduction programs to attract privatization interests from outside companies or support by stockholders. Finally more efficient technologies and plants that minimize waste provide competitive

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advantage and set an example of thinking and action that can contribute to an economic revitalization for the enterprise.

Its easy to see that there are a number of reasons why waste minimization is important. Many of the examples stated have direct and indirect economic consequences. Of course waste minimization also helps protect the environment for future generations and this should not be taken lightly. In some countries, such as the US, Western Europe, and now in some Central and Eastern European countries, it is the law that companies have waste minimization programs. Waste minimization and environmental management will also be an important part of a comprehensive environmental Data Management System and provide the basis for the upcoming program of ISO 14000 certification.

Waste Reduction Obvious Incentives

- Environmental Compliance
- Direct Cost Savings
- Indirect Cost Savings
- Avoided Liability
- Recovered Value

Figure 2-3 Waste Reduction Obvious Incentives

Waste Reduction Other Incentives

- Workplace Safety
- Employee Pride
- Customer Value
- Community Respect
- Stockholder Support
- Competitive Advantage
- Technology Advantage

Figure 2-4 Waste Reduction Other Incentives

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How Is Waste Minimization Accomplished And Who Is Responsible For Its Success?

These two questions of how and who are combined for logical reasons.

The answer to these questions is what this manual and the WEC waste minimization program is all about. The simple answer is that **waste minimization is accomplished by developing a systematic program of waste identification, uncovering possible solutions, and implementing the best solution.** Putting this program in place is management's responsibility. But of course management must gain the support and cooperation of the entire workforce for this program to be successful, since it is this workforce that must implement the program.

A Systematic Program

Because a waste minimization program will include a number of wastes and air emissions from a number of sources, some type of systematic approach should be followed. To expand a bit on this point, the program becomes more complex, especially as the size of the plant and the number of wastes expands. Unfortunately, many plants begin a program without real commitment or management support and without any systematic approach. Management fails to recognize that a good program requires both commitment and ongoing support, along with the allocations of the proper people who can organize and sustain a systematic program. Too often, management selects one or two projects to support and, when these have been done, it quickly jumps to some other program. In contrast, a systematic program that includes all wastes will be ongoing.

Good Leadership

A good program also requires the involvement of many people and the systematic collection of a lot of data, other information, and costs. Most importantly, a successful program needs a leader or a steering committee that understands how to make a program work and has the authority and management backing to make decisions and changes where they are needed. The organization and the people who should be involved in a program will be discussed in detail in Chapter 4 and 5.

All too commonly industry makes the mistake of equating waste reduction to environmental programs such as waste water treatment or waste disposal. Consequently. the waste reduction program is assigned to the environmental department manager, and very

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quickly the program stalls. The program fails because the environmental manager is usually a staff position and does not have any direct authority with the production, manufacture, and technical organizations where this work must be done.

A waste minimization program is not difficult or burdensome when it is properly organized, its work is shared across the many plant groups, and it becomes a natural part of every job.

Who can put solutions into practice?

In a good, well organized program, virtually everyone in the plant can play a role in putting solutions into practice. That's the beauty of waste minimization, if its done correctly, identifying wastes and developing solutions for these wastes throughout the entire plant becomes a natural activity and everyone can participate. Conversely, if a program focuses narrowly on only two of three wastes or only in one process, a large portion of the plant workers will be excluded. This will cause resentment and a loss in eagerness to help.

WASTE MINIMIZATION

WHO IS RESPONSIBLE???

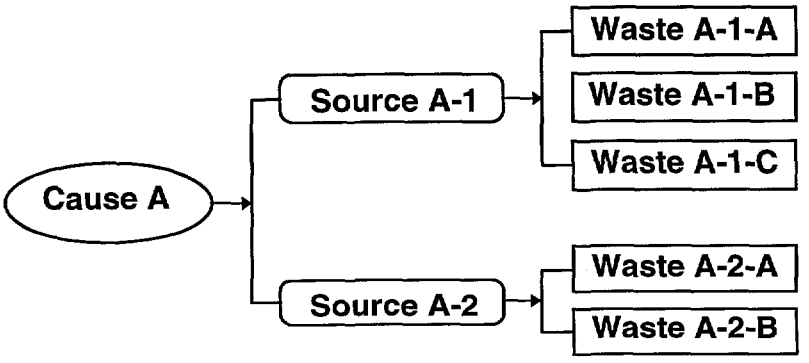
EVERYONE

Chapter 3: Understanding the Causes of Wastes

Many waste minimization programs focus on waste and go into an extensive discussion of waste sorting, identification, characterization, and analysis. This is quite necessary and is also a part of this manual. However what most programs overlook is a discussion of the causes of wastes. The WEC manual includes this discussion because experience has shown that a waste reduction process **must focus not on wastes or the sources of wastes** (i.e., end of the pipes or bottoms of tanks or drums stored in the corners of a factory floor) **but rather on the causes of waste**— and the question of why wastes are generated in the first place.

Sequence of Waste Generation

The classic approach to waste reduction is to look at the wastes and work backward. Unfortunately this approach usually corrects only a part of the problem, or must be repeated many times to make a significant overall reduction in wastes. However, if a company tries to understand the underlying causes of waste early in its waste reduction program, the company usually spends less time, fewer funds, and implements more effective solutions. This is because these "causes" of waste generally produce more than one waste. Also causes can be generic in nature and a solution for one waste might be applicable to others. For this reason, sharing successes between waste reduction teams in different areas can be beneficial.



This notion that waste minimization is a process of studying sequences is a very important element of the WEC program. The next chapter will develop this idea of sequences more fully and will show how a company can take advantage of sequence planning to develop and sustain progress in its waste minimization program. But first this chapter will examine two examples to illustrate the

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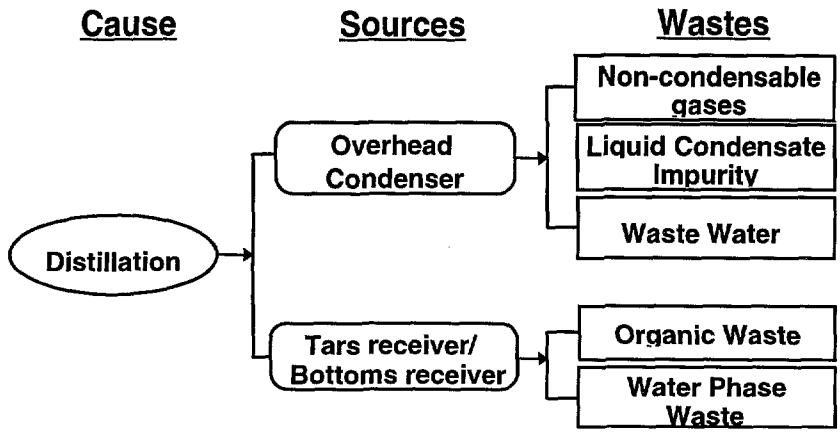
difference between waste and cause and the importance of sequence analysis.

Example 1 – Distillation Column

Example 1 is the production of a chemical where the waste generating cause is a distillation activity to purify the product. In this example, the cause is the distillation activity, the sources are an overhead condenser and a tar receiver, and the wastes are several, as illustrated.



A waste reduction program that focuses on the wastes—the organic wastes in the tar receiver—may identify some intermediate solutions such as recycling the tars to affect better separation or burning the tars in a boiler for its heat value.

Considering this same waste from the "cause" analysis method, one would observe that product purification by distillation in turn generates or "causes" several different wastes: air contaminates, waste waters, and tars. Moreover, this distillation activity requires steam (energy) and heat removal (cooling water) as well as the pumping of materials (electricity). Each of these may also be the focus of a cost reduction program.

Solutions

While the final solution to this collection of wastes is to somehow eliminate the distillation step in this chemical process, the initial study might focus on altering the variables of distillation to improve yield. More efficient distillation will naturally reduce wastes. Economic analysis might justify more frequent sampling of the column to ensure its operation within tighter specifications, or the use of an on-line analyzer. Another solution might focus upstream at the reaction step that produces the chemical and the impurities. Perhaps a solution would be to remove impurities in

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the ingredients before the reaction step or purchase purer ingredients from the supplier.

This example describes understanding the causes of waste, illustrates the difference between causes and wastes, and describes a process of tracking a sequence of waste producing causes so that possible solutions can be identified.

It is also important to achieve an understanding of the cause as early as possible in the waste minimization assessment process to avoid spending too much effort and perhaps funds on solving a single waste problem when the solution could be applied to a more fundamental problem. This is demonstrated in this next example.

Example 2 – Metal Parts Machine

A metal parts company has several stamping and fabrication machines, producing parts that are used in washing machines and automobiles. Recently, there has been an excessive number of rejected parts on the No. 2 and No. 3 machines because of surface scratches.

Since the sources of the wastes (rejected parts) are machine #2 and machine #3, these machines were examined carefully to locate the cause of the scratches. The metal forming dies were removed and examined but did not appear to be burred or have surface roughness that would account for the scratches. The waste minimization team decided that while these two machines were sources of waste, the cause might be external to, and perhaps upstream of, these machines.

The metal blanks that are formed by the machines were examined to rule out this as a source of rough surfaces. Other machines use blanks from the same source and do not have such problems. A careful examination of the lubricating oil used by these two machines did not indicate anything unusual. However, when the lubricating system was put in operation, an excessive amount of metal shavings was noted in the circulating oil. An examination of the recycle oil filter revealed a large hole which allowed large tramp metal particles to be recirculated into the stamping areas of the two machines. This tramp metal caused the scratches.

Sequence Tracking and Solutions

This example illustrates the importance of tracking the sequence of activities back to the cause of the problem rather than stopping at the source. Replacing the tooling in machines #2 and #3 might

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have helped temporarily with this problem, but the real solution was in eliminating the tramp metal by replacing the oil filter.

Another point to make is that a static examination of the recirculating oil system might not show up the filter problem. However, when the system was turned on to simulate operating conditions, the presence of tramp metal in the filtered oil clearly showed where the problem was.

Example 3 – Contaminated Waste Water

Another example is illustrated in a problem confronting the ACME Company (Figure 3-1 Waste Reduction Study). A large tank is used to collect and store contaminated waste water to prevent it from discharging to the nearby river. The amount and type of contamination prevents this waste water from being processed by the company's biological treatment unit and so the waste water must be trucked to a nearby commercial treating company. The fees for such treatment are quite large and so waste minimization – reducing the volume of waste water and the contamination – are clearly needed to reduce these costs.

The sequence of actions should start with trying to trace the sources of these waste waters and their causes. However, since the water collected in the tank is actually a mixture from many sources, some additional information must be developed first. These investigations include:

- Analysis of the tank water to determine the amount and type of contamination. This information is useful in relating the contamination to possible sources.

- Measurements or estimates of the volumes of flow from the various sources. This information is useful in identifying the largest and most contaminated streams and helps to establish a priority for waste reduction efforts.

In the ACME example, these two investigations identified the north sump as the sources for 90% of the waste water flowing into the tank. Also this stream contained a large portion of the tank's organic contamination.

Since the north sump or sewer receives waste water from a large part of a chemical process unit, the waste minimization team began to trace the sources of wastes that flowed into the north sump by asking the operations and maintenance groups a series of questions. From these answers the team was able to recommend the following solutions:

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- Most of the water that flows into the sump is "floor washes" – where the concrete floors are hosed once per shift to remove any chemical leaks or spills. For the floor cleaning "wash down," the frequency should be changed to once per week or only if necessary to remove large spills. Production and maintenance teams would patrol the area and tighten or replace any leaking components. Small spills would be sponged up with paper towels or rags.

- Pump seal leaks, the largest source of chemical contamination, presently drain to the floor. These would be collected using funnels and buckets. A longer term solution will be to replace the current seals with a new design that has better performance. An even better solution would be to replace the chemical pumps with pumps that have no seals and that are leak free. This investment requires economic justification, such as a capacity increase or modernization.

- The equipment blowdown activity is required to remove condensed moisture inside the equipment thereby preventing damage to a compressor. Identifying and correcting the source and cause of this moisture will eliminate this waste water source.

Notice that these corrective measures will not completely eliminate waste water in the north sump but they will reduce the volume by 80% or 90% and also reduce the chemical contamination significantly. This same approach, applied to the other sources of waste water should result in reducing the amount of water and contamination level in the tank to a point where it might be acceptable for biological treatment by ACME — thereby eliminating the need for truck disposal off-site.

Summary

These examples illustrate the value of a careful analysis of the causes of waste and the ongoing process of fact finding, discovery, and testing ideas. Many of the more difficult to reduce wastes will require a series of intermediate or partial solutions which will in turn lead to a better solution. This is what is referred to as a solution sequence. Chapter 4 will introduce the aspect of timing into this sequence approach.

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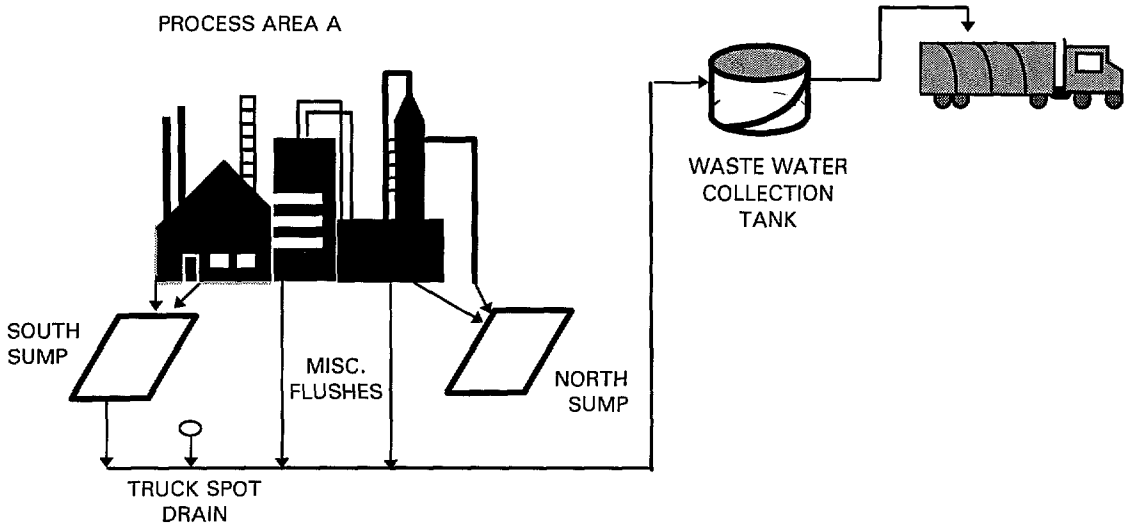
ACME COMPANY
WASTE REDUCTION STUDY

Find the source(s) and cause(s) for each waste stream.



INITIAL WASTE MINIMIZATION ANALYSIS

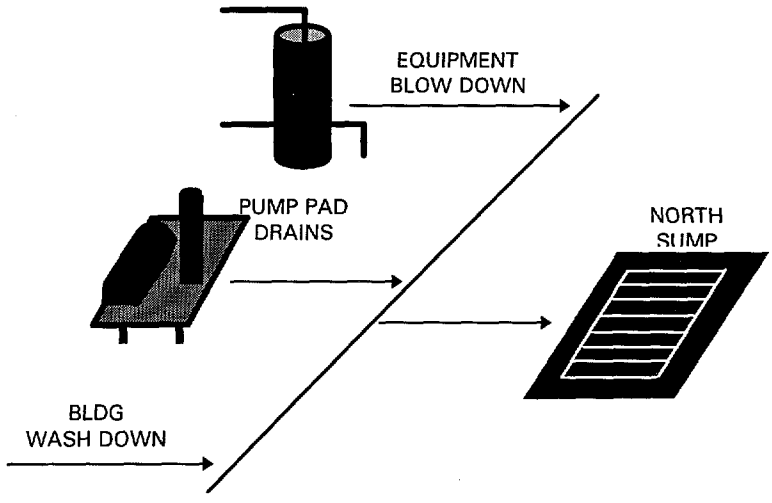


Figure 3-1 Waste Reduction Study

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Chapter 4: Recognizing the Process— The Continuum Today–Tomorrow–Next Year

Earlier in Chapter 3, the idea of understanding the causes of waste was developed and the concept of tracking the sequence of waste producing causes was introduced. These concepts will be applied in a later chapter that deals with types of waste reduction solutions. However there is another concept that is appropriate to discuss first, the concept of a "timing" continuum in dealing with the timing for application of solutions to waste problems.

Timing Sequence

In the example of the scratched metal parts, if the company had stopped with the first proposed solution, replacing the stamping die, the real problem of the failed oil filter might not have been noted for some time. This illustrates the cause sequence. There is also a "timing sequence" as applied to waste minimization. In the contaminated water example, the first solution for the leaking pump seals was to catch the leaking chemicals thereby preventing contact with the floor. This was only a temporary solution until better seals could be located. This is an example of a timing sequence. This is another area where the WEC waste minimization program has been developed in more detail than most of the other programs.

Reasons for a Timing Sequence

The reasons for a timing sequence are several:

- Waste minimization for the Central and Eastern European countries must have some immediate success and payback to maintain the momentum of a program and also provide for longer term solutions, where appropriate.

- Waste minimization opportunities for older factories and plants are mixed between near term and longer term solutions and they must be considered collectively rather than separately. This should prevent spending funds for a temporary solution that will be replaced by a better solution later.

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- Waste minimization opportunities through small projects and the necessary replacement of worn out equipment can only be realized if a program is developed that includes a time continuum for possible future solutions.

This timing sequence idea will be combined with a cause sequence in an example later in this chapter. However, a brief discussion of limits needs to be covered because limits affect timing.

Do Not Place Limits on Waste Minimization

One of the biggest mistakes companies throughout the world make with waste minimization is to regard it as program with rather narrow limits. These limits, while often not explicitly stated, exists nonetheless. Limitations include:

- Regarding waste reduction an environmental program only.
- Using only the engineering or technical departments to develop or screen solutions
- Budgeting only for a single year's program
- Considering only projects or solutions that reduce solid or liquid wastes, wastes that require off-site disposal, or wastes that are taxed by the government..
- Considering only wastes that are toxic, that are subject to reporting, or that cause environmental compliance problems.

Often these types of limits are not deliberate, but rather they are the result of an incomplete understanding of the potential value and benefits of a waste minimization program. To counter this, companies should clearly address this question of limits and objectives when setting up their program. Unless there is a compelling reason for setting limits, do not set them. However, if some types of limits are necessary to narrow the universe of consideration, use the widest possible limits initially.

Avoid Time Limitations

Perhaps the most important limit to avoid is the limit of time when considering possible solutions for a waste problem. Many companies miss the most cost effective solution because they jump at the first one identified or they don't make an effort to develop a longer range plan. Both of these problems are related to limited experience or the lack of a full understanding of a waste minimization program. This is best understood by studying the following example.

Example Distillation Problem

Consider the wastes from the distillation example used earlier. These wastes were sludge, tars, waste waters, and gaseous organics from a distillation unit.

Timing of Solutions

	TODAY	TOMORROW	AFTER TOMORROW
	Now to a few weeks	*Months to Several years*	*Beyond several years*
Possible Solutions	More frequent analysis	Continuous analysis	Improve reactor performance
	Tighter control settings	Computer control	Replace column
	Use different feed point	Retray and repipe	Develop uses for byproducts
	Improve condenser cooling	Replace condenser	Change catalyst

This example, drawing on the distillation column situation presented earlier, illustrates the timing continuum sequence of solutions in a waste reduction plan for the distillation column wastes.

Today

The near term solution, more frequent analysis for tighter control of the column operation, can be effected immediately—today. The other **Today** solutions, tighter control settings, using a different feed point, and improving condenser cooling, can be done fairly quickly, within a few days.

Tomorrow

The **Tomorrow** longer range solutions, such as the on-line analyzer or the computer control, will require Technical

department assistance and may require a formal project. Certainly the timing for such work is months to a year or longer. This is where some companies don't recognize that these two levels of solutions, the immediate and the longer range, need to be considered as a continuum of improvement and not an either/or case. The **Today** actions can be put in place while the **Tomorrow** project is being developed. The effectiveness of the **Today** actions in reducing waste will also provide guidance for better **Tomorrow** solutions.

After Tomorrow

The **After Tomorrow** phase of this continuum example is also a difficult step for some companies. They don't see value in looking too far into the future since they are already minimizing some waste. However, referring to the distillation example, a project to replace the column could be something the **After Tomorrow** phase would address. Indeed in many cases, and this may be one of them, the 80/20 rule may apply and it really won't be cost effective to go beyond the **Tomorrow** solutions. However, if the wastes are still excessive after the **Today** and **Tomorrow** solutions are applied, or if for other reasons the process is considered for changes, then the **After Tomorrow** solutions might be implemented.

Example Scratched Parts Problem

Using the scratched parts example from Chapter 3, the solution timing sequence might be as follows:

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Timing of Solutions

	TODAY	TOMORROW	AFTER TOMORROW
	Now to a few weeks	*Months to Several years*	*Beyond several years*
Possible Solutions	Repair oil filter	Redesign system to upgrade filter design	Eliminate the need for oil filtration

Personnel Involvement — Who?

It should also be noted that this time continuum also parallels the idea of who in an organization should be involved in the solution. The **Today** solutions can be accomplished by the production workers, operators, and mechanics, perhaps with the help of a process engineer. If column operating conditions are changed, a safety review and supervision approval may be needed. Overall most of these personnel are from operations.

The **Tomorrow** longer range solutions will require technical department assistance. Changes will require detailed design and engineering assistance.

The **After Tomorrow** solutions generally require more in-depth technical and even research and development (R&D) involvement. Again this illustrates how the timing continuum also creates a continuum of the people resource involved in this effort.

Personnel involvement could have been incorporated into the earlier sequence illustration as:

TODAY	TOMORROW	AFTER TOMORROW
Production/operations maintenance	Technical Engineering	Technical/R&D

This continuum concept has been extended by Du Pont in their waste reduction program to cover product development at one extreme and customer/packaging at the other. See Figure 4-1 for a complete view of this sequence.

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Additional Value of Time Continuums

Two additional ideas associated with the time continuum concept are that waste minimization programs, if structured as described above, will: 1) be a solid and steady contributor to the profitability of the business, and 2) bring about a change in the mind set or "culture" of a company and its employees.

This is in contrast to a program that depends on major projects that are performed only by the technical or R&D department. This type of "big hit" program makes it easy for the rest of the organization to ignore waste reduction because waste reduction is not regarded as their job.

Just like safety, waste minimization must be a part of everyone's job. By involving everyone in the program, it forces them to be more aware and to participate. It soon becomes a part of the job, and not a "Program of the Month."

Finally, the concept of waste minimization as a continuum across time and across the organization and across all activities strengthens the idea that this is a process—ongoing and never ending—not a program which usually has a stopping point.

THE TIME - ACTIVITY CONTINUUM

A Waste Reduction Program that extends from Product Development to Product Disposal

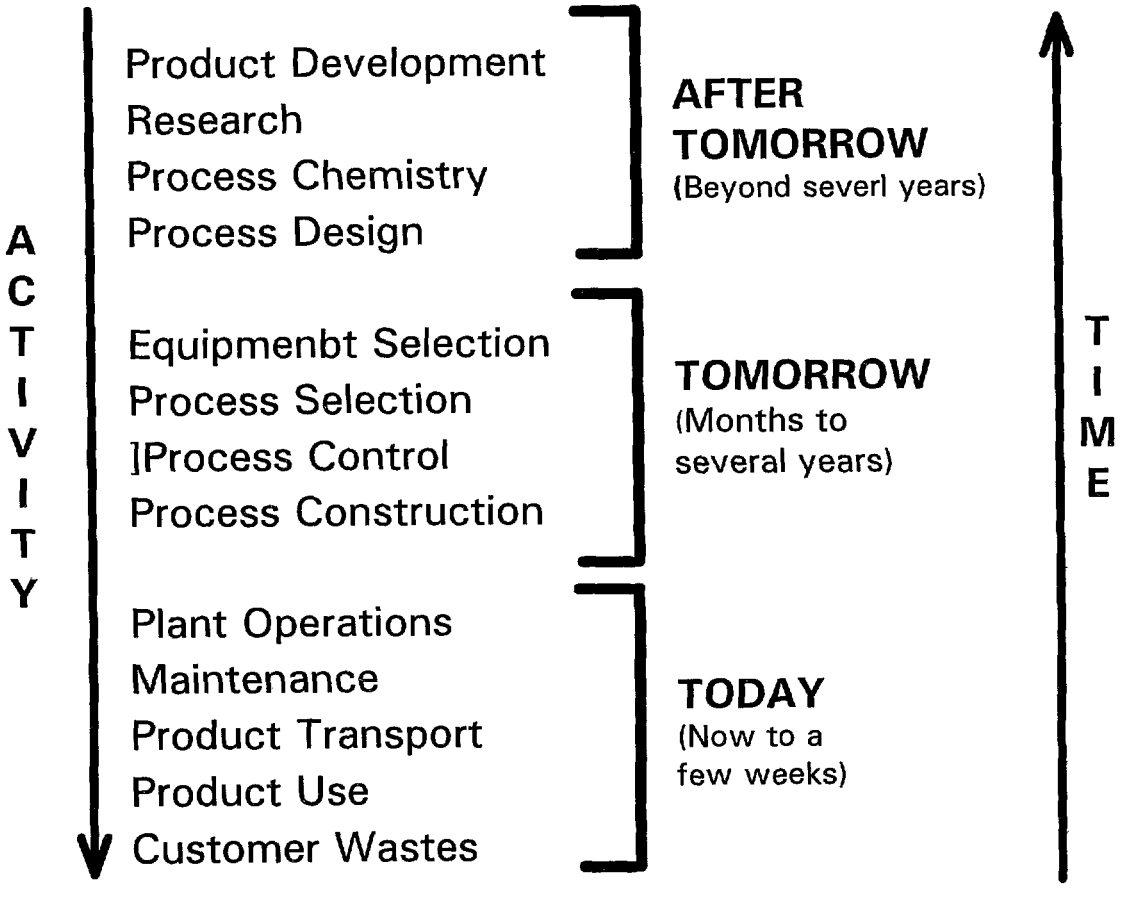

Figure 4-1 Waste Reduction Program in a Time Continuum

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Chapter 5: Elements of a Waste Minimization Program — The WEC 10-Step Implementation Plan

Waste minimization programs have been around for a number of years with varying degrees of success. An overall analysis of these programs and their results identified a number of important elements that are a part of the most successful programs. The WEC program has adapted these elements to better fit the Central and Eastern European industrial environment. This modified approach is called the WEC 10-Step Program for Waste Minimization Implementation. This 10-step program will be presented in this and the following chapters in a way that should be easy to follow — both for implementation and as a training tool for others.

Planning is Essential

Waste minimization as a program to improve the economic status of a company must be given the proper respect to insure its success. This means that management must value the program and provide leadership in developing a plan for its implementation. This "planning" is necessary in all phases of the program and is considered as a part of the systematic approach that the WEC recommends.

Tailor the Program to Fit Needs and Resources

Programs should be tailored to fit the company and local plant or factory situation. A 20-person shop cannot use the same program that a large 5000-worker plant uses. While both programs can use the same 10 steps, the details of these steps should be adjusted to fit the size of the individual plants. Also the complexity of the plant and its products and wastes will dictate certain differences.

Pick a Leader and Assign Responsibility

To the extent possible, companies should use existing elements of their operations in the waste reduction program. For example, if a company is using "quality teams" or "quality circles," then these groups should be used as waste reduction teams as well. If a company has an existing leader or manager of waste management

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or treatment, then that person ought to be involved in waste reduction too. However, the environmental manager should not automatically be the waste reduction manager; someone in operations or production should be appointed to this job.

It is interesting to note that at many factories and plants a number of younger people will volunteer to work on or even lead this program when given the opportunity. For them, it provides an opportunity to help the environment and contribute to the company's profit too. Moreover, they are often open to new ideas and approaches to solve problems.

Start Small But Expect Big Results

One additional suggestion in starting a program is to start "small." By "small" is meant that it's easier to select one area or department of a plant or factory to implement the waste minimization program and then learn from this experience to expand the program to the rest of the factory.

In many factories where this approach has been implemented, the other areas or departments, having noticed the success of the "pilot" area, have asked management to allow them to start the program as well. This is especially true where the early successes of the "pilot" area are publicized.

The WEC ten step process is shown in Figure 5-1. These elements of a waste minimization program will now be presented first in theory and then followed by a detailed example using a hypothetical company, the Acme Corporation. This approach will allow companies to set up their program step-wise using the example material directly or modified for their situation.

Elements of a Waste Minimization Program
The WEC 10-Step Implementation Plan

Step 1. Management Commitment, Leadership, and Values

Step 2. Organization, Responsibility, Accountability

Step 3. Divide the Plant Factory into Logical Areas

Step 4. Develop and Train the Area Teams

Step 5. Waste Accounting, Know your Wastes

Step 6. Cost Accounting

Step 7. Establishing Goals and Priorities

Step 8. Waste Minimization Analysis and Planning Develop a Plan Based on Goals & Priorities

Step 9. Schedule for Implementation and Assignment of Responsibilities

Step 10. Follow up to Sustain Progress

Figure 5-1 The WEC 10-Step Implementation Plan

Step 1. Management Commitment, Leadership, and Values

One of the major hallmarks of a successful waste minimization program is the attention and pride of management in the program. However, there are a number of managers and directors who must acknowledge that their companies just haven't got their program completely together yet. They don't realize that management commitment is more than a carefully worded, waste reduction policy statement in a fancy frame in the reception area of the factory or on a manager's wall. Incidentally, these are the same managers that appoint the director of environmental affairs as the leader of the waste reduction effort and expect miracles tomorrow.

Waste Reduction Must Be Recognized as Important to the Company—A Valued Program

Management must recognize that waste reduction is important for business reasons as a cost control measure. It also has additional values, such as: 1) complying with the expectations of the community and the public, 2) meeting the environmental regulations of the local and federal government, 3) helping a safety program, and 4) improving worker morale. Beyond the economic benefits, each company will have its own ranking of values. For those who have had to pay for expensive cleanups of old dumps, the avoidance of possible future cleanup costs and liabilities is important.

How can management show its commitment?

- Be present and positive at the start up of the program.
- Take a personal and frequent interest in the program.
- Take a direct interest in the selection of the people in the program and let them know of your interest.
- Review the program and offer comments. Acknowledge that the program will require time and some start-up expenses and be sure both are sufficient.
- Insist on some type of periodic progress tracking system and audit it frequently.
- Be sure all groups are aware of the program and its importance and involve as many as possible.

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- Challenge the organization to set goals for accomplishment and consider these goals as a measure of performance when evaluations of performance are conducted. Some companies include this performance in determining compensation increases.

- Support any recognition and award programs.

There are a number of additional tools management can use to show this commitment and value for waste minimization, but something as simple as frequent communications on this subject is perhaps the best.

Participate in public recognition of waste reduction successes. This program, like safety, thrives on goals, milestones, awards, and recognition. Management can emphasize its value by its participation in these events.

Figure 5-2 lists additional ideas published by the US EPA for managers to follow to maintain employees motivation, once a program has been implemented.

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To motivate employees, managers can:

- Provide feedback and reinforcement of employees' pollution prevention performance.
- Set an example by adhering to the pollution prevention program and actively considering employee ideas.
- Convey enthusiasm about meeting pollution prevention objectives.
- When new pollution prevention measures are implemented, explain how they fit in with the overall objectives.
- Regularly reinforce the importance of each individual's contributions to pollution prevention and their value to the overall objectives.
- Demonstrate personal commitment to the objectives and praise the commitment demonstrated by employees.
- Announce pollution prevention innovations by calling a meeting for all individuals who will be affected to discuss the change.
    1. Open meeting to questions and comments.
    2. Pay attention to signs of animosity or resistance and address these immediately.
    3. Gain cooperation by showing that you know and care how the employees feel.
- Establish a "group identity" and work at building pride in adapting to the pollution prevention program.
- Support for employees who have good pollution prevention ideas that have been rejected or overlooked.
- Establish quantifiable annual pollution prevention objectives:
    1. On a monthly basis, have employees chart their personal and the company's progress against these objectives.
    2. Incorporate pollution prevention goals, objectives, and accomplishments into annual job performance evaluations for people with direct process pollution prevention responsibilities.
    3. Readjust objectives if they prove unattainable.

Figure 5-2 U.S. EPA Employee Motivation

Reprinted from the Office of Solid Waste, U.S. Environmental Protection Agency, *Facility Pollution Prevention Guide* (Washington, D.C., 1992).

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Acme Corporation Organization Chart

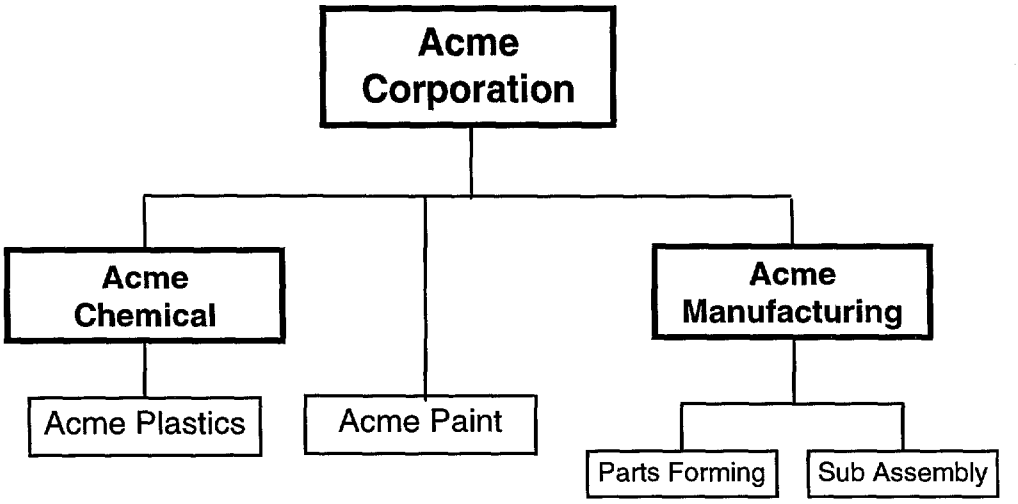

Figure 5-3 Acme Corporation Organization Chart

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Application to the Acme Corporation — A Detailed Action Plan and Examples of Implementation

In the introduction to this chapter, the Acme Corporation was mentioned as a hypothetical company that will be used to illustrate the application of the ten implementation steps. With this technique, the WEC can provide examples, forms, and checklists in this manual that industries and plants can customize for their own programs.

To appreciate this example, it is necessary to understand the background setting for the Acme Corporation and its decision to implement a waste minimization program.

Background on the Acme Corporation

The Acme Corporation is a large enterprise that has several divisions operating in different business areas. Within each division there may be one or more related business activities. (See the corporate organization chart in Figure 5-3.)

To start a waste minimization program throughout the Corporation that would be viewed as complementary to the environmental program already in place, the Corporation leadership (Chairman of the Board, General Directors, etc.) decided to restate the existing policy on environmental responsibility to include the importance of waste minimization as the mechanism by which environmental compliance and improvement would be achieved. In addition, the leadership wanted to stress the need to balance environmental activities and economic realities, using waste minimization as that balancing factor. Finally the Corporate leaders wanted to insure that the operations groups, and not the environmental staff, would be responsible and accountable for this program. The policy spells this out, along with an outline of implementation that includes details and the requirement for an annual report on progress towards goals.

Acme's First Step — Adopt a Policy

Because this is a large enterprise, with several divisions and smaller subsidiaries, it is appropriate that the various divisions demonstrate their agreement with and support for the policy and its implementation with formal endorsements. This is another technique to show management support and commitment. Examples of the policy and these endorsements are included in Figure 5-4, Figure 5-6, and Figure 5-7.

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Middle Management —The Problem and the Solution

First it is important for top management to realize that unless they can clearly communicate the value of waste minimization to middle and lower management, and convince them of this value, the program will not have the support it needs to succeed.

Middle and lower management may not be in a position to fully appreciate the value of waste minimization because they have a limited view of the economic and environmental situations, and yet they are expected to meet production, quality, safety, and profit objectives. Because they mistakenly equate waste minimization with the other environmental programs, they regard it as a "necessary evil" and an expense rather than a cost savings program. It is middle and lower management who needs to see the early and quick successes of a waste minimization program in order to be convinced of its value.

Upper management can reinforce the value aspect of waste minimization by including it as a topic of all of its business discussions. Another technique to accomplish this awareness is to involve middle and lower management in the initial planning of the waste minimization program and be sure that they are included in the selection of the various teams that will be implementing the program.

Where it is appropriate, active and successful participation in the waste minimization program should be one of the prerequisites for advancement to upper management. Some companies have publicized the fact that performance in environmental and waste minimization programs is included in the criteria for the periodic review of compensation. Such actions send a clear message to middle management regarding the value that is placed on this program.

Communicate with Employees

Beyond the development of a policy, or formal company commitment to a program and course of action, it is important to communicate this commitment clearly to the workforce who are expected to support and implement this program. In the US and in some other countries, it is customary to accomplish this by writing to the employees, or by holding meetings for this purpose. The Acme Corporation, because of its size and structure, chose to send letters to all its employees. Examples of these letters are included as Figure 5-5 and Figure 5-7.

Start "Small"

The Acme corporation's CEO recognizes the value of starting "small" and using the experience gained in this prototype to improve future implementation of the program. For this reason, the Acme Paint Company is selected to pioneer the program. (See the letter to the Acme employees.) This was a logical choice for the Acme management since the paint plant had already begun to work on several waste minimization projects and clearly needed to accomplish more. Also the middle manager, in this case Pete Kane the paint plant manager, was already committed to this program because he had recognized some early successes.

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Example Policy Statement — Acme Corporation

Acme Corporation

Executive Office

Environmental Responsibility

The Acme Corporation is committed to providing a strong economic enterprise that is also concerned for the health and welfare of its employees, and for the environment

Consistent with this concern for the environment, is the belief that the operations of the Acme Corporation should be in compliance with applicable laws and directives. Furthermore, this compliance is best achieved by minimizing the generation of wastes to the extent that is technically and economically possible. Wastes that cannot be eliminated will be managed in an environmentally correct manner.

Implementation of the Policy

Implementation of this policy will be the responsibility of the operations line management in each of the divisions and businesses of the Corporation.

Specific environmental program reports will be submitted annually to the corporate leadership and the director of environmental affairs.

These reports shall include a listing of overall goals. Accomplishments and the details of the waste minimization program.

Where appropriate, the cost savings and quantities of reduced wastes should be listed so that a corporate summary might be developed. Specific forms will be provided for the preparation of this data.

Figure 5-4 Acme Policy Statement

Example of Management Commitment — Acme Corporation

Acme Corporation

Executive Office

January 5, 1996

TO: All Acme Employees
FROM: J.J. Smith, CEO

As many of your are aware, the Acme Corporation has enjoyed a strong business year and the expectations are bright for the future. Unfortunately, a significant part of our expected earnings will have to be spent on environmental compliance and the clean-up of waste disposal practices of the past. This is a result of changes in the regulations that have been strengthened to match the global standards for protection of the environment. Acme Corporation believes that overall these standards are necessary to protect the environment for the generations to come and so we are committed to compliance and clean-up in all our facilities.

The challenge to all of us is to balance this environmental job and the need to expand and modernize our plants and factories with the limited earnings. After considerable study the joint Environmental-Engineering task force reports that a program of waste reduction, combined with recycling and waste management innovations could reduce the overall costs of the program by over 50%.

It is therefore our intent to vigorously push this waste reduction program giving it the support and resources it deserves. Additionally Mr. Frank Jones, General Director, has been asked to head up this program for the Corporation. He will invite many others to join him in forming steering teams and action teams at every level and in every division and department in the organization. For this program to succeed, everyone must do his or her part. In that regard, this program in similar to the safety program, where everyone counts.

We have asked Frank to start this program in the Acme Paint Company as a pilot program so that some experience and a model might be developed for the other groups. Also we intend to start a computerized waste and cost data system and the paint plant will be a good place to test such a system. We expect that other groups will be ready to start their programs in a few months, and we expect the Corporate Waste Reduction Committee to coordinate this.

Finally we have asked the Committee to establish appropriate priorities and goals for this program, using inputs from the divisions and departments involved. These will be widely communicated and will be reported on to the corporate management annually. Please consider this program as important to the future success of the Corporation, as its CEO, I, certainly do. Thanks for your continued efforts to our success.

Figure 5-5 Acme CEO Announcement Letter

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Example of Policy Endorsement — Acme Paint Company

Acme Paint Company

A subsidiary of Acme Corporation

Policy Endorsement
Regarding Environmental Responsibility

Acme Paint, a division of the Acme Corporation, endorses the policy on environmental responsibility which stresses waste minimization at the source as a primary focus of environmental responsibility. The Division will implement waste minimization, product stewardship, and customer partnering to improve both internal and external environmental practices and performance.

The Division will hold business managers and production managers responsible for the development of programs that follow the Corporate guidelines. These programs will include goals for progress, specific waste reduction plans and the waste and cost accounting necessary to support these plans.

An annual report on the progress of these waste minimization programs will be prepared for each production facility or business unit that can be forwarded to the Corporate leadership.

These reports should also include goals and program changes identified for the coming year and/or years to implement the strategic plans on the unit.

Figure 5-6 Acme's Policy Endorsement

Letter of Endorsement — Acme Paint Company Manager

Acme Paint Company
A subsidiary of Acme Corporation

January 15, 1996

TO: All Employees
FROM: Pete Kane, Plant Manager
SUBJECT: WASTE MINIMIZATION AT ACME PAINT

By now all of you should have received a letter from John Smith, the CEO of the Acme Corporation, describing the environmental and economic challenge that faces us. For most of us at Acme Paint this situation has already been recognized and some groups and individuals are already beginning waste minimization. In John's letter, he cites our paint operations as the place where the waste minimization pilot program will begin. I'm delighted that our plant has this opportunity to work with Frank Jones and his committee to contribute in this special way both to the environmental improvement and to the economic strength of the corporation.

As you know, I've been encouraging waste reduction for the past year. This is because waste are costs, and they take away from profits. Last year wastes were some 4000 tons and this cost our business over $400,000 in disposal alone. Unfortunately we haven't started to account carefully for the other costs, wasted ingredients, containers, and other hidden costs. In addition, if we can't reduce our solvent air emissions we will be forced to spend $2,000,000 on some type of vapor incinerator.

As you can tell by these data, wastes must be minimized in order for our plant to continue to be competitive with other paint producers. This waste minimization program which we will start next week will be critical to our continued success.

I hope you will work very hard with Sam Dunn and his plant waste reduction committee to make Acme Paint the waste reduction leader in the Corporation. I believe we can reduce our wastes and costs by 50% within 2 years. However, I'll let the plant committee come up with our official goals and priorities. Remember, waste reduction is everybody's responsibility and there are no bad ideas.

Thanks for your cooperation.

Figure 5-7 Acme's Letter to Employees

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Step 2. Organization, Responsibility, Accountability

The next element in a successful waste reduction program is the creation of some type of organizational structure or network. This is necessary for a number of reasons.

A program needs some degree of structured training, coordination, and communication, all of which requires some type of organization. Also a focal point is needed for making decisions, setting goals and priorities, tracking progress, and reporting results. Many companies use a committee or team, composed of representatives from various departments or plants, to provide the general coordination and program direction. The leader of this committee should report to top management. This emphasizes management interest. At each level of the organization this team and leader structure should be established. This is depicted for a typical large plant or factory in Figure 5-8 and Figure 5-9. A smaller plant is illustrated in Figure 5-10.

Steering Team Responsibility

Beyond communication, a waste minimization program requires considerable guidance and direction if it is to become ongoing and systematic, two elements of a good program. This guidance is exactly what is expected of the steering team. They must first decide the how, where, when, and who "issues" of the program and then provide the training and other "tools" necessary to carry out the program. Most of these items are discussed in Steps 3 through 10 of the program and consist of area/team selection and training, setting up systematic waste and cost identification, and then problem solving.

While explicit examples, using the Acme paint plant, are provided, the steering team may need to develop its own examples and systems for waste identification and reduction.

One such system that is useful for waste minimization is some type of waste data management system. Actually the waste data should be viewed as a part of the larger environmental database which ought to be the record keeping and tracking element of an environmental management system. Many companies and plants started their programs using hand prepared ledgers and data sheets. As the programs were expanded to include more wastes, and involved more areas, the need to convert to computerized databases was obvious. The steering team should address this issue in their review of existing systems and the need for new ones.

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Accountability and Responsibility—A Must for Success

Most importantly, a company needs to appoint a person within each production level or unit to be responsible and accountable for the program and its success for that area. Commonly this is the operations superintendent, director, or manager, who in turn shares this responsibility with the subordinates. Once this responsibility and its priority has been clearly established within the organization, the task of obtaining participation and cooperation becomes simple. For a small plant or factory, the production manager may also be responsible for the environmental and maintenance activities as well. He or she might also organize the waste reduction effort with the help of others, but appoint a supervisor to handle the day to day affairs.

Waste Minimization Teams

Within the various production units, plants, or factories, waste minimization is most commonly done through the use of teams or committees. Since waste reduction is very much like problem solving, a team can usually contribute a wider collection of data on wastes and its causes that can lead to more ideas and solutions than a single individual can. A plant-wide team can also provide coordination and communication, whereas a unit or production area team can provide the detailed information about the wastes that is needed for the solutions. This detailed information becomes the basis for the development of solution options, economic analysis, and selection of priorities. The unit or area team is often composed of 4 or 5 members, including several operators, a mechanic, someone from the quality control or process lab, and in many situations a technician or engineer. This combination ensures a good mix of data sources and ideas. The environmental department or coordinator advises these teams about the environmental concerns of wastes and the equipment that generates them as well as assists on permits if needed.

The environmental department at a large plant may have one or two of its people on the factory or plant team. Other staff groups that should be represented on the team might be shipping/receiving, cost accounting, process control, and the technical department. In small plants and factories, the environmental responsibilities may be a part-time job; someone with other responsibilities. Regardless, the waste minimization program needs some environment input.

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Spark-plugs

One of the major generators of success on area teams is the individual who has a personal commitment to cost savings or environmental improvement. These individuals, "string savers" as they are sometimes called, are real spark-plugs in a waste reduction program and should be encouraged to participate. In one plant in the US with an outstanding program, the core members of all of its area teams are volunteer spark plugs who have attracted others to join who are equally motivated. This plant has received recognition from the State of Texas and the US EPA for its outstanding program.

Acme's Organization

For the Acme Corporation, a steering team is established to organize and oversee the entire program, but each plant, division, or other operating unit is expected to establish some type of waste minimization organization also. For small plants or units, the team might be only 2 or 3 members. In the Paint Plant example, the organization has a plant steering team (Figure 5-8 depicts the organization and Figure 5-11 lists the team members) and 6 area teams (Figure 5-9) because it is a moderate size enterprise.

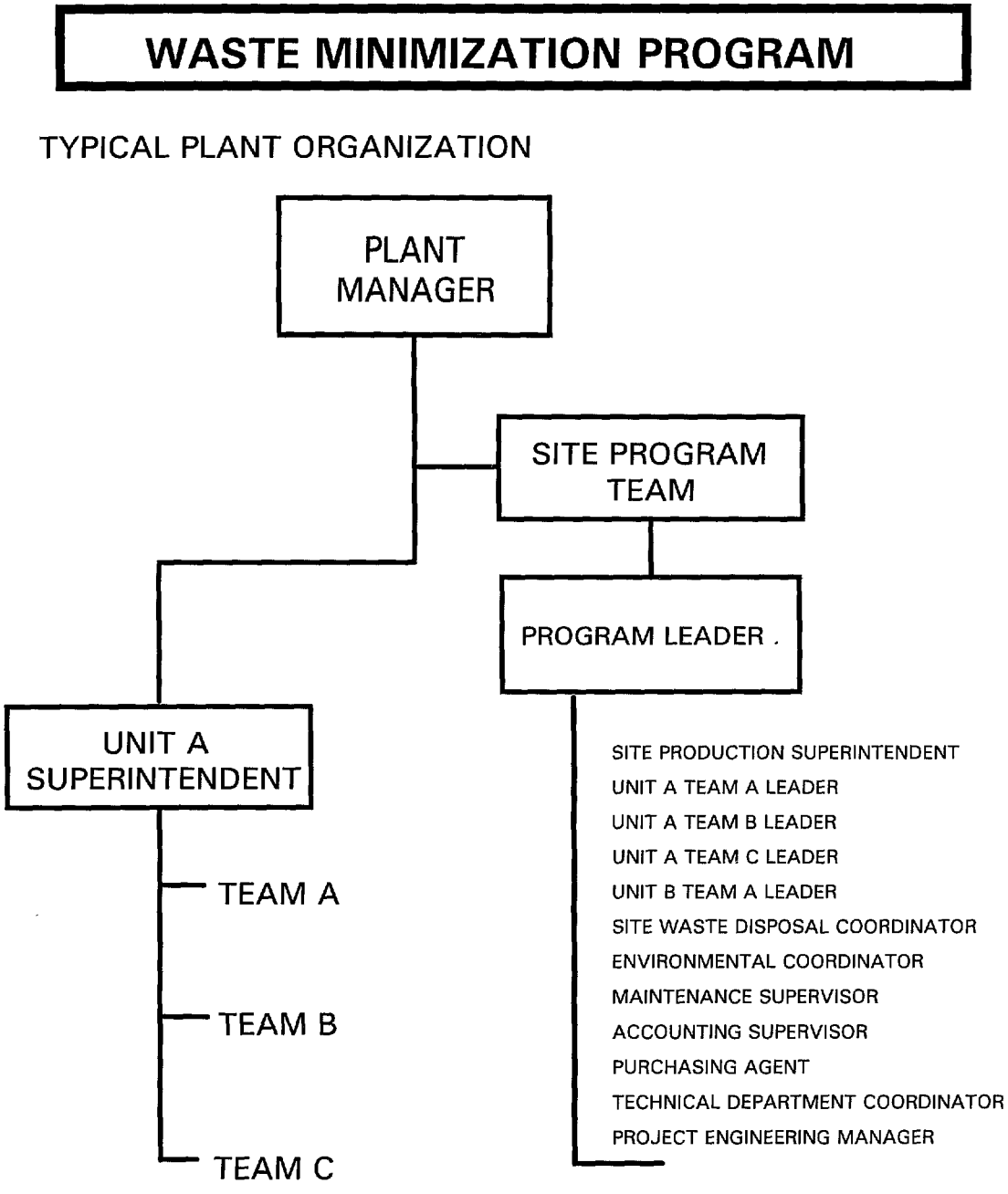

Figure 5-8 Waste Minimization Plant Steering Team Organization

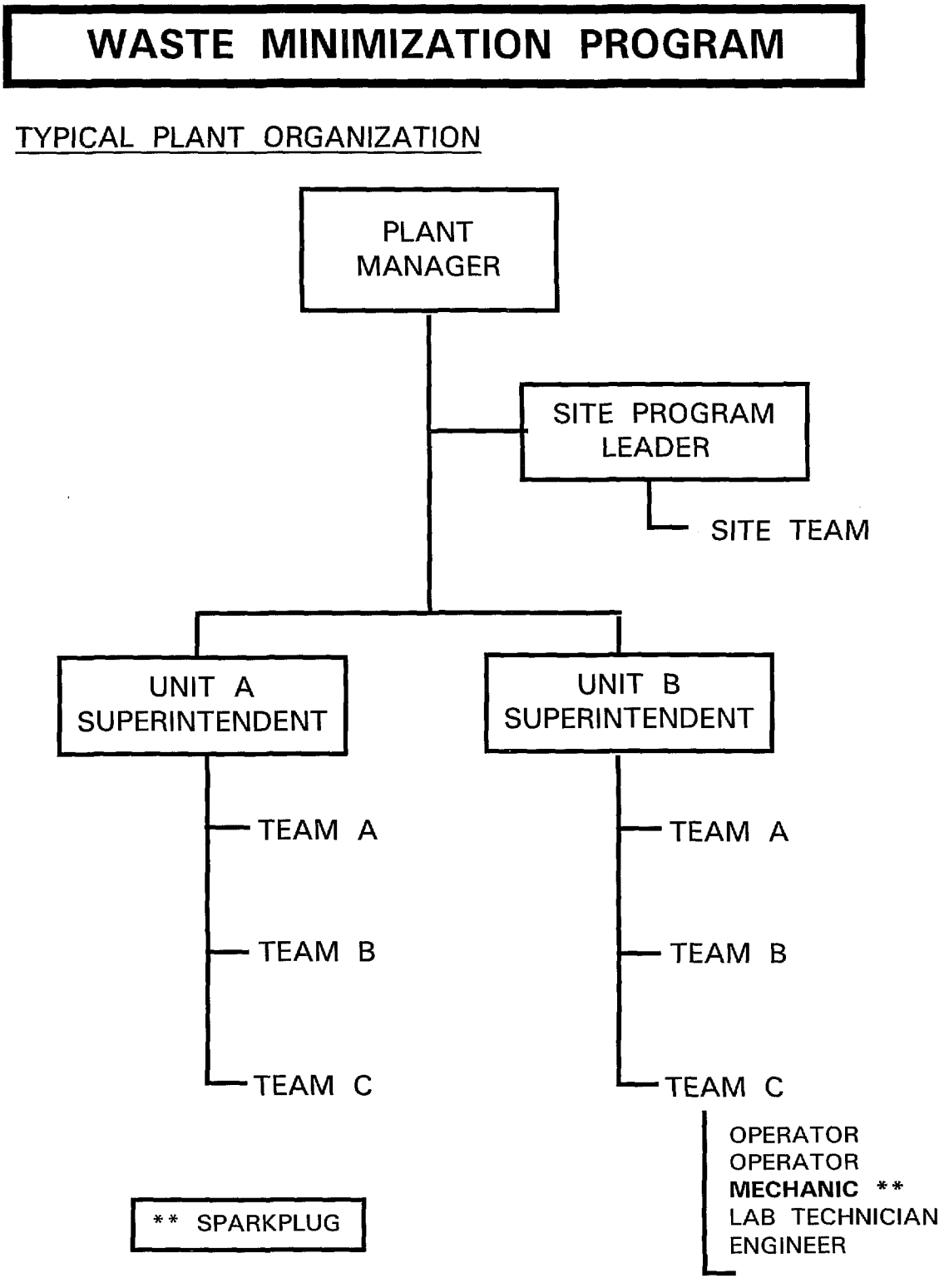

Figure 5-9 Waste Minimization Area Team Organization

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WASTE MINIMIZATION PROGRAM

FOR A SMALLER PLANT

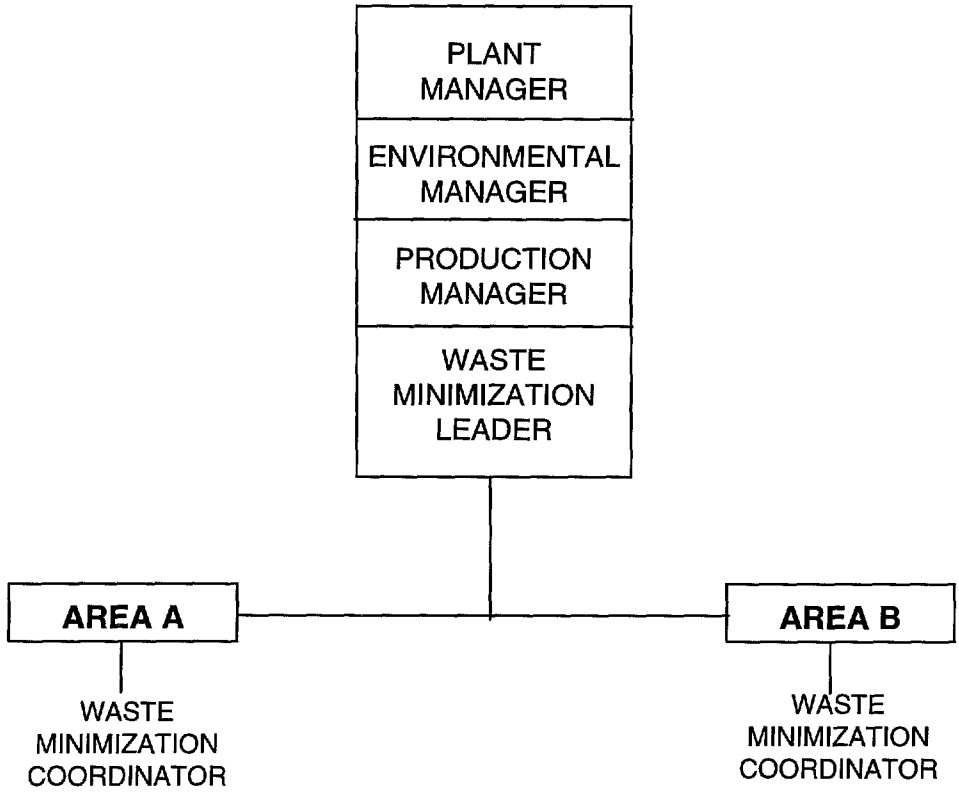

Figure 5-10 Waste Minimization Small Plant Team Organization

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Acme Paint Company Team Organization

Acme Paint Company — Waste Minimization Program

Site Waste Minimization Steering Team

Sam Dunn ..... Production Manager, Team Leader
Sally Reid ..... Accounting, Assistant Leader
Tom Beck..... Assistant Production Manager
Vic Edwards..... Technical Manager
Jack Perkins ..... Maintenance Department Manager
Frank Fields ..... Team Leader -- Mixing Area
Mary Watts ..... Team Leader -- Ingredients
Jane Doe ..... Team Leader -- Receiving/Shipping
Cliff Doe ..... Purchasing
Bill Smithe..... Team Leader -- Special Products
Tom Dooley..... Lab/Quality Control Services
Fred Capell ..... Team Leader -- Labs and Shops
Jenny Franks..... Team Leader -- Packaging
Harry Blume ..... Mixing Area Superintendent

Figure 5-11 Acme Paint Company Steering Team Members

Step 3. Divide the Plant Factory into Logical Areas

When setting up the organization structure of the waste minimization program carefully consider how to divide the plant or factory into logical areas so that the program becomes more manageable. Experience shows that a waste minimization program is more effective if it can focus on individual wastes and causes one by one. This is best accomplished by dividing the plant into areas, usually grouped by activity or location, and by using the workers in that area as members of an area waste minimization team. This same area division approach will also simplify the task of compiling information on the wastes generated in the plant or factory.

Creation of Area Teams at the Acme Paint Plant

At the Acme paint plant, Sam and his committee look over a plant map, process flow diagrams, and the organization charts and they select a breakdown of areas for the plant. They review this with Frank and Pete, make some minor changes, and then review the areas with plant supervision. Each step of this process is discussed with the supervision and input is sought so that there are no surprises and everyone understands what is happening.

Acme's Waste Minimization Areas

The Acme Paint Company has created areas and corresponding area waste minimization teams as part of the organization phase. Figure 5-12 illustrates the areas. Note also that each area is given a unique designation and some symbol, number or other method of identification, (See Figure 5-13) which will be used later in the program to identify the wastes generated in that area. This is necessary for waste minimization since the same wastes, for example oily rags, may be generated in two or more different areas but from different causes.

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Schematic of Acme Paint Company — Divided into Areas to Identify Wastes and Sources

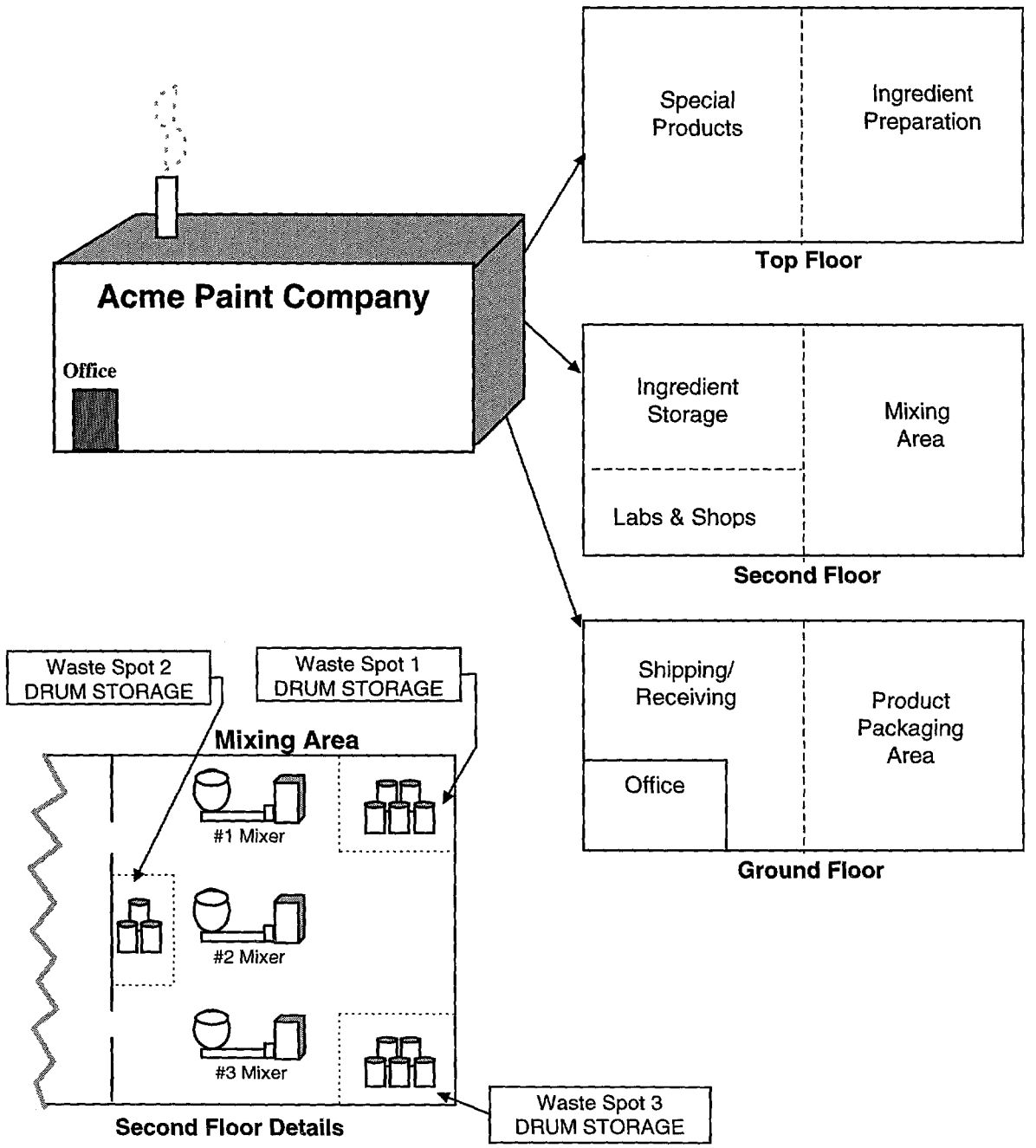

Figure 5-12 Acme Paint Company Area Organization

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Acme Plant Area Layout and Identification for Program Implementation

For the implementation of the waste minimization program, the site steering committee has divided the plant activities into the following six areas. Theses are listed below their respective area designation that will be used to identify wastes and emissions that are generated in that area. The Accounting Department has agreed to establish separate cost centers for these areas so that waste costs can be tracked by each area.

AREA	ABBREVIATION	WASTE PREFIX
Ingredient Preparation	INGP	IP
Mixing Area	MIX	M
Special Products	SPEC	SP
Packaging	PKG	PK
Shipping/Receiving	S/R	SR
Laboratory & Shops	L/S	L

NOTE: Office and miscellaneous wastes will be included in the L/S category for accounting purposes.

For additional details, see the plant area diagram on the previous page.

Figure 5-13 Acme Plant Area Layout and Identification

Acme Paint Company Area Team Members

The Acme Paint plant waste minimization effort is strongly supported by the employees who recognize this program as a means of improving working conditions and the environment. They also recognize that by improving efficiency, the plant can be a better competitor in the national and global markets. The area teams are a combination of volunteers and workers who were invited to participate because of their extensive knowledge of the area and their history of creative thinking.

Ingredient Preparation

Mary Watts	Clerk **(Team Leader)**
Joe Case	Operator
Dick Francis	Mechanic
Jack Fields	Operator
Rod Stone	Engineer

Mixing Area

Frank Fields	Supervisor **(Team Leader)**
Tommy Scott	Operator
Marianne Black	Engineer
Fred White	Mechanic
Jerri Atkinson	Lab Tech

Shipping/Receiving

Jane Doe	Accounting Clerk **(Team Leader)**
Sam Watts	Clerk
Pete Taugger	Packaging Specialist
Tom Jones	Buyer
Lou Crandell	Engineer

Figure 5-14 Acme Paint Company Area Team Members

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Step 4. Develop and Train the Area Teams

Since each area will be responsible for waste identification, cost analysis, and the development of the individual waste reduction plans, it is essential that the area teams include the people with the knowledge and understanding capable of doing the job. This means that the teams should have operators and mechanics as well as technical engineers and laboratory technicians if the area is a highly technical one. A paint plant is more complicated than a metal stamping plant but not as complicated as a petroleum refinery. So the team selection should take this into account. Area teams for some of the plant are shown in Figure 5-14.

It should be noted that before the area teams were selected, a request for any interested volunteers was made to everyone in the plant. Those who did volunteer were included in the team selection. Several had already been involved in earlier waste reduction efforts and would qualify as "spark plugs." Training these teams should be convenient to the team members, including using overtime if necessary.

Training

In the U.S. waste minimization was started internally in most companies, often in the factory or plant by the workers. By 'internally' we mean that an individual or small group began to study and reduce waste, learning as they went. In the beginning, there were no books or consultants to guide these efforts. Now there are many outside sources and some consultants. However, the best knowledge of wastes and causes of wastes in a factory comes from the workers themselves and they can usually work out the best solutions once they have been trained to do so.

The training should include covering the concepts of successful waste minimization contained in this manual in Chapter 1 through 4. These concepts should be reinforced with actual examples from the factory itself. The plant/factory steering team is responsible for this training and should be careful to make it as effective and interactive as possible. Waste minimization is a combination of observation, some factory knowledge, common sense, and a willingness to ask questions and challenge current practices and procedures. Also it is important for the team to understand the business and environmental aspects of waste. Figure 5-15 highlights these points in more detail.

An example of understanding costs is included in Appendix B and reproduced in Figure 5-16. It shows how a team recognized the importance of separating the various kinds of water used in the canning factory by costs and uses, and also the costs of various types of treatment/disposal.

Waste Minimization Team Training

Teams should learn to identify wastes and sources

- Material Safety Data Sheets
- Product and Ingredient Data Sheets
- Process and Procedure Manuals
- Safety and Hygiene Manuals
- Technical and Laboratory Staff

Teams should learn the business impacts of waste

- Disposal of wastes
  Who/How/Where/When
- Costs of Waste Treatment
- Costs of Ingredients/Products

Teams should learn the environmental and safety impacts of wastes and emission

- On the environment
- On plant treatment systems
- On worker safety
- On customers in their plant

Figure 5-15 Waste Minimization Team Training

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Water Is An Overlooked Resource

Water conservation is usually only considered when there is a drought or severe water shortage. A good waste minimization program will include responsible water conservation both for cost and environmental reasons. There are many possible ideas that waste minimization teams have developed to save water.

One such idea is to develop a clear understanding of how much water really costs. As an example, an industrial plant developed the following table of its water costs.

Water Type	Cost (USD)/1000 liters
Raw-surface	0.15
Raw - well	0.35
Filtered	0.5
Cooling tower	0.3
Boiler make-up	1.15
Deionized	5.5

This table helps the team focus on the biggest costs. Next the team identified typical activities routinely done in the plant that used water.

Activity	Amount of Water	Type of Water
Pump repair	30 liters	Filtered
Canning machine changeover	1000 liters/150 liters	Filtered/Deionized
Label machine repair	20 liters	Well
Steam room cleaning	1000 liters	Well
Ingredient mix/batch	50 liters	Deionized

This analysis allowed the team to identify opportunities to reduce water usage and in some activities replace more costly water with less costly water.

Extending this analysis to waste water treatment and disposal, the team developed the following cost data.

Waste Water Disposal Costs

Activity	Cost (USD)/1000 liters
Sewer to river	0.01
Primary treatment (Filtration)	1.00
Full treatment (Biological)	3.00
Special chemical treatment	8.00

Figure 5-16 Water is an Overlooked Resource

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Training for Waste Minimization Teams – Reference Manual

Since waste minimization is in many respects a state of mind — how workers at all levels regard the various resources (ingredients, supplies and utilities) used in production — providing these workers with various "tools" and other aids that reinforce this idea is important. This reinforcement and education can be accomplished in many ways.

One such tool that is quite useful in all types of production plants is a waste minimization reference manual or guidebook. Basically this manual is a collection of information and reference material on waste minimization that provides, in one place, the material related to the waste minimization for plant as well as the individual area or unit into which the plant or factory has been divided.

Normally this manual is divided into a number of sections for easy reference and can accommodate the replacement or addition of new sections and pages as appropriate. (Commonly a "3-ring" binder is used.) This binder is kept in the area and maintained by the plant and area team.

A sample listing of the sections of the manual used by Acme's Paint's mixing area in shown in Figure 5-17. However in general, the manual would contain both reference material, such as general cost data and other pertinent plant information, as well as listings of individual waste and implementation plan data. Some companies use these manuals both for reference and documentation purposes.

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ACME PAINT MIXING AREA
Waste Minimization Manual

Section 1 **Management Commitment**
- Acme Corporate Policy
- CEO Letter of Announcement
- Pete Smith's Letter of Announcement

Section 2 **Acme Corporation Goals, Priorities and Annual Reports of Progress**

Section 3 **Acme Paint's Program, Organization and Area Divisions**

Section 4 **Acme Paint's Goals, Priorities and Annual Reports of Progress**

Section 5 **Acme Paint's General Cost References**
- Cost Sheets
- Disposal Costs
- Ingredient Costs
- Other Costs

Section 6 **Mix Area**
- Waste lists
- Waste Profile Forms
- Plan
- Historical Data

Section 7 **Environmental Regulations and Schedule of Fees**

Section 8 **Success Examples - Both Acme's and elsewhere**

Section 9 **References of Equipment with Potential to Reduce or Eliminate Wastes**

Figure 5-17 Acme Paints Waste Minimization Manual

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While there is much benefit from reading and discussing success examples from other companies, examples of successes within the plant, involving "real" people and machinery, are best. Some companies have used outside consultants to help in setting up a program, training the teams, and getting started on waste identification.

However, some factories may also choose to use vendors, suppliers of machinery or raw ingredients, trade associations, or ministry personnel to assist in this training and program start up. Regardless of the choice of outside assistance, companies must recognize that waste minimization is and should be regarded as a never ending part of the production of goods, and as such, it must become part of every job training program. In this regard it is identical to safety. Outside experts cannot do the job. At best, they can only train and help a company to get started.

One of the best training techniques is for the team to conduct a brief survey of a factory area and observe the activity, paying particular attention to any wastes that have been generated. Starting with these wastes, the team should ask questions to identify the source and then the causes of this waste. Once this information has been gathered, more waste data, costs, frequency of generation, etc. is added. This is followed by brain storming possible solutions. Someone skilled in these techniques can help lead this process. After several such sessions, the individual team members will build their confidence and can do this without coaching.

Step 5. Waste Accounting, Know your Wastes

Next to the organization and training of people to get the job done, **waste minimization depends on a good identification and understanding of the wastes generated by the plant or factory.** Yet this is often a very weak part of the program because wastes are poorly documented.

It is unlikely that even experienced people who have worked in an area for years can list all the wastes generated in that area. This is because a large production area in a plant might generate 30 to 50 different wastes, waste waters, and air emissions. Another reason for this is that many wastes and emissions are generated only once, or a few times a year, because of annual turn around or maintenance — these wastes are often overlooked. Generally most

workers view the factory or plant in terms of ingredients and products. (See Figure 5-25.) But in reality, there are a lot more

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materials used in manufacturing a product and many of these materials end up as wastes as depicted in Figure 5-26.

Plant Perimeter Waste Accounting

Most plants and factories know only the wastes and emissions that leave the plant or factory boundaries because of government requirements, payment of fees, or because they are invoiced by a disposal company. However, many of these are not known completely; often, the amount of waste, the composition of the waste, and the frequency of the waste is not known. This is especially true for air emissions. The first step in the waste accounting process should be to identify and quantify the wastes that leave the factory, such as air emissions, waste water, and wastes transported offsite. Figure 5-23 illustrates these wastes with respect to how they leave the plant or where they are taken.

The problem is that many wastes are not generated continuously or even daily. Maintenance related wastes, laboratory wastes, waste lubricants, and upset or scrap wastes are generated intermittently and are often overlooked when waste lists are pulled together. For this reason, a team consisting of different job holders is useful to name all the wastes. Once the plant "boundary" wastes are identified, the individual area teams should develop a similar lists of wastes generated within each area. Eventually, it is recommended that the internal waste generation and the "plant boundary" waste accounting will be balanced so that all wastes can be accounted for by some disposal/management method.

Developing a Waste List

It is necessary to document or develop a list of all wastes, including waste waters and emissions, being generated. For each waste that is listed, some information must be gathered so that costs, quantities, causes, and eventually a waste reduction plan can be developed by the teams. A form or waste profile should be designed by the plant or factory team to collect data on wastes. It should be constructed to permit the listing of solids, liquids, and air emissions. Each of the teams should use the same profile form to permit ease of comparison and data base development. An example profile form is shown in Figure 5-18 and Figure 5-19. Even small plants or plants with only a few wastes should use data forms to record waste data and document the development of solutions to reduce these wastes.

Don't expect to develop a complete list the first try, but keep adding to it over the next several weeks. Figure 5-20 Data Sources for Waste Identification, illustrates the sources for much of this data.

The Acme mixing area team used a schematic process diagram to help identify the sources of wastes in the area and to physically locate the pipe or machine or other source of generation. A copy of this schematic is shown in Figure 5-21 along with the code waste/emission IDs.

Its also useful to develop a systematic method of waste naming and identification. Several examples from the Acme Paint plant are shown in Figure 5-22 that work quite well. These examples use a code that identifies which part of the factory or plant the waste is generated along with a unique number for the waste. This system allows for positive identification and can be easily computerized into a data base if such a tool is appropriate. Once the waste lists are developed, additional data must be collected on each waste so that the team can begin to develop possible solutions.

Two important questions that first must be answered are:

- Is this waste a single waste or has it been mixed with other wastes somewhere in the plant?
- What is the source of the waste?

Often the answer to the last question is a drum or a scrap bin. That's really not the source. That drum might be used to collect waste oil from three stamping machines on the second floor and one die press on the first floor of the factory. This is an example of a mixed waste which is discussed more fully in the next element. Questions and check lists have been used successfully to help compile a complete description and history of the waste. Figure 5-24 illustrates such a series of questions.

Other Ways to Identify Wastes

Another useful tool in helping to identify wastes is a process flow diagram, a production materials flow chart, or other pictorial sketch or diagram of the steps followed in the production process. For chemical plants and refineries this is quite important, but its also useful for multi-step metal or plastic parts production, vehicle plants, foundries, food plants, and many other activities. Several examples are included in Appendix A to illustrate this. Note that

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in these examples the waste sources have been located and identified with a special waste identification (ID) code. This system allows for good waste tracking and accounting either manually or in a computerized data management system.

It should also be noted that where the same waste is generated from different sources, it would be a mistake to consider these all as one source—one waste. For example two machines, doing the same metal forming operation, may generate the same waste, defective parts, but it might be for different reason and in different amounts. A waste data system should be designed to track each machine and each waste individually.

Other useful information sources for developing waste lists are environmental records and permits, shipping documents, ingredient lists, purchase requisitions, cost sheets, operating manuals, and material safety data sheets.

Notice that for the Acme parts forming operation example, the team has identified several sources of the same wastes. Waste lubrication oil is generated by all the machines throughout the factory. This includes three stamping machines on the second floor and one die press on the first floor. The team decided to give the waste oil from each machine a separate ID number and name in order to be able to spot any unusual waste oil generation related to each machine. If the team had decided to combine all the waste oil into a single waste code ID, it would not be easy to spot individual machine oil waste changes in the future.

Use Measurement Tools

In conducting waste identification, especially in chemical plants, printing plants, and refineries, determining the presence and quantity of air emissions, especially volatile organics and other vapors emitted from plant vent pipes, or vapors that leak from drying ovens or tanks or from valve and pipe connections, is quite difficult without some leak detection equipment. In the US and now in Central and Eastern Europe, companies have begun to use portable organic vapor analyzers and other measurement equipment to detect these emissions and quantify them.

Another category of wastes that is difficult to quantify is process or ingredient wastes in waste water. Again there are a number of instruments and laboratory procedures that can measure these components.

However, both types of instruments, the organic vapor detector and water meters, are expensive and their purchase must be justified by the savings they provide.

It is important for the area teams to get help from the technical department or the laboratory in determining the composition and quantity of certain wastes and waste streams. The US EPA and several American industrial organizations (the American Petroleum Institute - API, and the Chemical Manufacturers Association - CMA) have developed guidelines for estimating air emissions and other wastes from a variety of industrial activities. These should serve as useful references.

Mass Balance

Mass balance is a technique used by some industries to help account for all the ingredients and other supplies used in a manufacturing plant. Recently it has been applied to the process of estimating the quantity of wastes. For some plants (where ingredients are in low volumes, usually in containers, and where the process is simple) mass balance may work. For example, mass balance may be used to estimate the air emission losses of solvent in an automobile repair shop. However, in large and complicated plants, such as chemical plants, steel mills, or oil refineries, using mass balance to estimate waste losses is too inaccurate to be useful. This is because these plants use very large quantities of ingredients and have large amounts of products. Using the difference between two large values to quantify wastes has the potential for large errors which will result in poor waste accounting.

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WEC Waste Analysis Form		
Plant/Factory	Date	
Department		
Area		
Waste Minimization Team		
Waste Name		
Waste ID		
Waste Type (solid/liquid/gas)		
Source		
Amount Generated	Each Load	Annually
Containers?		
Where Disposed		
Pure Waste or Mixture?		
Hazardous or Toxic?		
Cost of Ingredients		
Cost of Transportation		
Cost of Disposal		
Cost of Treatment or Handling		
Cause of Waste Generation		
Possible Solutions		

Figure 5-18 Waste Analysis Form

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Waste Profile

GENERAL INFORMATION

Company/Location	Date
Address	
Gov't ID	Local ID
Facility/Contact	Phone / Fax

WASTE INFORMATION

Waste Name	Waste ID
Location/Source/Area	Facility ID
Gov't Waste Code	Local Waste Code
Area Contact	Phone / Fax

COMPOSITION

Major Components	CAS #	Typical Analysis	Upper/Lower Range	Exposure Limits	
1.					
2.					
3.					
4.					
5.					

TRACE COMPONENTS AND INORGANICS

Ag	As	Ba	Cd	Cl	Cn	Cr	Cu
Fe	Hg	I	N	Ni	P	Pb	S
Se	Zn	Ti	Other				
Test Method			Total Metals			GC/MS	

Does Waste Contain:

Sulfides.... Yes☐ No☐	Phenolics.....Yes☐ No☐	Halogenated Organics 1000mg...Yes☐ No☐
Cyanides.. Yes☐ No☐	Dioxins.....Yes☐ No☐	Insecticides/Pesticides .....Yes☐ No☐
PCB's..... Yes☐ No☐	Listed Solvents .....Yes☐ No☐	Herbicides/Rodenticides.....Yes☐ No☐

SPECIFIC PROPERTIES: Liquid ☐ Solid ☐ Mixed ☐ Sludge ☐ Gas ☐

Flash Point_____F(closed cup) BTU/LB_____ Corrosive_____

Color_____ ph_____ Odor_____ Reactive_____ Toxic_____

Pyrophoric_____ Radioactive_____ Shock Sensitive_____

Explosive_____ Etiological_____ Other_____

MANAGEMENT INFORMATION

Qty to be Managed	Container Description
One Time	Est. Wt.
Generated Regular	Est. Wt.

SHIPPING INFORMATION Onsite ☐ Offsite ☐

Shipping Description

Hazard Class.	Haz Sub.	RQ
Placard	Label	UN#

Figure 5-19 Waste Profile Form

Data sources for facility information include:

Regulatory Information:
- Waste shipment manifests
- Emissions inventories
- Biennial hazardous waste reports
- Waste, waste water, and air emissions analyses, including intermediate streams
- Environmental audit reports
- Permits and/or permit applications
- Form R for SARA Title III Section 313

Process Information:
- Process flow diagrams
- Design and actual material and heat balances for:
  — production processes
  — pollution control process
- Operating manuals and process descriptions
- Equipment lists
- Equipment specifications and data sheets
- Piping and instrument diagrams
- Plot and elevation plans
- Equipment layouts and logistics

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

Accounting Information:
- Waste handling, treatment, and disposal costs
- Water and sewer costs, including surcharges
- Costs for nonhazardous waste disposal such as trash and scrap metal
- Product, energy, and raw material costs
- Operating and maintenance costs
- Department cost accounting reports

Other Information:
- Environment policy statements
- Standard procedures
- Organization charts

Figure 5-20 Data Sources for Waste Identification

Reprinted from the Office of Solid Waste, U.S. Environmental Protection Agency, *Facility Pollution Prevention Guide* (Washington, D.C., 1992).

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Acme Paint Plant Mixing Area Process Diagram

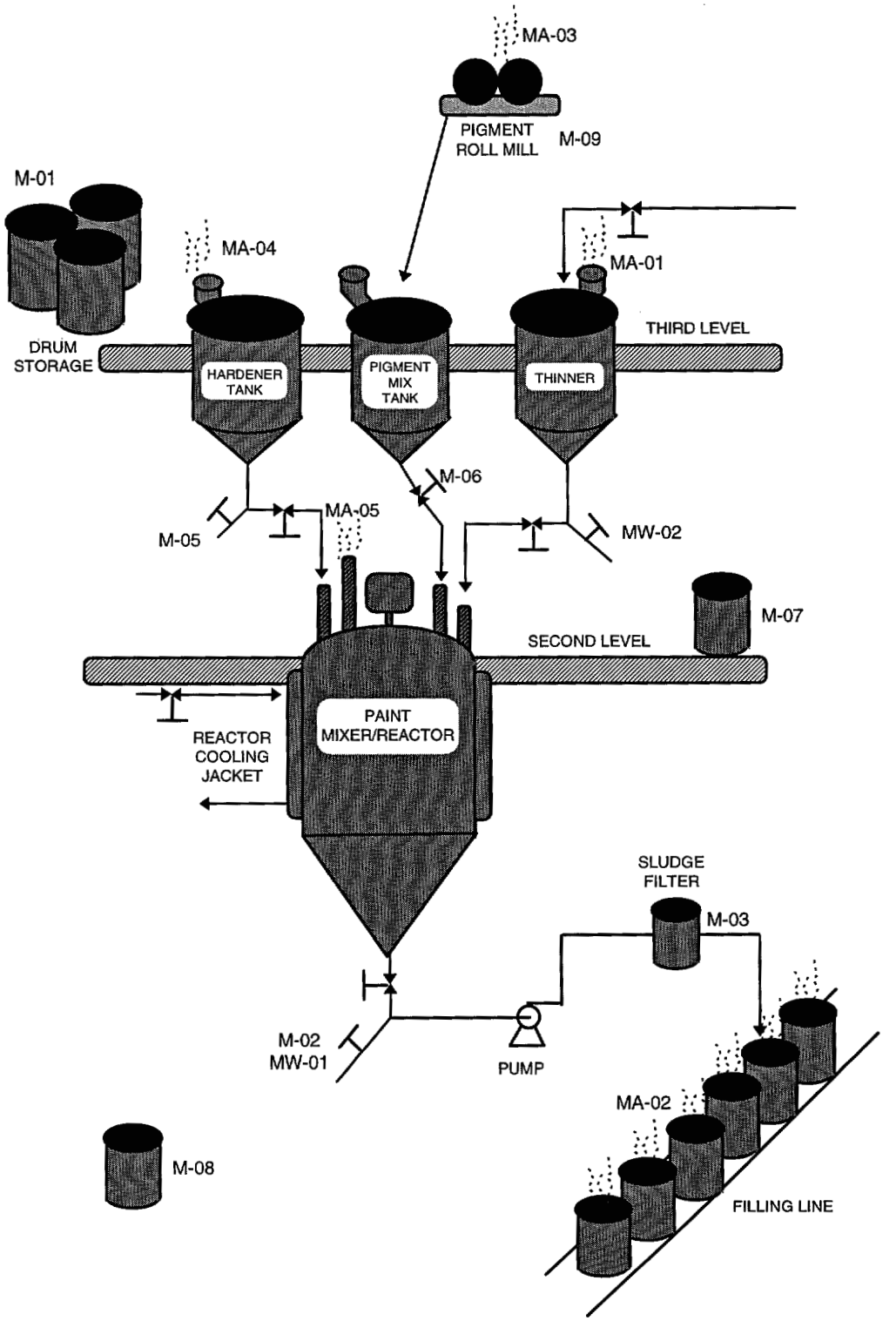

Figure 5-21 Acme Paint Plant Mixing Area Process Diagram

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Waste Naming and Identification

Waste List

These wastes, emission, and waste waters were identified by the areas' waste minimization team. This is a partial list and will be added to as new wastes are identified or generated.

Area ID #.	Waste Name	Source	Disposal
Mixing Area			
M-01	Empty Solvent drums	Solvent Loading	Offsite/Landfill
M-02	Rinse Solvent	Reactor Drain	Onsite/Boilers
M-03	Filter Sludge	Final Filters	Offsite/Incineration
M-04	Waste Paint	RX/Filter Drain	Offsite/Incineration
M-05	Waste Hardener	Hardener Tank	Offsite/Incineration
M-06	Waste Pigment	Pigment Mill	Offsite/Landfill
M-07	Wipe Up Rags	Misc.	Offsite/Landfill
M-08	Maintenance Waste	Misc.	Offsite/Landfill
M-09	Pigment Bags	Pigment Mill	Offsite/Landfill
MA-01	Solvent Tank Emissions	Solvent Tank Vent	Atmosphere
MA-02	Filling Line Emissions	Misc. Points	Atmosphere
MA-03	Pigment Mill Emissions	Pigment Mill	Atmosphere
MA-04	Hardener Tank Emissions	Hardener Tank Vent	Atmosphere
MA-05	Reactor Vent Emissions	Reactor Vent	Atmosphere
MW-01	RX Rinse Water	Reactor Drain	Offsite/Treatment
MW-02	Solvent Tank Rinse	Solvent Tank Drain	Offsite/Treatment
MW-03	General Washdown	Misc.	Offsite/Treatment
Shipping/Receiving Area			
SR-01	Packaging Wastes	Misc.	Offsite/Landfill
SR-02	Scrap Pallets	Receiving Docks	Offsite/Landfill
SR-03	Empty Drums	Drum Area	Offsite/Landfill
SR-04	Clean Up rages	Shipping Dock	Offsite/Landfill
SR-05	Damaged Cans	Warehouse	Offsite/Landfill
SR-06	Forklift Oil	Forklifts	Offsite/Landfill
SRW-01	Clean Up Water	Misc.	Offsite/Treatment

Figure 5-22 Acme's Waste List

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Waste Streams from a Typical Factory

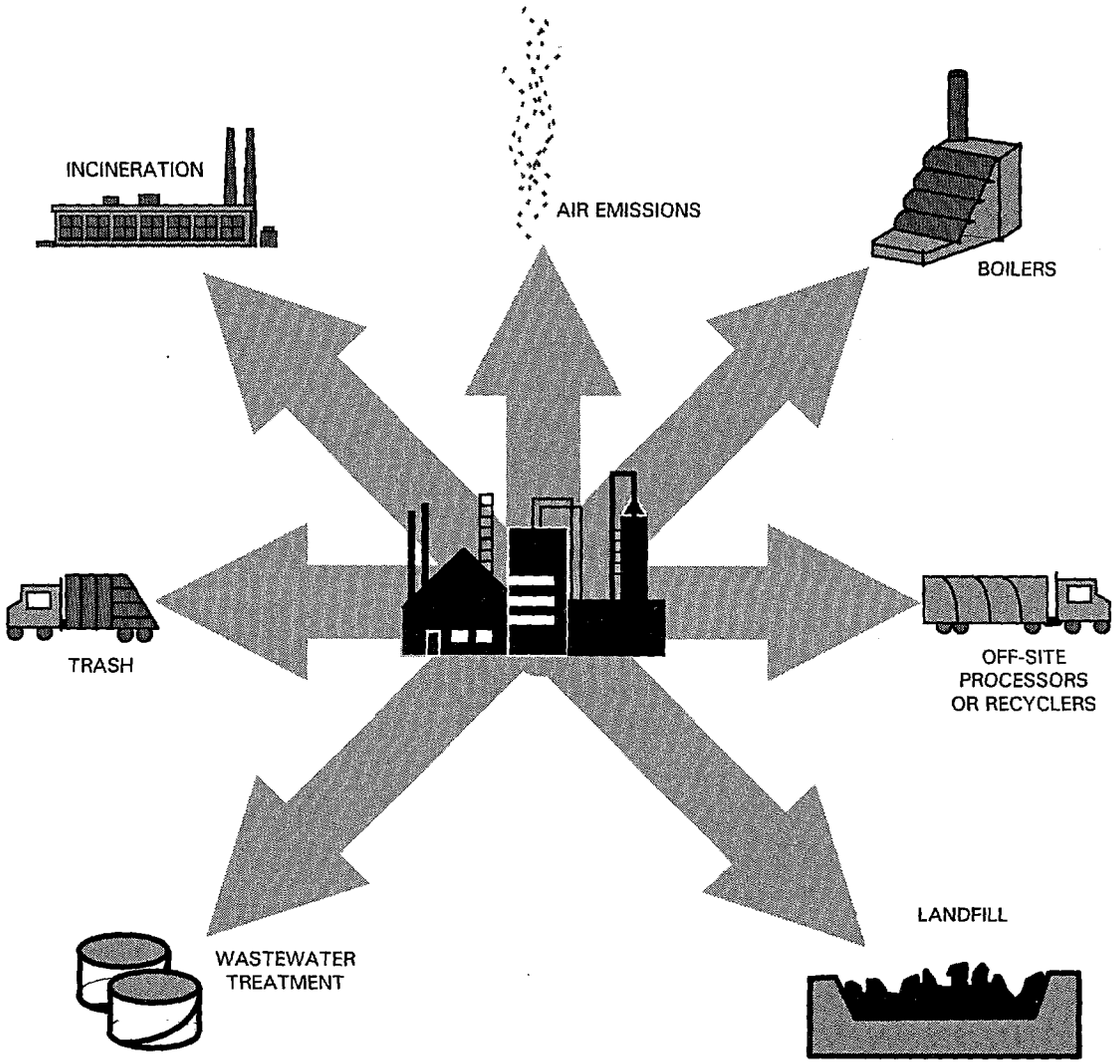

Figure 5-23 Plant Perimeter Wastes

INITIAL ANALYSIS OF A WASTE STREAM

Figure 5-24 Initial Analysis Of A Waste Stream

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Waste Management At A Typical Facility

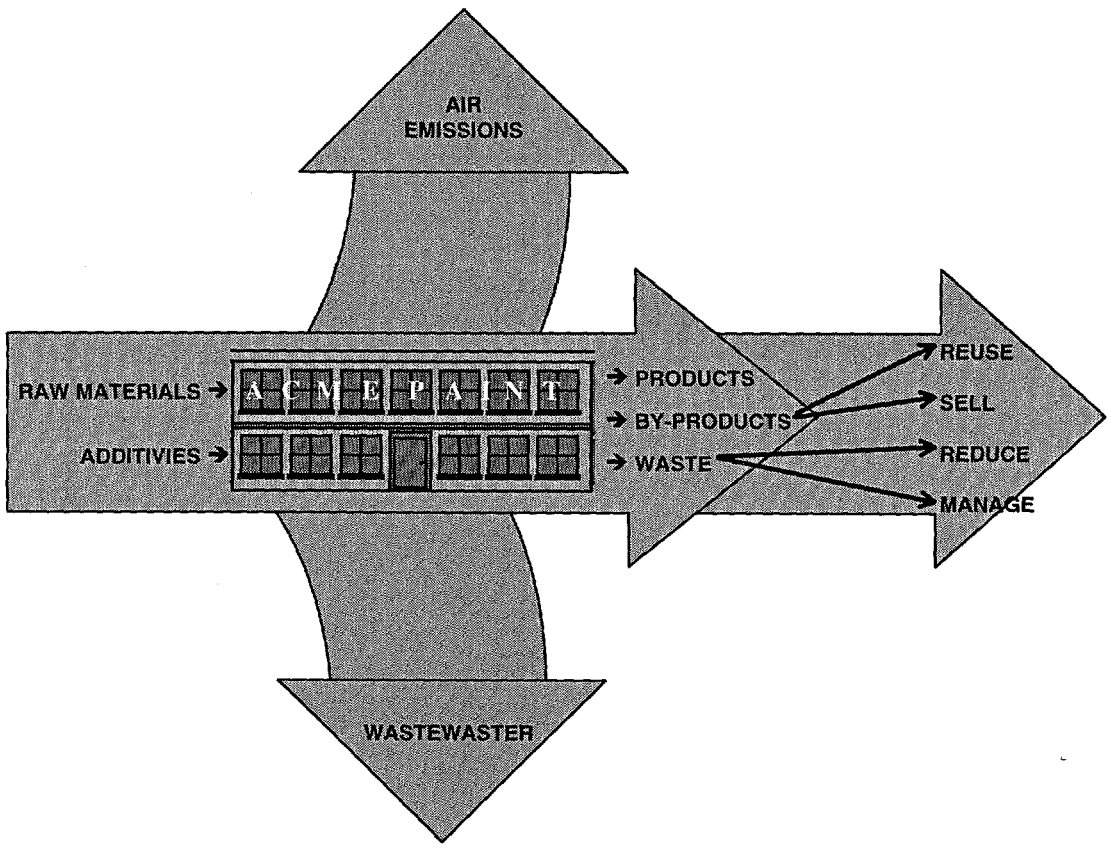

Figure 5-25 Waste Management at a Typical Facility

Secondary Waste Sources At A Typical Facility

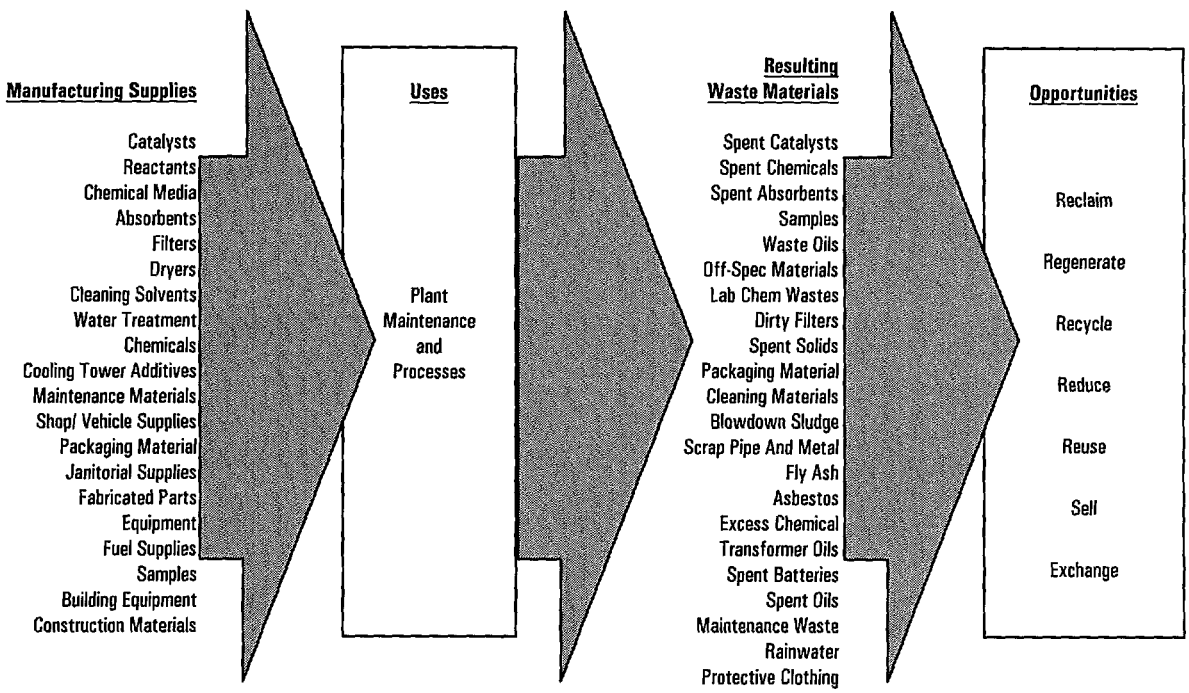

Figure 5-26 Secondary Waste Sources at a Typical Facility

Step 6. Cost Accounting

The next element needed for the development of a waste reduction plan is cost data on each waste. This, along with estimates of the quantity of waste generated in a day, week, month or a year, should provide some economic basis for determining which waste reduction opportunities will provide the greatest benefits and which waste reduction changes are cost justified.

There are a number of different techniques suggested for cost accounting. The obvious first place to look is on the plant's cost-of-manufacture sheets or records. Normally these waste costs, especially if contract services are used, will be shown in the "services" category or a similar category of charges against production for the month or year. These are considered direct waste costs.

The US EPA has an elaborate list of direct and indirect costs that they include in their total cost of a waste assessment plan. A copy of the disposal costs from this list is included in Figure 5-27 for interest. A commonly used check list of waste costs (Figure 5-28) is suggested as a start in this waste cost analysis.

The WEC waste minimization program recommends a simpler approach to allow a quicker assessment of costs. If the benefit of a somewhat costly solution for a particular waste is not obvious, then a more detailed cost assessment might be best.

Knowing the True Cost

Experience with a number of large companies has shown that knowing the true cost of waste is poor at best. Companies that rely on off-site contractor waste disposal can usually point to invoices as records of these costs. Unfortunately these invoices are usually for a month of service and might cover 10 to 20 shipments of several different wastes. To make matters more confusing, there may be several "extra service" charges also included, such as repackaging a waste from a leaking drum or the excessive delay in making an onsite pick-up. Finally these invoices usually combine all drums or loads of waste together for invoices. This prevents a waste minimization team from determining the disposal cost of each separate waste.

The experience of many companies with strong waste reduction programs is that the effort to collect costs and assign it to specific wastes and products is worth the effort when the individual waste reduction solutions are evaluated economically.

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Smaller companies usually are able to keep track of waste costs better than large companies because of their size. Both, however, have trouble tracking indirect costs and the value of lost resources.

Use Cost Data to Audit Current Practices

Included in Figure 5-30 is an example of how the Acme Paint Plant mixing area detailed the cost of empty drums and air emissions. These details also allow for auditing the vendors to be sure the charges are correct. The Acme team used the costs of ingredients and services from the Cost of Manufacturing sheet (Figure 5-29).

Perhaps this task of cost identification will be the most valuable part of the waste reduction program because it will bring waste costs to the attention of the plant management. Even today, many companies do not require that the product cost sheet show specifically what are the waste costs or the environmental costs and so the manager cannot monitor the costs of wastes directly.

Consider Lost Ingredients as Costs Too

One final aspect of waste costs must be an estimate of the value of the ingredients contained in the waste that might be "saved" if the waste could be reduced or eliminated. For some operations that use expensive ingredients, this can be a real education. An example is included in Figure 5-31 where a paint manufacture believed that each drum of waste paint was only costing $18 for disposal because that was the invoiced bill and it was being disposed of as a waste fuel. When the true cost of the waste, plus transportation, plus the empty drum, and the lost ingredients were added up, the cost grew to over $800 a drum. Because of the importance of costs in waste minimization, a more detailed treatment is included in Chapter 10.

Once the waste has been identified, and this includes waste waters and air emissions as well, then it's necessary to assign some cost to these wastes. Some will be easy, if they are disposed off-site and invoiced. Some will be processed on site, such as waste waters. These wastes should not be regarded as "free". The investment and operating costs of the waste water treatment must be paid by the organization and these costs will have to be allocated, or if measured individually, they can be charged an appropriate part of the treatment plant charges. Others will require engineering estimate. Remember to consider the hidden charges as well. Cost estimates should be documented in some form with the references

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or basis included. Some estimate for future costs should also be made; for example, a new incinerator that is expected to be operational next year will cause the incineration costs to change — probably increase.

US EPA Waste Disposal Cost

Typical Offsite Industrial Waste Management Costs*

Disposal		
Drummed Hazardous Waste**		
	Solids	$75 to $110 per drum
	Liquids	$65 to $120 per drum
	Lab Packs	$110 per drum
Bulk waste		
	Solids	$120 per cubic yard
	Liquids	$0.60 to $2.30 per gallon
Analysis		$200 to $300
Transportation		$65 to $85 per hour @ 45 miles per hour (round trip)

* Does not include internal costs such as taxes, fees, and labor for manifest preparation, storage, handling, and record keeping.

** Based on 55-gallon drums. These prices are for larger quantities of drummed wastes. Disposal of small number of drums can be up to four times higher per drum.

Taken from: *EPA Waste Minimization Opportunity Assessment Manual*, 1988, Table 4-3, page 21.

Figure 5-27 US EPA Waste Disposal Cost

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Commonly Used Check List for Waste Costs

Waste Costs Check List

- ☐ Transportation
- ☐ Disposal
- ☐ Disposal taxes
- ☐ Equipment rental
- ☐ Service charges
- ☐ Storage
- ☐ Treatment
- ☐ Special containers
- ☐ Permits
- ☐ Hidden costs

Figure 5-28 Commonly Used Check List for Waste Costs

Acme Paint and Manufacturing Company
Cost of Manufacturing

Production Area MIXING AREA For Period Jan, 1996

Category Of Expense	Unit Cost	Quantity Used	Cost
Ingredients			
L-1 Hardener	32.335/GAL	628,100	
L-3 Hardener	30.255/GAL	52,445	
P-1 Hardener	26.535/GAL	11,546	
Red #5 Pigment	653.00/LB	58	
Blue #24 Pigment	453.00/LB	213	
Black #1 Pigment	987.57/LB	934	
White #231 Pigment	345.85/LB	1,432	
Brown #4 Pigment	576.00/LB	142	
KL Thinner	1.555/GAL	67,800	
FT Thinner	1.24/GAL	47,534	
X-1 Polymer	34.00/GAL	434	
Silica powder	.85/LB	132,000	
Containers			
Gallon cans	.18/UNIT	604,000	
5-Gal cans	.85/UNIT	10,878	
Special tote bins	75.85/UNIT	87	
Utilities			
Electricity	5.09/KWH	42,599	
Steam	10.50/KLBS	1,323	
Water	10.00/KGAL	1,333	
Labor			
Wage roll	5.85/HOUR	480	
Supervision	9.50/HOUR	540	
Overhead & Benefits	10.85/UNIT	400	
Maintenance			
Labor (All)	7.78/HOUR	985	
Materials			
Transportation	.12/GAL	745,000	
Services			
Control Lab	9.00/HOUR	390	
Clerical/Shipping	4.00/HOUR	1,030	
Waste Disposal on Plant			13,500
Water Treatment			2,500
Environmental Support			3,000
Safety Support			
Off Site Waste Disposal			27,000
Depreciation and Taxes			
Total Cost of Manufacture			

Figure 5-29 Cost of Manufacturing

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A Comprehensive Waste Cost Estimate

Acme Paint Company Waste Minimization Program
Waste Cost Accounting Estimate

Category	*Waste*	*Waste*
Area:	Mixing	Mixing
Waste ID#:	M-01	MA-01
Waste:	Empty Solvent Drums	Solvent Emissions
Quantity/Basis:	500/month	2000 Kg/month
Unit Cost:	$5.00/drum	$0.80/KG
Ingredient Cost:	nil	Same
Preparation Costs:	$8.00 (cleaning)	nil
Disposal:	2.00 @ Offsite/Landfill	Atmosphere
Transportation:	$0.50 (100/$50 drums)	nil
Special Handling:	$1.00/drum (Crush)	nil
Fees:	$0.25/drum	$0.20/KG
Labor	$0.75/drum	nil
Utilities	nil	nil
Other:	nil	$1800/month (respirator cartridges)
Total per Unit:	$17.50	$1.00/KG
Total per Month:	$8.750.00	$3,800.00

Figure 5-30 A Comprehensive Waste Cost Estimate

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True Cost of a Drum of Waste Paint

"ICEBERGS" In Your Waste Pile

How Much of the Total Cost of Waste Do You Really Quantify?

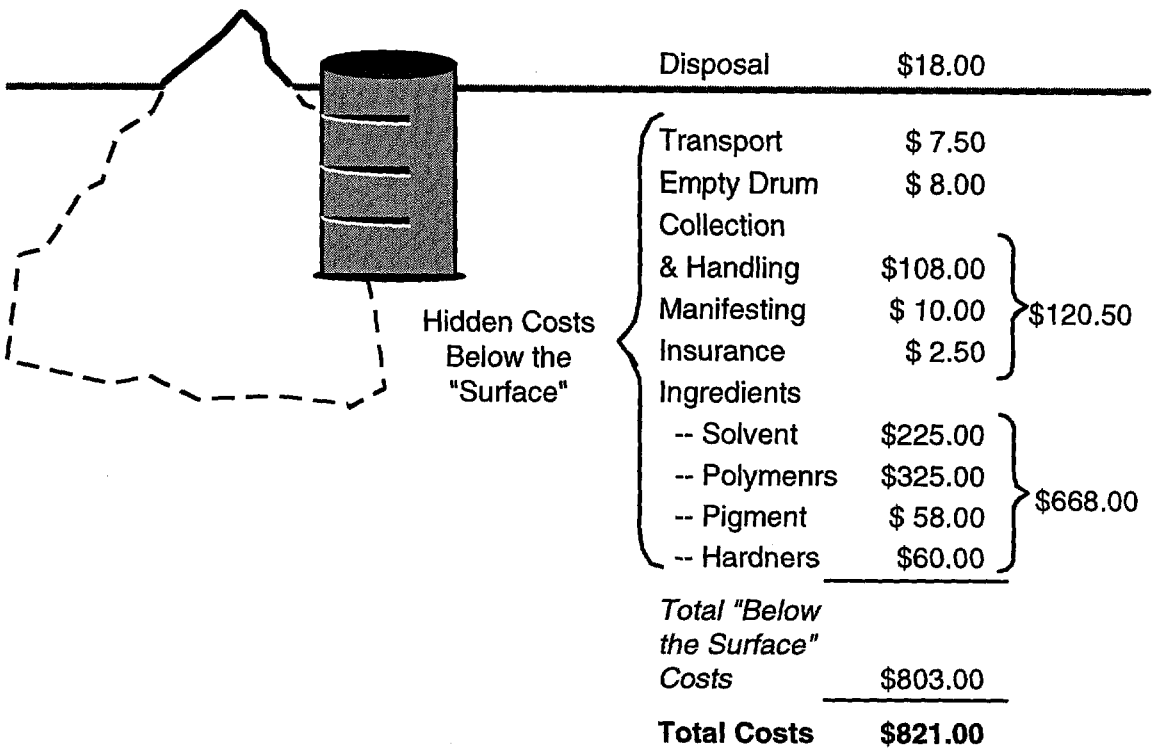

Figure 5-31 True Cost of a Drum of Waste Paint

Step 7. Establishing Goals and Priorities

Goals or "milestone" expectations of results are commonly used in programs such as waste reduction to "challenge" the progress of the organization and its teams and to provide it with direction. Each company should decide for itself if this is appropriate. Usually it is, but it should be used carefully. Overly ambitious goals will discourage the teams. Priorities are also useful when all the waste problems can not be worked on at the same time. Many companies make the mistake of selecting the largest waste, or the most costly waste, as its top priority. These are usually the most difficult to correct and take much longer to solve. It is better to start with a waste where success is quick and quite likely. **Remember, success leads to more success and early successes will encourage everyone to join the teams in the program.**

While in the example of the Acme Corporation the CEO mentions the possibility of a 50% reduction in costs resulting from waste minimization, he did not establish this as formal goal — but rather a target. This idea of a target was also expressed by the plant manager of the paint plant. However, both left the details of selecting specific goals and priorities to the judgment of the plant and area teams. Moreover the WEC program recommends that goal and priority setting be done only after the waste and cost accounting phase (Step 6) are completed. This information on waste and costs will provide a better basis for setting such goals and will help to focus the highest priority on those wastes or emissions whose reductions will benefit the plant or enterprise the most. For example, setting a goal for reducing "green house" gases, such as CO_2, will have little value if a plant releases only minor amounts of CO_2 but does emit larger amounts of benzene.

Once an initial accounting of wastes and costs has been made, it is advisable to begin to establish priorities and goals. NOTE: Too often, the most costly waste is targeted and because it is too complex to reduce quickly, the momentum is lost. This process of setting priorities and goals needs to be a cooperative effort. The area may want to work on a waste because of the housekeeping problems it causes. The environmental department may select another because of a compliance problem. Usually in each area several wastes are selected, for both short and longer range work and usually several benefits will result from these efforts. Figure 5-32 lists the priorities and goals for the two area of the paint plant. Note that several of these have both short and longer range goals that coincide with the implementation plans.

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Waste Minimization Priorities and Goals

Acme Paint Company Waste Minimization Program Plant and Area Goals and Priorities — 1996

The following goals and priorities have been identified and accepted by the management and employees of the Acme Paint Company, a subsidiary of the Acme Corporation

These goals were selected in October, 1994, with the understanding that they will be reviewed and updated annually. Additionally they may be changed depending on the individual circumstance of if business needs dictate.

For the Acme Paint plant.

Environmental Goals

- Reduce solvent and other hydrocarbon emission
- Reduce worker exposure to pigment dust/fumes
- Eliminate pigment in waste water discharges
- Reduce the offsite landfilling of potential toxic wastes
- Eliminate spills and leaks of process materials to the ground

Waste and Emission Goals

- Reduce solvent emission by 50% in 1996-1997 and 90% in 1998
- Reduce pigment dust from the pigment mill area by 70% in 1997
- Reduce offsite disposal of solvent by 50% in 1997
- Reduce packaging costs by 20% in 1997
- Reduce solvent drum disposal costs by 30% in 1997

Given the goals listed above, each area should establish priorities for the individual wastes and emissions that is consistent with the overall program. For example, the mix area has a primary responsibility to work on solvent emissions and solvent wastes that are disposed offsite. Also the mixing area is responsible for the pigment reduction programs.

Figure 5-32 Waste Minimization Priorities and Goals

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Step 8. Waste Minimization Analysis and Planning — Auditing the Activities or the Causes of Wastes

Earlier in Step 5, wastes and their sources were identified using a systematic approach. This information was recorded on some type of data collection form or summary and will be useful in developing some possible waste reduction solutions. In Step 6, important cost data was collected on each of the wastes in the program so that any possible solutions could be evaluated for its economic impact on the business.

This step (Step 8) brings together all the previously collected information and allows the waste minimization teams to engage in the process of solution development or "brain storming."

This problem solving is really the major activity of waste minimization since it uses all the information developed previously. However, more understanding of the waste sources/causes and historical background is usually needed before possible solutions can be formulated. This additional understanding is developed usually by asking questions of various team members or others who are familiar with the wastes and documenting the answers in the waste data file. Pretty soon the questions will stop and possible solutions will begin. The value of conducting the problem solving with the entire team present, if possible, is that a question asked, or a solution suggested by one member, while not too useful by itself, might trigger an idea or a solution from another member that is important. This synergy in problem solving is often remarkable in producing good solutions.

Its important to conduct these brain storming sessions in a way that encourages this synergy and gains participation by everyone on the team. Often its useful to point this out to everyone at the start of the meeting as a part of the "ground rules" and Figure 5-33 lists some other rules for the group to follow in screening and selecting solutions.

Basic Rules for Good Analysis

- There are no bad ideas
- Everybody's ideas are important
- Don't act on the first solution unless it is necessary

Figure 5-33 Basic Rules for Good Analysis

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The identification of the sources of waste has been mentioned as a part of waste identification. The waste oil from four different sources; i.e., three stamping machines on the second floor and one die press on the first floor of the factory, was the example cited earlier in this chapter. Once the sources have been identified, the cause of the generation of the waste—in our example, why these machines are generating waste oil—needs to be identified. Is it a leaking lubrication fitting or is it because the oil reservoir is overfilled when the machine is cold? The cause is not always simple to find, and the waste reduction team will not be able to assign a cause for many wastes. In such situations it may be useful to list what the team believes is not the cause. This will help narrow the search later when the waste reduction plan is developed for this waste.

Also there may be several causes of a waste, a primary one and a secondary one. In some cases there may be an identifiable cause during routine operation and another cause due to upsets, startups, or shutdowns. Some operations generate more wastes during an outage turnaround than when they are running smoothly. For example, in an ethylene plant during a major turnaround, most of the equipment has to be cleaned thoroughly so that any degraded product (coke and tars) will not flake off the equipment interiors and plug up piping and filters at startup. For this reason, the ethylene plant generates more waste in a shutdown due to cleaning than it generates in a normal year of operation.

Lists of some generic causes along with operational and design factors are included in Figure 5-34 for interest.

NOTE: Because determining the cause and the solutions for waste minimization is so critical to this program, a separate chapter (Chapter 6) in this manual has been developed to elaborate on the many aspects of this activity. Chapter 10 discusses waste minimization opportunities in capital projects, both large investments in new equipment and entire plants as well as small projects and minor replacements. Both categories offer excellent opportunities to reduce wastes in a cost effective manner.

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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 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 cleanup	• Indiscriminate use of water for cleaning or washing	• Vacuum pumps instead of steam jet ejectors • Choice of process • User 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, spend 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 work piece	• Countercurrent rinsing • Fog rinsing • Dragout collection tank or trays

(Continued on next page)

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Causes and Controlling Factors in Waste Generation (Continued)

Waste/Origin	Typical Causes	Operational Factors	Design Factors
Disposal of unusable raw materials or off-spec products	• Obsolete raw materials • Off-spec products by contamination, improper reactant controls, inadequate precleaning of equipment or work piece, 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
Cleanup of spills and leaks	• Manual material transfer and handling operations • Leaking pump seals • Leaking flange gaskets	• Inadequate maintenance • Poor operating 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

Taken from the EPA Waste Minimization Opportunity Assessment Manual, Table D-2, p. D-2.

Figure 5-34 Causes and Controlling Factors in Waste Generation

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Develop a Plan Based on Goals and Priorities

Up to now all the effort has been directed at collecting information about the wastes, the causes of the waste, what happens to the waste once its generated, and at what cost. Now the real waste reduction process begins.

For each waste on the lists compiled by the teams, a list of possible solutions needs to be developed and then each solution is evaluated for its workability. Using this list of solutions a plan needs to be developed along with a timetable of when the steps in the plan might be accomplished. This plan and timing development was discussed briefly in Chapter 3, Understanding Causes, and in Chapter 4, Recognizing the Process—a Continuum, where the wastes and causes from a distillation column and some parts machines were evaluated.

NOTE: One category of "causes" for waste that the WEC program recommends as an early candidate for attention is the procedures and practices in a plant, the routine way jobs are done. This is such an important cause of wastes , that Chapter 7 of this manual has been devoted to expand this subject. Another cause of wastes that is frequently overlooked — and can be corrected with low cost and innovative solutions — is maintenance. Chapter 8 discusses this subject in more detail.

Find a Use for Waste Early in Solution Selection

An alternative to waste reduction by a process change is to find a use for the waste as an ingredient, a fuel, a solvent, or as a co-product. If a "waste chemical" is a complex chemical compound; i.e., it has a very specialized chemical structure, it might have potential as a co-product to be used in some other application. Du Pont sells over 100 million pounds per year of by-products from its nylon intermediate plants that would otherwise be wastes. However, the key to this success was to recognize that to sell these materials into a premium market, they had to be treated as a co-products and not wastes. This meant tight quality specifications were established and the co-product was actually "refined" to meet these specifications. Research efforts were supported to identify new uses for these materials. Finally co-products were aggressively marketed to increase the volume of sales to match production.

It is also important to realistically price the material for sale in the recycle market. Too many opportunities are lost because the generator wants to recover 100% of the value. Also, some wastes

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might need an additional stage of purification or filtration before they are usable but overall that is less costly than disposal.

In the case of the scratched parts, an early solution might be to buff the scratches out of the parts in order to avoid wasting them until a better solution is identified.

Some countries and regional agencies have established waste exchanges to expedite this effort. Usually an ingredient supplier or broker might know of a waste reuse opportunity. The team should seek assistance from the plant purchasing or marketing group in trying to locate uses for wastes.

Acme's Analysis and Plan

For the Acme Paint Plant, this process of problem solving has produced a wide variety of possible solutions for the wastes used in the two areas under study. For the paint mixing area, the major focus of reductions is on solvent wastes and solvent emissions. These are major environmental issues and worker exposure concerns. Both short and long term solutions were developed, and several had significant cost savings or cost avoidance aspects. Figure 5-35 lists these in tabular form. Note that recycling or reuse were selected as the immediate solutions for the empty drums and rinse solvent — but other ideas were also considered.

For the shipping and receiving area, recycling and recovery of containers and packaging materials offered the near term opportunities because of costs and housekeeping considerations. Renegotiating purchasing and sales contracts are longer term solutions but would take months to complete.

Acme's Solutions

Acme Paint Company Waste Minimization Program

Solutions and Timing Analysis

Waste	Acme #	Area	Solution	Timing	Cost
Empty Solvent Drums	M-01	Mixing	Recycle Use special containers New solvent Water base		
Rinse Solvent	M-02	Mixing	Reuse Recover by vendor Replace with pig. cleaning Teflon pipe lining Slanted pipes		
Solvent Tank Emissions	MA-01	Mixing	Vent hood Carbon bed Incinerator New solvent Water base Tighter Lid		
Pigment Mill Emissions	MA-03	Mixing	Vent hood Carbon Bed New solvent		

Figure 5-35 Acme's Solutions

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Step 9. Schedule for Implementation and Assignment of Responsibilities

It's critical to the success of a waste minimization program that the team develop a schedule for the implementation of the plans — both the short and long range plans — to help drive the program. Management will need to know how the team proposes the waste minimization solutions be done — how, by whom, and when. While a specific date or time table may not be practical for all the solutions, many, if not most, should have definite schedules established. Some may be dependent on the timing of other related events; for example, a new gasket to stop an oil leak should be installed during the next major shutdown of a stamping machine. However this shut down may not be scheduled due to production demands until the annual plant outage.

Along with implementation scheduling, the assignment of responsibilities should be established so that individuals or groups will understand what is expected of them and can make the necessary preparations to implement the action plan or schedule. This assignment should be done as specifically as possible; i.e., by individual name rather than group assignment.

Acme's Solution Implementation Schedule

In this step of the program, the Acme Paint waste minimization teams examine the short and long term solutions in relation to the production and maintenance schedules in the two areas used in this example. The objective is to try to "piggyback" the waste reduction projects on top of necessary or routine work or other projects to minimize any extra costs due to lost production. Specifically the teams want to avoid any unnecessary clearing of equipment for repairs or replacement.

For the shipping/receiving areas, it is important to schedule the change-over to new containers, packaging materials, and other details to avoid adverse impacts on customers or production. Figure 5-36 details the results of this process and gives some examples for several of the wastes and emissions from the mixing area. Note that sometimes the responsibility for implementing the solutions is assigned to two or more groups who must coordinate this activity. It is also important to note that the Acme team has selected both short and longer term solutions in order to build in continuous improvement.

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Acme's Solution Schedule

Acme Paint Company Waste Minimization Program

Solutions and Timing Analysis

Waste	Acme #	Solution	Responsibility	Timing	Cost
Empty Solvent Drums	M-01	Recycle	Purchasing/Shipping	Immediate	nil
		Use special containers	Prod./Purch./Engr.	6-9 months	10K
		New solvent	Tech./R&D/Prod.	2 years	?
		Water base	Tech./R&D/Prod.	4 years	??
Rinse Solvent	M-02	Reuse	Prod./Tech.	Immediate	nil
		Recover by vendor	Purch./Tech.	6 months	+50K
		Replace with pig cleaning	Maintenance	3 months	+80K
				8 months	42K
		Teflon pipe lining	Engineering	8 months	13K
		Slanted pipes	Engr./Prod./Maint.		
Solvent Tank Emission	MA-01	Vent hood	Prod./Tech./Engr.	5 months	35K
		Carbon bed	Tehc./Prod.	4 months	50K
		Incinerator	Engr./Tech.	2 years	120K
		New solvent	R&D/Tech./Prod.	2 years	?
		Water base	R&D/Tech./Prod.	4 years	??
		Tighter Lid	Prod./Engr.	Immediate	4K
Pigment Mill Emission	MA-03	Vent hood		5 months	35K
		Carbon Bed		4 months	50K
		New solvent		1 year	?

Figure 5-36 Acme's Solution Schedule

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Step 10. Follow up to Sustain Progress — Documentation of Results

Once a program and the process to produce results is in place, it is management's responsibility to maintain it. A waste reduction program is easier to sustain than to start anew every few years. There are a number of suggestions that can help management. (See Figure 5-37.) Reviewing goals and setting new ones is one such technique. Annual contests on the best ideas or team efforts is another. Putting the cost savings of waste reduction into terms of profits to the business can be a positive message, along with quantifying the amount of wastes withheld from the environment. Sharing a portion of the savings from the waste minimization program with the teams or the organization as a whole is also a workable idea.

Get Suggestions from the Teams

Perhaps the best idea for sustaining the program will be recommended by the teams themselves. Workers need to feel their ideas are worthwhile.

Acme's Follow-up

A waste minimization program is an ongoing commitment to improvement in the management of resources — so as to reduce the generation of wastes. The Acme Corporation recognizes this and has installed a follow-up program to insure continuation. In his letter to the employees the CEO placed the responsibility of an annual progress/status report on the operations management. Ideally these reports should address not only the wastes and costs reduced, but also the impact that waste and emission reductions have on the environmental objectives as well. For Acme Paint, the reduction in solvent wastes in the mix area improved compliance with emission limits and reduced the solvent levels in the ingredient charge area by over 50%. This is still short of the 90% reduction goal but indicates to management and the workers that real progress has been made.

Figure 5-38 is an example such a report. It is an overall summary for Corporate Management and addresses the corporate expectations.

Another aspect of follow-up is to track the status and success or failure of projects. This is needed because sometimes the first waste minimization solution may not work and the follow up will help to determine why it didn't work so that the next solution will avoid the same problems.

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Sustaining a Waste Reduction Program

Key ways to maintain and improve the pollution prevention program:

Integrate pollution prevention into corporate planning:

- Assign pollution prevention accountability to the operating units where waste is generated.
- Track and report status.
- Conduct an annual program evaluation at the corporate level.

Provide ongoing staff education programs:

- Make pollution prevention awareness program a part of new employee orientation.
- Provide advanced training.
- Retrain supervisors and employees.

Maintain internal communications:

- Encourage two-way communication between employees and management
- Solicit employees' pollution prevention suggestions.
- Follow up on suggestions.

Reward personnel for their success in pollution prevention:

- Cite accomplishments in performance reviews.
- Recognize individual and group contributions.
- Grant material rewards.
- Consider pollution prevention a job responsibility subject to review.

Provide public outreach and education about pollution prevention efforts:

- Submit press releases on innovations to local media and to industry journals read by prospective clients.
- Arrange for employees to speak publicly about pollution prevention measures in schools and civic organizations.

Figure 5-37 Sustaining a Waste Reduction Program

Reprinted from the Office of Solid Waste, U.S. Environmental Protection Agency, *Facility Pollution Prevention Guide* (Washington, DC, 1992).

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Acme's Progress Report

Acme Paint Company Waste Minimization Program

Annual Report on Waste Reduction

The Acme Paint plant has completed the first year in its waste minimization and environmental responsibility program. The detailed results of the program have been transmitted to Frank Jones and his committee as well as to the environmental director.

Overall the following results have been achieved:

- Solvent emissions to the atmosphere were reduced by 50%
- Waste disposed of offsite were reduced by 45%, saving $200,000
- Worker exposure to solvents and pigment vapors was lowered by 65%

The plant received over 350 worker suggestions for waste reduction and workplace improvement. All have been included in the reduction planning program.

Figure 5-38 Acme's Progress Report

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Chapter 6: Understanding The Types Of Waste Minimization Solutions

Once wastes, sources, and causes have been identified, the real heart of a waste minimization program is determining the best solution to reduce or eliminate a waste. In some situations this can be very simple if all the details of the waste, causes, and its costs are clearly understood. Usually there is a "common sense" answer. However, even when the details are known, the solution may not be obvious for many industrial wastes. Sometimes the solution selected will not be the best but it will be better than the present state of affairs. Developing solutions is akin to inventing new devices—it requires a number of skills, both technical and creative and it usually takes several attempts to succeed.

Searching for Solutions

Perhaps an example will illustrate this point. A major US chemical company tried to solve ten of its largest waste problems with a team of eight of its brightest engineers. Two years later they reported virtually no progress and had developed only a few proposed solutions that were very expensive to implement. It was obvious they needed a new approach for developing solutions. One of these waste problems was presented to newly formed area waste minimization teams in the plant and in six months several solutions were tested with limited results. These solutions cost very little to implement and, while they weren't the final answer, some overall progress was made where there had been none. But the teams didn't stop working on the problem and began to look beyond their areas at options that might be available elsewhere in the plant or in neighboring plants. Soon the teams identified two better solutions and tested them with excellent results. The lessons learned from this are:

- Many solutions are not technical but practical in origin.
- People who work with the process and the waste routinely can usually contribute significantly to a solution. They may need an outsider to challenge their routine.
- Sometimes the answers can be found outside the area.

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- First ideas may not be the best but they provide a start that can lead to better solutions.

- It is unusual to develop the complete solution to a waste problem as a "first idea." Partial solutions serve as a foundation for better ideas.

What follows is a brief discussion of possible solutions that could be applied to several of the most common causes of wastes identified in industry. A number of organizations have published similar lists of solution options, notably the US EPA, NOTA, the US Chemical Manufacturers Association, and API among others. It is useful to provide these ideas to the area teams as "idea generators" even if they do not directly apply. Success stories are also a good generator of ideas.

This review of waste minimization solutions by logical categories is included to provide some actual examples and as a collection of experiences from many years of working with leading companies in their waste reduction efforts. It is also included to provoke thoughts and ideas about waste reduction. This manual cannot present all the material that could be written, but rather it has attempted to focus on that material that is most appropriate for the Central and Eastern European industries.

1. Ingredients

Many waste problems can be traced to ingredients or service systems. In an earlier example, the scratched parts were traced to the failed filter (Chapter 3, Understanding Causes). Unfortunately if the waste is a mixture of materials or if it occurs at the product end of a manufacturing process, it may be difficult to relate it to ingredients.

Involve Your Supplier Early

To solve waste problems through ingredient changes it is important to work with your supplier to better understand the possible options and their costs. A manufacturer of brass plated products was trying to reduce plating wastes and toxic rinse waters when a team member asked why didn't they buy the coiled metal stock already plated. It turned out that the supplier was already brass plating products for other customers and could do this on the same coating line for a modest cost increase. This eliminated several wastes and allowed the plating equipment to be removed, thus providing some much needed floor space for expansion of other production machines. This is an example of the potential multiple

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benefits that carefully thought out waste reduction plans can provide to business.

Don't Forget Containers and Packages

There are countless ways ingredient changes can reduce wastes and the plant or factory area teams need to explore these. In addition, you should consider the packaging of ingredients as a waste source. Empty drums, boxes, and other containers and wraps must be managed and disposed of. Often these are contaminated with content residues, so they must be cleansed before disposal, thereby generating wastes. Again, by working with your supplier, you can eliminate or reduce many of these wastes. The key is awareness, good data, and creative thinking. Several success stories have been documented by companies where ingredient or packaging changes have saved millions of dollars.

2. Inventory Control

Closely akin to ingredient opportunities for waste reduction is the value of inventory control. Several companies were embarrassed when they learned how much waste and its associated cost were generated due to poor inventory control.

Too Much is Too Much

A classic example is where a purchasing agent negotiated a lower price for an expensive catalyst if it was bought in 6-pound drums instead of the present 4-pound drums. However the purchasing agent was unaware that the area technical group had changed operating conditions so that the production batches needed only 3 pounds of catalyst. The partially used 6-pound containers soon became a waste problem because the opened containers caused the catalyst to quickly deactivate, rendering it unreliable for future use.

3. Process Changes

Changes to the process or how parts are manufactured are the classical approach to waste reduction and are well discussed in the many waste reduction manuals referenced elsewhere. The WEC waste reduction program discusses this in Chapter 9 and certainly suggests using this technique where it is justified and affordable. However, since this may not be an option for a large number of the factories and plants in Central and Eastern Europe, this manual offers some additional suggestions and practical experience.

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Piggybacking

Process changes can effect waste reduction at little or no additional cost if the changes are well planned and done as a part of some other project. Some companies use the term "piggybacking" to describe this method of combining jobs. For example, a waste reduction team may identify that a change in how materials are charged to an iron cupola hearth will reduce wastes, but this will cost $50,000 in work and lost production. This becomes a "tomorrow" solution and is delayed for seven months until the hearth is shut down for necessary replacement of safety devices and some instrumentation. By carefully planning this repair job, together with some piping redesign and reuse, the waste reduction work can be included in this project for only an additional $15,000. This "piggybacking" approach saved $35,000 of expense.

Minor Process Changes

Process changes that are merely changes in operating conditions, temperatures, pressures, machine cycle times, etc., are also minimal in costs. Too often these minor changes are overlooked; however a 1 or 2 degree change in the temperature of a dryer or changing the rinse time by 30 seconds can have a big effect on quality and on waste due to yield loss.

Safety Considerations

Carefully consider the effects on safety before trying process changes. Both process safety and worker safety need to be a primary consideration of such changes.

Apply the Solution at the Correct Place in the Process

Often the generation of waste is a progressively cumulative process. A small amount of an impurity in the ingredients may cause a slightly greater amount of waste during the reaction. However to remove it later in the intermediate purification step, distillation for example, might require a large amount of purge waste. The question this example poses is where in the process is the economical place to remove it? Or should it be removed at all, if the customer can tolerate it in his ingredients? Decisions such as these demonstrate the need to involve a diverse group in the waste reduction team, including product and marketing specialists. In a wood products plant, wastes resulting from poor adhesion of a

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glued laminator were increasing until a waste reduction team identified a shelf life problem with the glue. Once fresh glue was used all the time, the adhesion problem disappeared.

Don't Discard Good Ideas—Changes Might Make Them Feasible

Also it should be noted that proposed solutions and the plans to implement them need to be reviewed from time to time because of changes in the factors that led to their selection or changes in other factors such as markets and co-product opportunities. Waste reduction solution opportunities can be very dynamic. While one team was trying to reduce wastes due to trace contamination, another team was trying to convince the customers that the contamination did not affect the use of the product in the application. When these teams met, they realized which solution was best.

Process change to effect waste reduction is certainly a time continuum example. Figure 6-1 shows an example of this depicting a generic reactor process step. It is shown in context of a timing continuum and therefore includes equipment and ingredient options as well.

4. Equipment Changes

Many waste reduction solutions result in recommendations for equipment changes. This is usually the first and easiest choice for teams to agree on. However it sometimes becomes an expensive solution, normally takes a long time to implement, and may not really be needed. Challenge your teams to consider equipment changes as a second or third option, and only after the no-cost options, such as process or procedure changes, have been explored.

Consider Equipment Solutions Last

Waste reduction teams are no different from other groups regarding "pride of ownership." Once they buy into an idea they tend to close their minds to any other ideas. So an early choice of an equipment change will blind the team to other less costly solutions. One team used waste reduction as a justification for a new larger tank that they wanted to make their job easier when simply a new level gauge would have accomplished most of the waste reduction for less money.

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Replacing an old machine with a modern one is a tempting suggestion. Often a rebuilt machine will do as well.

New Equipment May Provide Additional Benefits—Play All the Angles

As was discussed above, if equipment changes are really the answer and no other less costly options can be identified, then examine the "piggyback" possibilities. Often new or replacement equipment can be designed to add to capacity, allow for anticipated new products, or eliminate a reoccurring maintenance problem and thus accomplish a dual purpose. Waste minimization, in its broadest application, means that an organization is maximizing its resources and profitability. If the economics including the secondary benefits can justify a new machine or process unit, the team should support such a proposal.

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Waste Reduction Assessment
in Synthesis /Reaction Operations

TODAY

Fugitive Leaks
Sample Reassessment
Control Optimization
Cleaning Practices
Agitator Seals
Pump Seals
Equipment Fouling
Better Catalyst Filtration
Anti-fouling Additives
Cleaning Waster Reuse/Recycle

Upstream
Ingredient Purification

TOMORROW

Repipe
On Line Analyzers
Remodel for Optimum Size
New Operating Conditions
New Agitator Design
Agitator Seals
Sealess Pumps
Improved Catalysts
Upgraded Heat Removal
Stage Reaction
Adiabatic Reactors
Fixed Bed Catalysts
Gravity Flow
Process Simplification
Micro Kinetic Modeling
Continuous Reactors
Control System Replacement
Ultra Sonic Mixing
Anti Fouling Surfaces
Melt Additives

Upstream
Ingredient Substitution

Downstream
By-product Marketing

AFTER TOMORROW

Process Simplification
New Ingredients
Photo Sensitive Reactors
Jet Agitation
Thermal Piping
New Catalysts
Enzyme Catalyst
Isothermal Kinetics
Reactive Distillation
Continuous Reactor
Ultra Sonic Mixing
Micro Kinetic Modeling
Laser Excited Reaction

Upstream
Purchased Intermediates
Different Ingredients

Downstream
By-product Market Development

Figure 6-1 Waste Reduction in Synthesis/Reaction Operations

Keep Current on New Equipment—Investigate Before Ordering

The generic reaction example cited in the Process Changes also has some ideas for equipment options. Older plants and factories are historically burdened with equipment that was designed and installed to make a product, period. The idea of designing equipment to reduce or eliminate waste was at best secondary, if at all. Most process designers and industrial planners have little or no appreciation for wastes generated by the production facilities. This is especially true of wastes that are related to start up and shut downs, or when something gets out of adjustment. For this reason the older plants and factories have a lot of waste-producing equipment. As this equipment wears out and needs replacement, pay attention so that it is not replaced "in kind" with the same design.

As an example for a factory where cleaning solvent is stored in a tank, replacing an open top tank with one fitted with a closed top and designed to contain the vapors of the solvent will pay for itself quickly in reduced solvent evaporation. Of course this assumes that the team has already determined that the solvent must continue to be used, and no substitute will work.

Companies and the equipment suppliers are beginning to work together to solve waste problems by better equipment design. Pumps, valves, tanks, and reactors are just some of the examples of where this is working.

5. Practices

The WEC manual defines practices as **how workers really do the job.** This may be very different from how management believes the job is done or how the foreman instructed the workers do the job. Practices are responsible for a significant portion of the total wastes generated by industry. (This is also the leading source of waste in homes as well.) Therefore, the WEC program stresses this as the foremost cause of waste on which a team or a company should work. It is also the least costly to correct.

Changing Workers' Behavior

Changing workers' behavior, the way they think, and then act with waste producing situations, requires a well planned program. It begins with a clear message from management that this is important to the business and to the stability of the company enabling it to continue to provide jobs.

Most workers are eager to do the right thing with reducing waste, saving costs, and protecting the environment. The reason they may not is because they haven't been trained properly, or they are unaware of any adverse results of their actions. Another cause may be the lack of equipment or process information. Its easy to see that there are many opportunities to improve waste reduction by improving or correcting these other factors.

Start with Facts and Observations

One of the first tasks a waste reduction team can do is to have each member keep a daily log of jobs and actions done that either produced wastes or had the potential to produce waste if other conditions existed. To help the teams, an actual "walk through" demonstration should be held by several trained people. (See Step 4, Chapter 5.) This is not unlike techniques used in safety programs to increase safety awareness. These logs should be reviewed by the team and area supervision for their learning value and to begin to modify those practices and situations generating wastes.

It is difficult to judge the correctness of a practice without viewing it in the context of the actual situation. A number of examples have been cited in the referenced manuals. The various teams should review these to determine if they apply. As the list of wastes are assembled and their causes (also sources) identified, the team can begin to identify those related to practices.

Mixing Wastes—A Recipe for Problems

One practice that definitely hurts a waste reduction program is the casual mixing of wastes in drums, bins, and boxes because the containers are handy. Such mixing can cross-contaminate a waste that, if uncontaminated, might be recycled or sold for some other use. Mixing wastes also confuses the identification of the cause and foils good data tracking.

Chapter 7 expands on both practices and procedures with additional examples.

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6. Procedures

Procedures are basically the formal or official directions for how jobs should be done and how the machine or equipment should be operated. Procedures, like practices, are well intentioned and are usually carefully developed.

Procedures May Not Reflect Waste Reduction Thinking

However the objective of a procedure is to produce a product or perform a task safely and efficiently. This does not always ensure that minimizing waste was a consideration. Like practices, procedures that inadvertently cause or increase wastes should be identified in the auditing step of the program. Those wastes caused by outdated or inappropriate procedures are ideal candidates for early action.

Another example where procedures may actually cause more waste in scheduling products and the transactions between products. Often the production scheduling group fails to consider the amount of waste generated when an illogical production cycle change is made. One solution to this problem is to extend the duration of production runs if the inventory situation can be managed.

Again, as was cautioned earlier, pay close attention to the safety aspects of procedure changes.

The Synergy of Solutions

It should be clear that each of these categories of waste causes and remedies are in reality closely linked with others. For example, equipment, processes, and procedures are interrelated and so a change in any one of these requires a broader review of these interactions.

7. Product Changes

One common failure of waste reduction programs is to draw a boundary around the plant or factory that excludes the products, the outputs from the factory, from the waste reduction analysis. Such narrow thinking suggests that nothing with the product can even be considered as a way of reducing wastes. Both the product and the product packaging should be very much a part of a waste reduction review. The following example illustrates this.

Partner With the Customer for Mutual Benefits

A small custom supplier of metal parts for an automobile company was trying to reduce wastes generated from its product painting shop. It had already tried a number of ideas with limited success. It was about to spend $200,000 on a new paint line when the marketing manager mentioned this event to the auto parts buyer and engineer. They suggested that instead of spending this money, the supplier should ship the parts with only a dip primer application and the auto company would apply the final coat as a part of its painting operations. Of course this solution was traded for a small price reduction in parts, which allowed each company to profit. Consequently, the parts supplier routinely invited the auto company to provide someone to be on its waste reduction 9team when product quality issues were involved. This cooperation through waste reduction served to strengthen the business relationship of these two companies—an added benefit.

8. Maintenance

If first the operations and then the production department is responsible for waste reduction, then the next most responsible group is maintenance. There are many examples of how the lack of maintenance or poor maintenance has resulted directly or indirectly in waste.

The early manuals on waste reduction placed all the responsibility on production because wastes were associated with poor yield of product from ingredients. This was typified by the process flow diagrams that showed ingredients entering a process block and products, byproducts, and wastes exiting. (See Figure 5-23 and Figure 5-24.)

Major Source of Maintenance Waste

In reality, most chemical and manufacturing plants are better shown by an expanded diagram that includes all the auxiliary activities and wastes. This includes maintenance related wastes, such as gaskets, pump packing, dirty filters, oil sludge, auto batteries, worn tires, spent catalyst, laboratory wastes, and discarded piping.

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Plant Upsets and Outages are a Major Source of Waste

Waste caused by plant upsets and outages are significant because they represent wasted raw materials and supplies that are costly to replace and dispose of. Moreover the additional wastes generated during start-up or recovery from an upset may be large too. Most of these wastes can be influenced by how maintenance affects plant operation. Good maintenance usually means good plant operation and very few upsets or unscheduled outages.

Include Mechanics on the Team

If the area waste reduction teams do a good job of identifying the causes for waste, and if the mechanics participate, then you can expect a good estimate for maintenance waste. Unfortunately a lot of maintenance activities produce secondary wastes and hidden wastes so that a true amount is hard to total up. For example, hidden wastes are wastes formed inside equipment—sludge and scale that is only seen when the equipment or vessel is shut down and cleaned out.

Fix It Right the First Time and Use Quality Parts

A common maintenance-caused waste is when repairs are made improperly, and the plant has to be shut down and cleared for a repeat of the job. It is common for maintenance to brag about how quickly they can repair a pump or some machine when they really should be doing things to avoid the need for the repair in the first place. One such approach that is quite effective in this regard is failure analysis studies. These studies have helped to identify the most durable and long-wearing parts such as pump seals, hydraulic hoses, compressor shafts, bearings, etc. Usually the premium costs of the higher quality and longer service parts is justified in longer run times and less wastes.

9. R&D

The Research and Development department is really the first player in waste reduction. They should be held accountable for creating a product and a process to make the product that avoids or minimizes waste. Unfortunately most of the manufacturing processes in use in Central and Eastern Europe today has been out of the R&D departments for tens of years.

Involve R&D in Plant Waste Problems

However, there are positive things that can be done to involve R&D. For this reason, where possible, R&D should be included in plant teams or at least made aware of the activities to reduce wastes. Unless someone tells them, they have no idea how plants and factories really operate especially with respect to wastes. In the laboratory little or no attention is paid to waste beyond direct ingredient yields. Often if R&D are asked how a process change will effect the product, they will know but might not be able to comment on wastes because it is not a priority.

R&D's Real Role in Process Improvements

As was depicted in an earlier figure showing the Time Activity Continuum (Chapter 4, Figure 4-1), the most important role for R&D is in the "After Tomorrow" portion of the timing continuum. They should be working on new products and processes with a very strong consideration on wastes and the use of materials that might add new waste problems to the plant. Materials, such as mercury and other heavy metals, CFC's, organic and chlorinated solvents, should be minimized or avoided in new processes.

Chapter 7: Procedures And Practices — Low Hanging Fruit

Manuals and articles on waste reduction always include a brief mention of easy and quick waste reductions through improved housekeeping and common sense actions. These reduction are referred to as the "low hanging fruit." Unfortunately, not enough attention is paid to this subject because it isn't very "high tech" and normally won't reduce the larger waste streams. However, based on a number of experiences, it has been estimated that for many plants and factories, this waste is 25 to 30 percent of the total. Also, unless a waste reduction team really understands the causes of wastes correctly, too much emphasis will be placed on changing the process or the equipment instead of changing the procedures and practices.

Practices Are Not Understood

One of the reasons that teams jump beyond practices and quickly focus on changing the equipment or the process is because practices are hard to take apart and examine carefully for waste generation. When faced with a situation that requires some decision and action on the shop floor, an operator will "just do it." Unless there is a good training program in place, a person rarely thinks about the results of these snap decisions.

An example of this might be the options a third shift operator considers at 3 AM when a high level alarm sounds on the north product tank. He can't get the switching valve to close and the tank is almost to the overflow point. Another example is where the control room operator calls for an extra sample of product and there is no purge collection container nearby to purge into before catching the sample. In each situation, the person's actions will either cause more wastes or prevent wastes from happening. The difference between the correct and the incorrect action in these examples is training.

Training Is the Solution

Considerable training is provided to ensure that machinery is operated properly to produce quality product, to protect the machine from damage, and to protect the worker from injury. Unfortunately, this training has not been extended to include enough environmental awareness and waste reduction. One

suggestion to prevent this is for each waste reduction team to collect all of the practices of the area that have caused wastes in the past. From these experiences they can develop a set of "do's and don'ts" for the area. These can be reviewed periodically and added to as needed. This type of training has proven quite effective when included with other job performance and quality programs and training . These "do's and don'ts" can also be shared with other plant teams to expand the awareness.

Procedures—Are They Up To Date?

Depending on the age of the plant and its complexity, procedures—the rules for how jobs should be done and how equipment should be operated—will be good or they will be out of date. In some industrial plants, these procedures must be reviewed and updated each year. In others they have not been reviewed since startup. Regardless, it is quite common for these procedures to omit any mention of wastes or of activities that might generate wastes. Many quality improvement programs, such as ISO 9000 and ISO 14000 will require such reviews and changes in the future.

The exception to this is the consideration given for product quality and production yields. As an example, the procedures for operating a stamping machine may call for setting the final clearances for the die press by running a number of parts in the press and using the measurements from these parts to adjust the clearances. This trial and error method may have been satisfactory when the scrap could be thrown in the plant dump pit. Now the scrap must be hauled to an expensive landfill and the value of the scrapped parts has tripled. The method for setting the machine should be changed and the procedures modified accordingly.

Use The Waste Reduction Teams

The solution to this out-of-date procedure problem is to involve the area waste reduction team in reviewing procedures, the same as for practices. The procedure reviews should be easier since most procedures are written and standardized. Once again the real key to success is the awareness and training of the waste reduction team to be able to visualize all of the ways a procedure can generate wastes. This isn't as easy as it sounds because quite often the effects are indirect rather than direct.

For example, the procedures for operating a chemical reactor may call for keeping the temperature between 50 and 65 degrees Centigrade. However in studying the downstream distillation column it was noted that during the summer the byproduct waste

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increased. Additional study indicated that more waste is generated if the reactor temperature stays above 60 degrees for long periods and this is more likely to happen in the summer when the cooling water is hotter. Thus by relating procedures to indirect wastes, the team was able to identify the problem and recommend a solution.

Summary

Because procedures and practices are so individual to a plant or factory, it is difficult to list specific solutions to the related waste problems. The best advice is that these two areas are still major sources of wastes even in plants that have been working on practices and procedures for some time. As such, they should be the early focus of the area waste reduction teams. Success in these areas requires in-depth, detailed knowledge of the process or activity. Perhaps the biggest opportunities are in reducing the wastes that are caused in start ups, shutdowns, changes in production rate, or product changes. Upsets are also a time when procedures and practices fall short of addressing wastes.

Chapter 8: Maintenance—An Overlooked Cause Of Wastes

Chapter 6 discussed how maintenance practices were a cause of wastes, second only to operations in quantity. All too often this fact is overlooked by companies when they put together a waste minimization program. There are a number reasons for this, and by reviewing the reasons in greater detail, some solutions to these maintenance-caused wastes should be identified.

Why Maintenance Wastes Are Overlooked

Maintenance wastes are difficult to identify and quantify. This is because wastes, all wastes, are still not known by companies to the detail necessary to determine sources let alone causes. Generally companies know perhaps 50 percent of the wastes they generate in their plants. These are usually the wastes that are large in volume, that are difficult to manage, that must be reported because of fees or taxes.

Recall the diagram used earlier in Figure 5-26 that showed a long list of non-ingredient related wastes that are typically generated by auxiliary activities. Many of these are maintenance-caused wastes and are overlooked because they are non-toxic, small volume individually, and end up being collected in drums or boxes along with other plant trash and floor sweepings. They are generated throughout the plant and often in remote areas. They are frequently generated during shut downs or equipment outages and are lost in the confusion that accompanies such periods.

Types Of Maintenance Waste Causes

Several generic maintenance activities have been categorized as causes or generators of waste. These include:

Inadequate Training

All too often a small maintenance job will be performed by a mechanic-in-training or an apprentice without adequate training or supervision because it is a noncritical, simple job. Small jobs, done improperly, can cause leaks, equipment failure, or improper instrument functions, all of which can result in wastes. As an example, a mechanic-in-training was assigned to repair the electrical connections on a level indicator instrument. He had seen

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the job done several times and so he didn't hesitate to accept the assignment. Unfortunately, he forgot to mark the connectors when he disassembled them and so he cross-connected them in the repair. The result was an incorrect liquid level signal for a large process storage tank. On the next shift, the operator was distracted as the tank was being filled and failed to notice that the level signal was not acting properly. The tank was overfilled resulting in a large amount of waste and a major environmental incident.

Lack Of Awareness Of Wastes

Mechanics often are called to repair a machine or install a component. Usually by the time they arrive at the job, operations has already cleared the machine or emptied and flushed the piping system so that the work can start immediately. Consequently, the mechanic has no idea that this repair job has already caused tens or hundreds of liters of wastes (the flush) and will require more flush before startup. This awareness that each repair job generates significant amounts of waste has prompted some companies to require that routine maintenance jobs be studied for waste reduction. It has also prompted companies to evaluate the causes of the failure that required the repair and, where it is justified, use avoided-waste costs as part of the justification to switch to different and more reliable equipment or parts. One example of this is the use of superior quality pump seals or even newer sealless pumps to correct a chronic leaking pump seal problem.

Another example of this lack of awareness relates to the lubrication of machines. Mechanics would regard a slight oil leak differently if they realized how many drums would be filled with oily wipe rags until the machine was shut down and the leaking gasket replaced. One plant marked all of its dirty rag drums with a large sign indicating how much it costs to dispose of each drum of rags. This price tag of $350.00 cut the number of full drums by 50 percent. This same plant put on a special program on machine repair and gasket installation to retrain the mechanics on proper methods.

Selection Of Supplies

In many shops and factories mechanics are not trained to recognize that changes in environmental laws and waste disposal practices make certain maintenance practices and supplies a problem. The best examples are the use of chlorinated solvents as degreasers and general clean-up liquids and using asbestos containing material for gaskets. These materials not only pose a problem for disposal

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when they are properly contained and drummed, but in the case of the chlorinated solvents, they are persistent threats to drinking water when they are spilled onto unprotected soils. This has resulted in hundreds of cubic meters of soil removal to "clean up" only a few liters of spilled liquid. The use of asbestos, leaded paints, asbestos-containing adhesives, gaskets, and coatings are other examples of problem supplies. The maintenance department should work closely with the environmental staff, the purchasing department, and the operations waste reduction teams to identify materials and practices that have caused wastes in the past and correct them accordingly.

Systematic Maintenance Management

For larger plants and factories a substantial reduction in wastes from shut down, start up, and maintenance activities can be accomplished through the application of computerized management maintenance systems (CMMS). This a very popular trend in upgrading the methods used by companies to maximize the operational time of machines and other equipment involved in production.

These CMMS systems combine preventative and predictive maintenance programs with various types of historical analysis of maintenance and operations to optimize the "up time" and costs of these programs. By introducing the additional consideration of avoided waste generation, and the cost savings that results from these avoided wastes, this computerized maintenance accounting system can become a waste minimization tool as well.

Chapter 9: Waste Minimization Through Capital Projects

In the earlier chapters of this manual, we discussed how process changes, equipment changes, and R&D efforts might be applied to waste minimization programs in a plant or factory. Several concepts were specifically developed including the idea of "piggybacking" waste reduction changes on top of other necessary projects to reduce the cost of the waste reduction change and increase its effectiveness. This chapter expands on these ideas for major capital projects and especially for smaller projects that are usually necessary to keep the plant or factory running. Smaller projects are by their nature much more numerous than major projects and are not as optional.

Major Projects

Larger projects, major expansions, replacements, or the construction of a new factory or plant are excellent opportunities for the incorporation of advanced, waste reduction ideas. In fact the correct approach for major projects is to conduct a total environmental review that includes wastes and air emission reductions during the earliest stages of a project.

The practice of reviewing environmental issues to reduce wastes has been extended into the energy and water conservation areas too. Even a few percent reduction in energy can result in significant reduced air emissions. Depending on the fuels involved, a reduction in acid gas and greenhouse gas can also be realized. Many plants and factories continue to operate cooling water and scrubber systems without flow meters or control valves to monitor flows.

New ideas and considerations about the process technology selection, the possible substitution of key ingredients, and the use of less waste causing equipment are all decisions that are best made very early in a project. Moreover, these early decisions might effect the project economics and must be acceptable to management. Some experience has shown that environmental and waste reduction provisions, beyond what would be a prudent to meet the existing laws in the U.S. for example, may cost an extra 2 to 8 percent of the total capital cost. However these additional items, if properly engineered and operated, will reduce operating cost by 1 to 2 percent annually. These economics depend on a

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number of factors including the costs of ingredients and the local options for recovery, reuse, or sale of co-products.

Project Environmental Reviews

Project reviews have been used for years to ensure that the critical elements of a project have been identified and resolved during the design phase, so that extra time and money is not spent correcting mistakes or omissions. Process hazards and safety reviews are standard and routinely used widely by industry to address these areas. In the same way a project environmental review process has been developed by a number of companies to be sure that issues such as needed permits, compliance issues, and waste management (disposal) are covered. More recently waste reduction has been added by some to this review process and the results are significant.

The logic for this is that waste reduction and environmental improvements are more effective and will cost less if they are developed and incorporated into the early design, rather than added on after the design has been set. This is a challenge to the thinking and methods used by the R&D and process development engineers. Unfortunately, these groups have not historically been sensitive to wastes—other than yield losses—and they must be trained to consider wastes, waste waters, energy utilization, and air pollution in the design. Today there are numerous references and examples that can be used to accomplish this training. (The U.S. Chemical Manufacturers Association recently published a manual on this subject.)

Knowledge Doesn't Guarantee Success

However, management, including project management, are responsible for insisting that such project environmental and waste reduction reviews be conducted and the results be properly documented and implemented. The benefits of such a program can be significant. The major part of the savings and waste reduction reported by 3M in the 1975 to 1985 period was due to advanced engineering of new projects. Du Pont started its formal project environmental review system in the late 1980's and developed a 10-step process. At Du Pont every project must have such a review before being built and the project funds request must include a detailed summary of the results of this review. Du Pont took this step to raise the importance and value of environmental concerns and waste reduction to the same level as process hazards and safety.

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This review requirement illustrates an important point in project review work. A company may develop some excellent procedures, check lists, and guidelines for its environmental and waste reduction program but if every level of management doesn't insist the program be followed and personally audit its adherence, then the program will not be 100 percent effective.

Waste Minimization Opportunities In Small Projects

Of the two categories of project work, large projects (normally new plants or production lines) and small projects (usually necessary work), the latter category has not been properly recognized for its potential value in waste reduction. For this reason the WEC program has expanded its focus on small projects, believing they offer near term benefits with little or no additional cost over what is absolutely necessary to support current operations. Also a small project program is ideally suited for application to older plants and factories that might require a greater amount of repair and replacement work than their newer counterparts..

Small Projects are Frequently "Must Do" Jobs

Waste reduction opportunities can be found in a number of routine plant and factory activities. Opportunities when purchasing ingredients, doing routine maintenance, and performing other activities have already been discussed in Chapter 6. Another rather routine activity is "small projects." These cover a wide range of work, usually dealing with equipment repairs, minor equipment replacement, and incidental process modifications. Generally these are necessary to keep the plant or factory running or to make a change for improved safety, fire protection, environmental improvements, or other urgent reasons. "Small" refers to the size, cost, or complexity of the job. Cost is normally in the range of a few thousand to perhaps one hundred thousand dollars, but this will vary widely from company to company.

Finally, many of these small projects are done by the plant's own engineers and mechanics. Some of these small projects require special equipment or skills, and an "outside contractor" may do the work under direction of the plant engineering or maintenance department. Even in times of limited economic resources, these small projects are numerous and should be managed carefully to maximize their potential to provide multiple benefits. The following example illustrates this.

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Example—Piggybacking to Fix a Chronic Leak

A product pump in a large dairy products plant needs to be replaced to allow for steady plant operation. However, at the same time some additional work may be undertaken to correct a chronic process leak associated with the discharge piping from this pump. Thus a necessary production related replacement will also provide a waste reduction benefit. This was accomplished because the area's waste minimization team was aware of the need for this project and had already developed a solution plan for the waste. They had earlier identified this leak as the source of waste product liquids. Moreover they had traced the cause of this leak to the excessive vibration of the pump and discharge pipe combined with the use of pipe flange gaskets that were too stiff and brittle. The team mapped out a plan to correct this leak and had already located more flexible gaskets. However, when the pump was replaced, the pump base was strengthened to reduce vibration, the discharge piping was replaced with some welded flange pipe, and the new flexible gaskets were used where bolted flange joints remained.

Finally during the investigation for causes, the team noted that the pipe supports were badly corroded and near failure. If a failure had occurred, the piping could have had a large product release that might have resulted in a loss of business. Naturally the supports were replaced with corrosion resistant material to prevent a reoccurrence of this situation.

This example illustrates the many benefits that a waste reduction program can provide in addition to just reduced wastes. The important point is that the team focused on causes and did not stop after the first cause was identified. This example of piggybacking several jobs on a routine pump replacement shows the value of developing solutions and implementation plans that utilize small projects. The incremental costs for the extra materials and labor to properly correct the leak were more than justified by the improved reliability of the system alone.

Small Projects Have Big Potentials

In a large plant or factory there are hundreds of small projects undertaken each year. If each of these was reviewed for the potential extra value in waste reduction, general environmental improvement, housekeeping, and workplace safety, a lot of improvements could be accomplished with no or only modest increases in costs. If these "values" were correctly added together they would show a "profit" in most plants.

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Why Aren't Small Projects Being Fully Utilized Now?

In many plants some small projects are presently being worked for extra benefits. But this is done by a few people in only one or two areas of the plant and waste minimization is accomplished by chance. In order to maximize the benefits of small projects, the WEC waste reduction program includes this concept in its manual to point out how the small project review process can be started where there is none now, or how an existing program can be improved.

The key to this process is the review itself and how it is accomplished. The goal should be that every small project will be reviewed for opportunities. Just like the review process for large projects mentioned earlier, this review process should be structured so that it becomes a part of the routine process utility waste reduction, safety, and environmental improvement effort. Finally the reviews and activities that result from these reviews should be documented appropriately so that the critical details can be referenced for later follow up.

How are Small Project Environmental Reviews Done?

The title for this process uses the word "environmental" and not waste reduction. This change is justified because a review that considers all environmental aspects of a small project will of course include waste reduction. Unfortunately the reverse is not true.

Since the overall objective of a small project review is to expand the benefits where this can be done logically and with little or no cost, it makes sense to consider the entire spectrum of environmental benefits and not just waste reduction.

Not every small project has the potential for environmental improvements or considerations. Most such projects can be identified quickly and a brief written note to this effect can be included in the project's file. To ensure something does not get overlooked, such decisions should be carefully documented.

Where To Start

Every project has a primary purpose or objective. In the earlier small project dairy plant example, the objective was to replace the pump for production reasons. While each plant or factory has its own procedures for initiating such work, usually it starts with the production or maintenance department responding to a need.

For example, an order is written up identifying a pump to be replaced, perhaps indicating the type of replacement pump if it is not an identical replacement, and a cost break down of materials and labor. The issuance of the order should start the environmental review process. In an ideal world, the group writing the order would consult a list of planned waste reduction solutions and note that fixing the piping leak associated with this pump should be included in the project objectives. In the real world, the environmental objectives or considerations of a small project must be developed at the time of order issuance and added to the project.

Who Should Be Involved?

In the larger factories or plants, a plant engineer or a "small project engineering group" is normally assigned the task. This person or group should start an environmental review of the project, paralleling the development of the other details; such as scheduling the job, ordering the parts or materials needed, and addressing safety issues and other items necessary for the job. Depending on the size and nature of the project, the project leader might recruit some additional help to compile the necessary information to make up the formal review. Operations and maintenance representatives from the group or department requesting the project, along with some waste reduction team members, and someone knowledgeable in environmental requirements are logical recruits. Such review efforts can be informal and should be started immediately in order to not delay the project. In small plants or factories, the maintenance mechanic may also serve as the small project waste minimization coordinator too because these two activities go hand in hand.

Use the Guidelines

Once the review team has been assembled and the review started, the process should follow the guidelines that have been developed for this purpose. Each plant should develop its own guidelines, designed to fit its organization, procedures, and available resources. An example of such a review system is included in the Appendix. A review process should consist of the following:

- Gather data to determine the current state of environmental issues related to the equipment, activity, or section of the plant where the project is located.

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- Develop the spectrum of environmental effects with and without the project including wastes and waste reduction solutions.

- Question the need for new permits, governmental notification or approval, and the need for documentation of the same.

- Ask questions about process safety, workplace safety and exposure, and other related issues.

- Address each of these points in a brief paragraph on the review results so that management understands the overall outcome and conclusions of the review.

One of the significant values of this process, besides assuring management that some key problem hasn't been overlooked, is to document the improvements that have been included in the project along with the estimated cost and environmental benefits. This review report or project environmental summary is essentially an environmental report card on the project. It should include the amount and specific types of wastes and air pollutants that will be reduced or eliminated by the project and the ones that will remain. It might also include recommendations for future projects that might further reduce environmental problems.

Additional Benefits Of Small Project Review Process

Besides the direct value of maximizing the environmental and business benefits of small projects, this process and its report summaries do the following:

- Provide detailed documentation that may be useful in local community relations programs and can be included in communications with stockholders, governmental agencies, and potential investors.

- Identify both old and new areas of concern that could not be included in this project for whatever reason and should be considered in the future.

- Highlight the operating and regulatory limits of a new project so that these can be incorporated into the operating procedures and directions.

- Provide other project teams and waste reduction teams with ideas and success stories that might be similar to other yet-to-be-addressed problems.

Summary

Large and small project reviews can be a major source of cost effective waste reductions and environmental improvements but installing these systems in your company or factory does not automatically guarantee success. It is only the first step. For this program to be successful, the people using it must be trained to look for waste reduction opportunities and to be aware of potential environmental benefits. This training, like safety awareness training, must be an ongoing activity.

Another critical element in this program is the waste reduction solution plans developed by the plant or area teams. These "maps for waste reduction" should be the first source of ideas for the project team. Finally, this process needs management interest and support. If a project review team recommends that a replacement pump be fitted with a different sealing system and a base plate, then management should support these recommendations even if it means some additional cost. If the team did their job properly, the overall savings and benefits will justify this additional cost. Management must put their trust in this program and believe that it can produce the expected benefits.

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Chapter 10: Importance of Cost Accounting in Waste Minimization

Need for Cost Accounting

In Chapter 5, the 10-step implementation program is described in considerable detail, including both the theory or rational and content of each step. This is followed by an illustration and/or example of how that step is implemented by the Acme paint and metal parts company. It is interesting to note that these 10 steps, with little or no modification can be the blueprint of putting together a safety program, a quality program, or an economic revitalization program. In fact all of these subjects, safety, quality, waste management, and environmental concerns, relate to the economic vitality of the enterprise, both directly and indirectly. Of particular significance in the waste minimization program is the impact of the costs of wastes on the economic strength of the enterprise.

It has been said that an enterprise or institution will tend to operate as inefficiently as it can afford to. Explained in other words, businesses and other organizations usually don't give enough attention to costs, wastes, or expenses until they are faced with some degree of economic crises. Only then do they begin to examine where the wastes are being generated and take action to do something about them.

Waste minimization programs fit this description, in that they receive attention only when costs of wastes are well defined and clearly documented. Step 6 of the 10-step program addresses this waste cost accounting in a general way. This chapter will discuss waste cost accounting more extensively.

Direct Costs — Waste Disposal

Perhaps the easiest waste cost to identify is the cost of disposal. This is because most waste disposal involves moving the waste from some point of generation or accumulation to a disposal facility, a landfill or lagoon, an incinerator, or a waste water treatment facility. If this is a hazardous waste, in most countries it will require some type of documents and even fees. This paperwork and invoice for services clearly documents the cost.

In addition to disposal costs, there is normally some cost for transportation. Again this is usually invoiced by the hauler and can be readily identified. However if a company transports the waste themselves, then this cost if frequently overlooked.

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These two costs, transportation and disposal (or treatment), are the only costs that many companies consider as waste costs and very likely they are grossly under estimating the true cost of waste.

Indirect Costs

As cited in Chapter 5, there are other indirect or hidden costs to also account for. These include:

- Cost of drums or reusable trash bins
- Cost of labor to gather, sort, or otherwise prepare the waste for disposal
- Costs for preparing the paperwork
- Costs for special equipment
- Costs for any delays or waiting time because of improper scheduling

Waste Paint Drum Example

In Chapter 5, Figure 5-31 is a graphic example of the hidden costs involved in the disposal of a drum of paint plant wastes. In this example, the indirect and hidden costs were many times more than the direct costs. Part of the reason for this was the value of ingredients that were being wasted in each drum. It is interesting to follow how the waste minimization team at this plant was able to substantially reduce these costs, both direct and indirect.

The major source of the wasted ingredient was the paint color laboratory where paints and paint colors were formulated to match customer specifications. The lab chemists and technicians had no real appreciation of how much wasted solvent, thinner, resin, and hardener was being generated or its value until the waste minimization team began to focus on this.

After several weeks of brainstorming meetings, the team decided on the following action:

1. The lab staff would use much smaller containers for mixing paint samples. Presently they were using 2 liter cans, but would switch to ½ liter cans.
2. The lab would not rinse the mixing equipment and containers with fresh solvent or thinner — they would drain and then wipe the containers with a paper towel. If a rinse was necessary, recovered thinner rather than fresh solvent was used since it was much less expensive.
3. A small distillation column was acquired for the cost of $3,000. This batch could recover 30 liters of solvent or thinner a day

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from paint wastes. This recovered material could then be used as rinse material for cleaning equipment as well as for mixing new formulations. The still bottoms would be dumped into waste drums for disposal, after the volume was reduced by 80%.

4. The team identified a source of used drums that could be reliably used for wastes. These drums cost only $2.00 each.
5. The team located a used hydraulic press that was converted into a trash compactor to reduce the volume of empty cans and other trash.

These changes, along with some others, combined to reduce the costs of each drum of waste to less than $150.00. Moreover, the total amount of waste was reduced by more than 50%. This illustrates how knowledge of the true and complete cost of waste can be used by a waste minimization team to energize others to become involved.

Cost Accounting for Project Justification

While most of the waste and cost saving ideas listed for the paint laboratory were sound ideas that clearly reduced costs, several of these, including purchasing the batch still required some investment. For these, a simplified cost analysis was performed to justify the investment. Larger projects will require a more detailed cost analysis and these should be put together by the waste minimization teams working with the factory cost accounting department. Some projects will need to be evaluated by what is called a Profitability Analysis. This analysis is done differently by different companies but usually the "bottom line" of such analysis is "What is the payback period?" or "What is the internal rate of return (IRR)?" Both approaches have the same focus — is the project a reasonable one to invest capital in?

Payback Period

Payback period is the amount of time for the project to generate enough savings to pay back the initial cash outlay for the project. The time frame of an acceptable payback period depends on the company. Usually good waste reduction projects will pay back within 3 years, however, 4 years is not uncommon.

Internal Rate of Return (IRR)

Internal rate of return is a discounted cash flow rate of return on the money invested in the project. It is similar to calculating the interest earned by money deposited in a bank account. For projects

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with low risks, an IRR of 12 to 20 percent, after taxes, is normally acceptable. However, if the local interest rate on loans is above 15%, and IRR on a waste reduction project should be above 25% to compete for funding. Several lists of capital costs are shown in Figure 10-1.

As with the cost analysis of small projects, large projects depend on a complete and accurate assessment of all costs. Importantly, today's costs might be acceptable to use in evaluating a quick (today) project, but for the longer range "tomorrow" projects, these costs must be projected into the future by the use of reasonable escalation forecasts.

Some ideas related to operating costs and savings associated with waste minimization are shown in Figure 10-2 which have been copied from the Texas Waster Commission's Manual on Pollution Prevention.

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Capital Costs

Capital Investment for a Typical Large 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
- Spar parts
- Taxes, freight, insurance, and duties

Materials
- Piping and ducting
- Insulation and painting
- Electrical
- Instrumentation and controls
- Buildings and structure

Connection 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
Contractor's Fees
Start-Up Costs
Training Costs
Contingency
Interest Accrued During Construction

Working Capital

Raw Material Inventory
Finished Product Inventory
Materials and Supplies

Figure 10-1 Capital Costs

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Incremental Operating Costs and Revenue

Operating Costs and Savings Associated

Reduced waste management costs (Disposal)
This includes reduction 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; recordkeeping

Input material costs saving (Raw Materials)
An option that reduces waste usually decreases the demand for input material

Changes in Utility Costs (Utility Costs)
Utility costs may increase or decrease. This includes steam, electricity, process and cooling water, plant air, refrigeration, or inert gas.

Changes in costs associated with quality (Quality)
A source reduction/waste minimization 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 operating and maintenance labor, burden and benefits (Labor)
An option may either increase or decrease labor requirements; which will impact direct labor costs as well as burden and benefits.

Changes in operating and maintenance supplies (Supplies)
An option may result in an increase or decrease in the use of supplies.

Changes in insurance and liability savings. (Insurance)
An option that significantly reduces hazardous waste may reduce a company's insurance premiums.

Changes in overhead costs (Overhead)
Large source reduction/waste minimization projects may affect a plant overhead costs.

Changes in revenues from increased (or decreased) production
An option may result in an increase or decrease in the productivity of plant; which will result in a change in revenues and/or costs.

Increased revenues from by-products
An option may produce a by-product that can be sold to a recycler or sold to another company as a raw material.

Figure 10-2 Incremental Operating Costs and Revenue

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Appendix A

Waste Identification Example for ACME Factory

A good waste minimization program is built around a systematic waste identification and waste data development. This is one of the hardest concepts to sell to plants and factories because they believe that either they know all the wastes already, or that such detail is unnecessary if they "know" most of the wastes, or the ones that account for most of the volume.

On these next few pages are examples of how the waste minimization team of ACME factory has systematically sorted and identified the solid and liquid wastes from three of the "production" areas in the factory. In addition to preparing a flow diagram of the three operations, parts forming, sub-assembly, and painting, and locating the source of each waste, they also identified what is the present disposal practice or destination for each waste. This information will be entered into the individual waste profile sheet as well.

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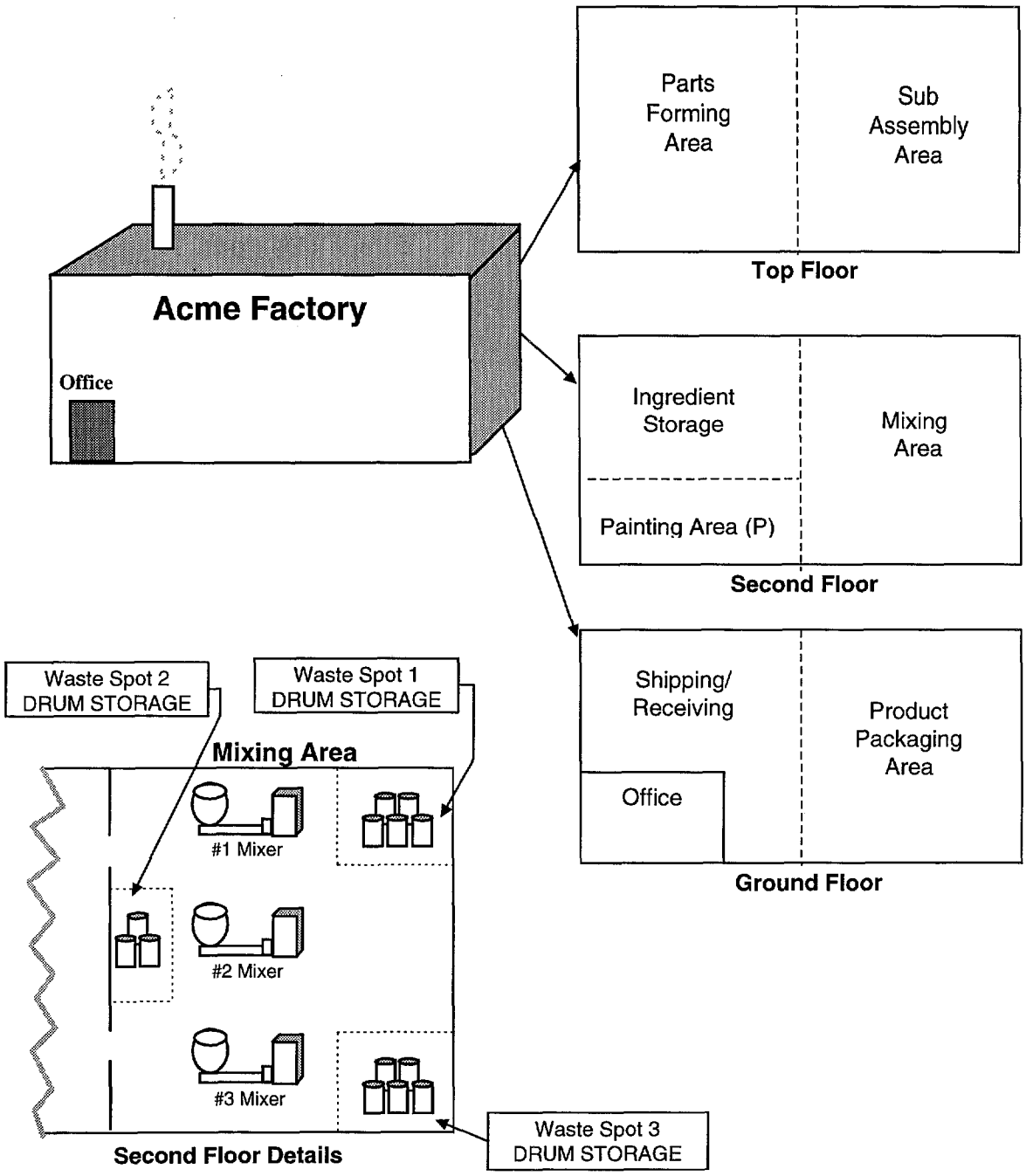
Schematic of Acme Factory Divided into Areas to Identify Wastes and Sources



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Acme Factory Waste List

Solid Wastes — Source, Destination

Parts Forming Area (Area PF)

ID NO	Source	Destination
PF-01	Metal Scrap - Machine 1	Recovery
PF-02	Metal Scrap - Machine 2	Recovery
PF-03	Plastic Scrap - Machine 3	Recovery
PF-04	Floor Waste	Landfill
PF-05	Oily Rags	Incineration
PF-06	Used Machine Oil	Oil Reclamation
PF-07	Rejected Blanks	Recycle
PF-08	Waste Stamping Lubricant	Incineration
PF-09	Machine Clean-out Sludge	Landfill
PF-10	Faulty Parts - Machine 1	Recycle
PF-11	Faulty Parts - Machine 2	Recycle

Sub-Assembly Area (Area SA)

SA-01	Metal Reject Parts	Recovery
SA-02	Metal Scrap - Machine 1	Recovery
SA-03	Metal Scrap - Machine 2	Recovery
SA-04	Machine Oil Drum	Oil Reclamation
SA-05	Oily Rags Bin	Incineration
SA-06	Fastener Scrap Box	Recovery
SA-07	Misc. Packaging Wastes	Landfill
SA-08	Rejected Plastic Part Box	Recovery

Painting Areas (Area P)

P-01	Scrap Paint - General	Incineration
P-02	Paint Waste - Booth 1	Incineration
P-03	Paint Waste - Booth 2	Incineration
P-04	Solvent Flush - Booth 1	Incineration
P-05	Solvent Flush - Booth 1	Incineration

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Acme Factory Parts Forming Area

Waste Minimization Solutions

Parts Forming Area (Area PF)

ID NO	Source	Solution Implemented
PF-01	Metal Scrap - Machine 1	Machine Adjustment*
PF-02	Metal Scrap - Machine 2	Stamping Cam Replacement*
PF-03	Plastic Scrap - Machine 3	Recycle
PF-04	Floor Waste	Segregation and Recycle*
PF-05	Oily Rags	Better Maintenance*
PF-06	Used Machine Oil	Recycle
PF-07	Rejected Blanks	Recycle
PF-08	Waste Stamping Lubricant	Recycle*
PF-09	Machine Clean-out Sludge	Landfill
PF-10	Faulty Parts - Machine 1	Machine Adjustment*
PF-11	Faulty Parts - Machine 2	Maintenance*

* Denotes results from Waste Minimization program.

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Acme Paint and Manufacturing Company
Cost of Manufacturing

Production Area _____ For Period _____

Category Of Expense	Unit Cost	Quantity Used	Cost
Ingredients			
L-1 Hardener	32.335/GAL	628,100	
L-3 Hardener	30.255/GAL	52,445	
P-1 Hardener	26.535/GAL	11,546	
Red #5 Pigment	653.00/LB	58	
Blue #24 Pigment	453.00/LB	213	
Black #1 Pigment	987.57/LB	934	
White #231 Pigment	345.85/LB	1,432	
Brown #4 Pigment	576.00/LB	142	
KL Thinner	1.555/GAL	67,800	
FT Thinner	1.24/GAL	47,534	
X-1 Polymer	34.00/GAL	434	
Silica powder	.85/LB	132,000	
Containers			
Gallon cans	.18/UNIT	604,000	
5-Gal cans	.85/UNIT	10,878	
Special tote bins	75.85/UNIT	87	
Utilities			
Electricity	5.09/KWH	42,599	
Steam	10.50/KLBS	1,323	
Water	10.00/KGAL	1,333	
Labor			
Wage roll	5.85/HOUR	480	
Supervision	9.50/HOUR	540	
Overhead & Benefits	10.85/UNIT	400	
Maintenance			
Labor (All)	7.78/HOUR	985	
Materials			
Transportation	.12/GAL	745,000	
Services			
Control Lab	9.00/HOUR	390	
Clerical/Shipping	4.00/HOUR	1,030	
Waste Disposal			
Water Treatment			
Environmental Support			
Safety Support			
Off Site Waste Disposal			
Depreciation and Taxes			
Total Cost of Manufacture			

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WEC Waste Analysis Form

Plant/Factory	Date
Department	
Area	
Waste Minimization Team	
Waste Name	
Waste ID	
Waste Type (solid/liquid/gas)	
Source	
Amount Generated	Each Load / Annually
Containers?	
Where Disposed	
Pure Waste or Mixture?	
Hazardous or Toxic?	
Cost of Ingredients	
Cost of Transportation	
Cost of Disposal	
Cost of Treatment or Handling	
Cause of Waste Generation	
Possible Solutions	

Appendix B

Waste Minimization Success Stories

The WEC waste minimization program is based on the belief that waste minimization is successful when the management and workers in a plant or factory are convinced its part of their job and are committed to making it work.

To help this effort this WEC manual presents concepts (tools) and shows how its 10-step program can be implemented in a typical plant. As an additional tool, this section, containing a number of success stories, has been included to illustrate the value that various parts of the program can contribute to its overall success.

The WEC encourages the publication and sharing of success stories and other program examples between companies and various industrial sectors and will from time to time collect and distribute these to help in this effort. An example of this newsletter is also included in this section.

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Energy Savings - Municipal Utility

A mid-size municipal heating plant was having a severe economic problem due to increases in the cost of its fuel (coal and heavy liquids). However, it could not pass on these increases to the community because the area was already in economic problems.

The plant manager read about a successful energy and cost reduction program at a nearby refinery and decided to try such a program for his plant. A team was formed, and after a visit to the refinery, they returned with a number of ideas and suggestions.

The first project was to survey the steam generating unit and the major export pipes to identify any areas of excessive heat loss. This was done using a borrowed heat scanning instrument. They quickly determined that there were a number of steam leaks in the boilers and at pipe flanges under the insulation. Moreover, much of the insulation had been damaged over the years and was no longer effective.

Implementing a program of leak prevention and insulation replacement produced a 22% increase in exportable steam. This increase was compensated for by reduced fuel use, offsetting the earlier cost increase. The net effect of this first project was cost savings that could pay for the new insulation and provide extra funds for more energy savings projects.

Condensate Is a Valuable Resource

Many plants and factories that use steam fail to realize that the condensate (hot water formed from condensed steam) represents both valuable heat and water resources. At a cannery where steam is used throughout the plant, production was becoming limited by the lack of enough steam. The waste minimization team was asked to take on the job of tracking down wasted steam.

After studying the problem and watching how steam was used in each step of the cannery process, the team decided that the real problem wasn't a waste of steam, but rather a waste of condensate. Most of the steam traps were leaking and the condensate return system had not been maintained properly. Moreover, heat losses in these systems were excessive. The net effect of these problems was to place a bigger load on the existing boiler than it was designed to handle. By collecting more and hotter condensate to return to the boiler, it could generate additional steam and allow production to increase. This was accomplished at a cost of only 10,000 USD, but produced increased sales of 52,000 USD.

This same team identified the cost effectiveness of using previously wasted, hot contaminated condensate in a new heat exchanger to preheat the make-up water, reducing the heat load on the boiler even more.

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Water Is An Overlooked Resource

Water conservation is usually only considered when there is a drought or severe water shortage. A good waste minimization program will include responsible water conservation both for cost and environmental reasons. There are many possible ideas that waste minimization teams have developed to save water.

One such idea is to develop a clear understanding of how much water really costs. As an example, an industrial plant developed the following table of its water costs.

Water Type	Consumption liters/min.	Cost (USD) /1000 liters
Raw-surface	500	0.15
Raw - well	100	0.35
Filtered	400	0.5
Cooling tower	800	0.3
Boiler make-up	70	1.15
Deionized	35	5.5

This table helps the team focus on the biggest costs. Next the team identified typical activities routinely done in the plant that used water.

Activity	Amount of Water	Type of Water
Pump repair	30 liters	Filtered
Canning machine changeover	1000 liters/ 150 liters	Filtered/ Deionized
Label machine repair	20 liters	Well
Steam room cleaning	1000 liters	Well
Ingredient mix/batch	50 liters	Deionized

This analysis allowed the team to identify opportunities to reduce water usage and in some activities replace more costly water with less costly water.

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Brewery Saves More Than Cans

A large regional brewery began a program to encourage its customers to participate in a glass bottle and aluminum can recycling program as a cost reduction program to reduce its packaging costs. This prompted several of the loading dock workers to notice that the packaging area always had several loads of damaged paperboard carton covers to be disposed of. They suggested to their supervisor that, "If the customers could recycle, why couldn't the plant?"

They began with recycling the damaged paperboards back to their supplier. After several weeks, the packaging area started a waste generation study and identified a major cause of this waste. It was one of the carton folding machines that was out of alignment. This success triggered programs in the brewing and bottling departments.

Management recognized that the entire brewery wanted to participate and so they formalized the program throughout the company. They included a program to recognize the best success each year, and the brewing department won that award by converting the used hops and grain into a soil fertilizer. This save 50,000 USD in disposal costs.

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The WEC Waste Minimization Newsletter

The WEC waste minimization newsletter has been prepared especially to support the program that has been started in Central and Eastern Europe. The success stories and other information provided in this newsletter illustrate the key concepts of the WEC program —

- the value of management commitment
- the value of a plant or factory-wide organization; involving all the workers and management working together in teams
- the value of simple and no or low cost solutions
- the value of small projects with their small successes
- the value of actual waste measurements and documentation
- the value of including all the wastes, air emissions, and waste waters in the program
- focusing on wastes at the source
- identifying the cause and developing a plan to reduce or eliminate the waste — waste minimization and not waste management.

Following these concepts can produce successes in every type of enterprise and the following examples are proof of this.

The Shipping Department Leads A Large Computer Company's Waste Minimization Program

A computer company started its waste minimization program by establishing teams in each department. At first there was a lot of activity in trying to set goals and plans to meet these goals in each of the departments. However, most of the areas just couldn't get much of a start. They either tried to work on the largest waste or the most persistent one, or they tried to work on all of their wastes at once and accomplished very little.

In contrast, the shipping department's team quickly identified packaging waste as their top priority and developed a short and longer range plan to reduce this waste. First the team corrected some of the automatic folding equipment to reduce misformed boxes. This change, along with some corrections in the gluing machine, reduced waste packaging by 20%, saving $15,000/year. Next the team suggested that three different size boxes be replaced with a single box plus some new insert spacers. This suggestion not only reduced wastes, but also reduced the need for extra inventory and improved the protection for the computers during transit. Finally the team suggested a simplified box design that allowed for faster packaging of components and fewer rejects due to improper packaging.

The success of this department was recognized by the company and now the team members are asked to help other teams throughout the company to improve their focus on waste reductions.

In Waste Minimization, Small Improvements Can Add Up To Big Savings

Frequently good waste reduction suggestions are ignored because they are considered too small to be important. This is a major mistake and will discourage good ideas. In a metal foundry, with its many waste water streams, a 1-liter-per-minute reduction was initially ignored because it was considered insignificant. However after someone sat down and "did the math" it was implemented because this reduction amounted to over 500,000 kilos /year.

In many enterprises, the frequent samples that are taken to track the quality of the products actually result in a considerable amount of waste, if they are not recycled back into the production system. At a large plastics plant, quality control samples amounted to over 300,000 kilos of lost production in a year. The waste minimization team, composed of lab technicians and process operators, was able to reduce or recycle over 80% of this material. A metal parts fabricator was able to recover some $20,000 of parts value by providing separate containers for the quality control department to use in segregating the inspected and tested parts.

In Many Cases Waste Minimization Is Simply Doing The Job Right.

For the management of a large paper coating company, waste minimization got a big boost by the plant team when they started a program called "know how the job should be done and then just do it". This resulted in a major effort to use the proper closures and lids on all the various solvent and thinner containers. The team posted slogans and signs in areas near these containers and also painted the lids and closures with bright red stripes.

This program of awareness and reminders resulted in a savings of over 20,000 liters of solvent and thinners in the first year. Other wastes were targeted with this "do the job right" program and resulted in an additional cost savings of over $50,000.

Food Processor Saves In Two Ways

A major food processor, faced with new reductions in process water discharges, started up a waste water reduction program. The program, using several teams of workers, mechanics and supervision, quickly expanded to include the minimization of packaging material wastes and cross contamination of production wastes. Finally the teams developed several new techniques for cleaning equipment that reduced both the waste water generated and the amount of organic contamination in the waste water. The overall result of this program, after the first year, was over 40 % reduction in waste water and a $130,000 savings in packaging materials and ingredients. The success of this program was the involvement of teams that included the production workers and others who had the day-to-day knowledge of the operations.

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Waste Minimization Can Have Multiple Advantages To A Business

A metal parts manufacturer was asked by his largest customer to increase production by some 20% in order to supply components for a new product line. The management of the parts supplier figured that to meet this increased production, it would be necessary to add a second shift or put the existing workforce on overtime. During a plant-wide meeting to explain this situation to the workers, management was surprised at a number of suggestions the workers offered to increase production without the need for overtime.

The most productive suggestions involved waste reduction and quality improvements. These were quickly implemented and were quite successful, thereby meeting the needs for more production without overtime or the second shift. This was the first such meeting between management and the workforce where ideas were solicited toward a business need. It illustrates the value of using the entire organization to solve business problems and the power of waste minimization to rally the workforce toward a common objective.

Records Are Valuable To Identify Waste Minimization Opportunities

A mid-size paint manufacturer was considering a possible plant expansion and the purchase of some new equipment. The plant's engineering department had already drawn up the details for procurement when one of the mechanics heard from his supervisor that the expansion plans included purchasing ten new pumps identical to the pumps that were in use on the three existing paint filling lines. This mechanic was a member of the waste minimization team and had been keeping extensive records on the performance of the various mechanical equipment as it related to the generation of wastes. His records showed that these particular pumps were prone to frequent problems due to the viscosity of the paints, the type of solvents used and the abrasive nature of the pigments.

In fact , based on this information, the plant was testing a completely different type of pump and the results were excellent. The supervisor, using the maintenance records of the waste minimization team and the results from the new test pump, was able to convince the engineering department to change the specifications for the new pumps. This saved the company considerable future problems and waste generation.

Measurements and Metering -- Critical Tools For Waste Minimization Success

Virtually every company that has developed a successful waste reduction program has recognized the critical importance of waste measurements and the value of metering for continuous streams. This was illustrated recently when a waste minimization team was trying to gather information about several wastes and their sources in a paper mill. The team asked four of the senior operators to estimate the amount of spent bleach that was dumped from the bleaching vats each month. After receiving four widely different answers, the team asked the area foreman and technical engineer. These two answers were also different . Finally the team set up a measuring system and developed their own data. The actual amount was 25% greater than the largest estimate given by the operators or supervision. In fact, because of sloppy practices and

procedures, the mill was using about 40% more bleach per ton of pulp than was specified. This also required the use of extra chemicals to treat the spent bleach and so the mill was paying double for this oversight.

At an electric power station, the cost for treating boiler feed water caught the attention of the waste minimization team. They eventually identified that the problem was actually a contamination of the condensate return. Because of this contamination, much of it had to be discharged rather than reused. By installing several water quality meters in the condensate collection system, the team could quickly identify where the contamination was and correct the cause. This use of meters paid for itself within the first month of use.

Simple Solutions Are Easy To Implement and Can Produce Quick Cost Savings

- In a metal plating shop, the WM team suggested filtering and reusing the plating solutions rather than dumping them after a certain length of use. Some additional high strength plating solution was added to insure good quality.
- In an auto paint shop, a closed container was used to collect the spent solvent. After the paint solids had settled the relatively clean solvent could be decanted and reused.
- In a plastics molding plant, color coding the scrap drums allowed different plastic scrap to be kept separate, allowing recycling.
- A textile mill began to require that yarns be supplied on returnable bobbins, and packaged on pallets that could be reused to ship out product.
- A rubber compounding factory asked its supplier that the raw rubber bales be packaged in compatible plastic wrap that could be compounded into the product.
- A petroleum refinery WM team determined that process quality samples could be reduced in frequency and size by over 50% without any adverse effects.
- A food processor reduced its packaging wastes by 75% by switching to a plastic shrink wrap system. It also speeded up the packaging line and required 2 less workers.
- A chemical plant used colored plastic tape to identify flanges and valves that were prone to develop fugitive leaks. This facilitated frequent leak checks and repairs where necessary.
- A pharmaceutical manufacturer surveyed its requirements for chemical ingredients and specified specific volume packages for each of its major ingredients. For some, the suppliers agreed to convert to returnable containers
- A candy company discovered that by mixing together the leftovers from three of its most popular products, it could actually produce a new product that quickly became a "best seller". This was a suggestion of its WM team.
- A wood products company minimized its waste water by providing brooms for cleaning the floors of the mill, replacing the practice of wash downs with water hoses. Containers for wood scraps were also provided. Finally, at the suggestion of the WM team, a plant wide vacuum system was installed to collect wood dust, thereby keeping it off the floor. This system also improved housekeeping and helped reduce slipping accidents too.

Appendix C

Major Project Environmental Review 10-Step Process

The complete and thorough review of major projects to maximize environmental improvements and waste reduction is an opportunity that must not be left to chance. Several companies have developed extensive procedures, guide, and checklists to assist project engineers and project management in this review process. The 10-step program developed by the Du Pont company's engineering and new project group is offered as one such example.

See eleven examples from the WEC Waste Minimization Demonstration Projects.

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Waste Management Hierarchy

Avoid Waste Generation:

- Waste Prevention or Minimization at the Source (Most Desirable)

  - Basic chemistry (R&D)
  - Equipment Selection and Design
  - Process Control Design
  - Process Operating Procedures
  - Closed Loop Recycling

When Waste Is Generated:

- Waste Treatment Elimination or Minimization (Desirable)

  - Recycle within process
  - Coproduct sale
  - Return to vendor for reclamation and reuse

- Waste Treatment (Least Desirable)

  - Generate material with no impact to the environment (possibly that can be recycled)

- Hazardous Waste Disposal (Last Resort)

  - Ultimately must eliminate completely

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Benefits of an Effective Waste Management Program

Direct:

- Reduced capital and operating costs for waste treatment facilities
- Reduced offsite disposal and/or waste treatment costs
- Reduced manufacturing costs due to improved yields
- Income/savings derived from sale/reuse of wastes
- Reduced environmental compliance costs (fines, shutdowns, etc.)
- Retained sales (products that might have been taken off the market because of environmental problems)
- Reduced/eliminated inventories and spills

Indirect:

- Reduced likelihood of future costs from
  - Liability associated with remediation
  - Complying with future regulations
- Use of emission offsets (internal and external)
- Improved community relations
- Increased environmental awareness by plant personnel and management

Bottom line is enhanced corporate image and competitiveness resulting in:

- Higher market share and/or pricing
- Lower costs

STEP 1

Conduct Initial Screening Preproject Assessments

Initial Screening

- Does the project involve the use of chemical ingredients?
- Does the project involve equipment containing fuels, lubricants, greases?
- Does the potential exist for reducing or eliminating wastes, internally recycling materials, or reusing by-products?
- Are there potential problems with existing site conditions such as the presence of contaminated soil and/or groundwater?
- Does the project have potential to contaminate or impair groundwater or soil?, and
- Does the project involve the storage and transport of secondary waste?

Preconstruction Site Assessment

To determine:

- If site remediation is needed prior to construction,
- The proper Health & Safety plans for construction activities,

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Step 1 (continued)

- Regulatory requirements that apply, and
- The appropriate disposal options for any excavated soils.

Environmental site assessment should also:

- Prevent unplanned shutdowns due to unexpected contamination after start-up,
- Protect against liability by construction workers,
- Minimize soil removal and ensure proper disposal, and
- Avoid environmental regulations and constraints.

Background Environmental Assessments

- Background air quality
- Current emissions at existing sites
- Monitoring equipment
- Impact on existing waste treatment facilities
- Environmental Impact Analysis (EIA)?

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STEP 2

Select a Project Environmental Leader

- Assign responsibility
- Early
- Sufficient time
- Role
  - lead or coordinate
  - not necessarily expert on regulations or technology

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STEP 3

Define Project Environmental Objectives

Inclusions

- Government regulations and company policy
- Emission/Discharge goals (considering hierarchy)
- Focus on source reduction/reuse versus treatment
- Other project specific goals as appropriate

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Hierarchy of Emissions and Discharges

- Carcinogens

- Hazardous/Toxic Substances

  ⇒ Air Emissions
    - Locally regulated pollutants
    - Nonregulated pollutants

  ⇒ Liquid and Solid Discharges
    - Heavy metals
    - Locally regulated pollutants
    - Nonregulated pollutants

- Nonhazardous Substances

  ⇒ Very low concentrations of toxic materials
  ⇒ Air emissions
  ⇒ Liquid and solid emissions
  ⇒ Inorganic salts

- Nonhazardous Wastes
  (packaging/sanitary/biotreatment wastewater and sludge, etc.)

- Carbon dioxide

- Water and Air (oxygen and nitrogen)

  ⇒ Drinking and breathing standards

Note: Odor, visible plumes, thermal, and noise pollution should also be considered and may rank very high on the hierarchy, depending on the particular project.

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Types of Emissions and Discharges

- Direct process streams (including after treatment),
- Fugitive emissions,
- Oils, lubricants, fuels, Freons®, Dowtherm®, etc.,
- "Noncontact" process water (cooling tower, steam, etc.),
- Batch process wastes (dirty filters, fly ash, water washes, etc.),
- Packaging materials,
- Old equipment disposal,
- Office/Cafeteria waste,
- Contaminated soil,
- Contaminated groundwater,
- Sediment and erosion control,
- Sanitary waste,
- Stormwater runoff discharges, and
- Construction debris.

STEP 4

Identify Needs for Permits

Typically required for:

- Treatment, storage, or disposal system for solid or hazardous waste,
- Exhaust other than air, nitrogen, oxygen, water, or carbon dioxide (Note: $C0_2$ may require a permit in the future),
- Pesticides/herbicides,
- Incineration or burning,
- Dredging or impacting wetlands,
- Erosion and sedimentation control,
- Monitoring or dewatering wells,
- Landfills or land treatment sites,
- Altering water systems,
- Altering process or sanitary wastewater collection or treatment system, and
- Stormwater runoff.

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Step 4 (continued)

Permit requirements:

- Vary country to country
- Can take years
- Often time-limiting step/should address early
- Limits often negotiable

Difficulty in obtaining affected by:

- Rapport with regulators
- Location of Facility
- Public Acceptance
- Waste Reduction Analysis Performed?

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STEP 5

Determine Environment Compliance Requirements

Must Meet:

- Local regulations
- Corporate policy
- Site requirements

May go beyond regulations and company policies to:

- Improve public image
- Address future regulations
- Improve competitive advantage

STEP 6

Perform Overall Waste Minimization Analysis

Identify and Analyze Process Streams (Checklist A):

- Nonuseful or waste streams (key step)
- Feed
- Intermediate
- Recycle

Analyze nonuseful streams (Checklist B):

- Eliminate/minimize at source? If not,
- Avoid waste treatment via reuse? If not,
- Effectively treat and dispose

Evaluate entire process:

- Operating conditions
- Operating procedures
- Equipment selection and design
- Process control schemes

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STEP 7

Apply Best Environmental Practices for Emission/Discharge-free Facilities

Design so as to minimize (Checklist C):

- Unplanned releases
- Spills
- Fugitive emissions (leaks)

Analyze fugitive emissions:

- Prevent/minimize leak at the source:

  - eliminate equipment pieces and connections
  - modify/replace equipment pieces

- Capture leaks for recycle
- Abate leaks

STEP 8

Determine Waste Treatment and Disposal Requirements

Treat nonuseful streams (Checklist D):

- Last resort
- After minimization/reuse options studied
- Seldom has attractive economic returns
- Select most cost effective options
- Goal is to produce emissions/discharges that have no impact on the environment

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STEP 9

Perform Engineering Evaluations of Waste Management Options

Engineering and Economic Analysis of:

- Waste minimization options (Step 6)
- Fugitive emissions options (Step 7)
- Waste treatment options (Step 8)

Economics based on:

- Investment
- Operating Costs
- Revenues or savings (if any)
- Cost of capital

Economic choices based on:

- Net present value
- Internal rate of return

STEP 10

Complete Project Environmental Overview

Summary of Results (Checklist E):

- Use as part of Project Approval
- Audit construction and operation for compliance with environmental design recommendations.

REVISIONS IN MANUFACTURING PROCESS PROCEDURES REDUCED POLLUTANT EMISSIONS INTO THE AIR

Company: Achema **Country:** Lithuania

Industry: Chemical **City:** Jonava

Waste Minimization Demonstration Project: In the Nitric Acid Production Units' catalytic conversion reaction process, reduce the consumption of methane and catalyst.

Project Start Date: June 1993 **Completion Date:** September 1995

Monetary Benefits				
Investment - US$			Yearly Savings - US$	Payback In Months
U.S. Aid	Plant	Total		
24,000	29,000	53,000	168,000	3.8

Monetary Benefits Result From: Reduction in costs for raw materials and catalytic convertor, plus improved production efficiency.

Environmental Benefits			
Pollutant	Yearly Reductions Into		
	Air	Water	Land
Nitrogen Oxides	16 tons	----	----

Health and Safety Benefits:. Improved air quality in plant and adjacent residential areas.

Equipment Supplied By USAID To Company For Project:
Stack Emissions Analyzer

Company Profile	
Location: Approximately 75 miles northwest of Vilnius.	
Ownership: Joint Stock	**Year Plant Start-Up:**
Latest Annual Sales: US$	**Number of Employees:** 2,200

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REVISIONS IN MANUFACTURING PROCEDURES
REDUCED WATER CONSUMPTION & GENERATION OF WASTE WATER

Company: AGRYF Meat Plant **Country:** Poland

Industry: Food **City:** Szczecin

Waste Minimization Demonstration Project: Revise plant's cleanup procedures to reduce water consumption and generation of waste water.

wazzu Project Start Date: **Completion Date:** August 1995

Monetary Benefits				
Investment - US$			Yearly Savings - US$	Payback In Months
U.S. Aid	Plant	Total		
10,000	3,000	13,000	80,000	2.0

Monetary Benefits Result From: Reduction of 50% in cost of fresh water, plus improved production efficiency.

Environmental Benefits			
Pollutant	Yearly Reductions Into		
	Air	Water	Land
Waste Water Contaminants	----	140,000 m^3	----

Health and Safety Benefits:. Improved quality of waste water discharged into the Baltic Sea.

Equipment Supplied By USAID To Company For Project:
Spray Guns, w/Nozzles

Company Profile	
Location:	
Ownership:	**Year Plant Start-Up:** 1986
Latest Annual Sales: US$	**Number of Employees:**

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REVISIONS IN OPERATING PROCEDURES REDUCED POLLUTANT EMISSONS IN STEAM

Company: Arpechim **Country:** Romania

Industry: Oil Refinery & Petrochemical **City:** Pitesti

Waste Minimization Demonstration Project: In the Refinery Facility, reduce the organic and inorganic contamination of steam.

Project Start Date: March 1993 **Completion Date:** October 1995

Monetary Benefits				
Investment - US$			Yearly Savings - US$	Payback In Months
U.S. Aid	Plant	Total		
34,485	4,000	38,485	112,000	4.1

Monetary Benefits Result From: Increased sales of recycled condensate to the steam supplier.

Environmental Benefits			
Pollutant	Yearly Reductions Into		
	Air	Water	Land
Contaminated Steam Condensate	----	27,000 tons	----

Health and Safety Benefits: Improved quality of waste water discharged into the Arges River.

Equipment Supplied By USAID To Company For Project:
Organic Carbon Analyzer, w/Trainer
Conversion Trainer

Company Profile	
Location: Approximately 70 miles west of Bucharest	
Ownership: State	**Year Plant Start-Up:** 1949
Latest Annual Sales: US$ 348 Million	**Number of Employees:** 8,000

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REVISIONS IN MAINTENANCE PROCEDURES REDUCED POLLUTANT EMISSIONS INTO THE AIR AND LAND

Company: Chemopetrol **Country:** Czech Republic

Industry: Oil Refinery and Petrochemicals **City:** Neratovice

Waste Minimization Demonstration Project: In the Oil Refinery, reduce the discharge of volatile organic compounds into the atmosphere by detecting and repairing equipment leaks, as well as reduce the generation of waste material..

Project Start Date: September 1992 **Completion Date:** March 1994

Monetary Benefits				
Investment - US$			Yearly Savings - US$	Payback In Months
U.S. Aid	Plant	Total		
19,365	0	19,365	185,000	1.3

Monetary Benefits Result From: Reduction in costs for raw materials, plus improved production efficiency.

Environmental Benefits			
Pollutant	Yearly Reductions Into		
	Air	Water	Land
Volatile Organic Compounds	970	----	?

Health and Safety Benefits:. Improved air quality in plant and adjacent residential areas.

Equipment Supplied By USAID To Company For Project:
OVA Monitor
Data Logging Monitor

Company Profile	
Location: On the Elbe River, approximately 30 miles northwest Prague	
Ownership:	**Year Plant Start-Up:**
Latest Annual Sales: US$	**Number of Employees:**

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IMPROVEMENT IN PRODUCTION EQUIPMENT
REDUCED WATER CONSUMPTION & GENERATION OF WASTE WATER

Company: Garwolin Dairy **Country:** Poland

Industry: Dairy **City:** Garwolin

Waste Minimization Demonstration Project: Reduce water consumption and generation of waste water in the cleaning operations, and improve production efficiency.

Project Start Date: **Completion Date:** March 1995

Monetary Benefits				
Investment - US$			Yearly Savings - US$	Payback In Months
U.S. Aid	Plant	Total		
6,450	0	6,450	10,000	7.7

Monetary Benefits Result From: Reduction in cost for fresh water, plus improved production efficiency.

Environmental Benefits			
Pollutant	Yearly Reductions Into		
	Air	Water	Land
Waste Water Contaminants	----	30,000 m^3	----

Health and Safety Benefits:. Improved quality of water discharged into neaby stream.

Equipment Supplied By USAID To Company For Project:
Tuff -Cat Power Washers
Strahman Automatic Water-Saver Spray Nozzles

Company Profile	
Location:	
Ownership: Cooperative	**Year Plant Start-Up:**
Latest Annual Sales: US$	**Number of Employees:**

REVISIONS IN OPERATING PROCEDURES
REDUCED POLLUTANT EMISSIONS INTO THE AIR AND WATER

Company: Magyar Viscosagyar **Country:** Hungary

Industry: Synthetic Fibers **City:** Nyergesujfalu

Waste Minimization Demonstration Project: At the Polymer Powder Dryer Process, reduce the discharge of acrylic polymer powder by detecting and repairing equipment leaks.

Project Start Date: November 1993 **Completion Date:** February 1995

Monetary Benefits				
Investment - US$			Yearly Savings - US$	Payback In Months
U.S. Aid	Plant	Total		
18,636	0	18,636	29,000	7.7

Monetary Benefits Result From: Reduction in costs for raw materials, plus improved production efficiency.

Environmental Benefits			
Pollutant	Yearly Reductions Into		
	Air	Water	Land
Acrylic Polymer Powder	10.5 tons	16.0 tons	----

Health and Safety Benefits:. Improved air quality in plant and adjacent residential areas as well as a reduced risk of fire and/or explosion in the plant.

Equipment Supplied By USAID To Company For Project:
Continuous Particulates Monitor, w/Trainer
Portable Air Velocity Kit

Company Profile	
Location: On the Danube River, approximately 30 miles northwest of Budapest	
Ownership:	**Year Plant Start-Up:** 1941
Latest Annual Sales: US$ 60 million	**Number of Employees:** 1,900

REVISIONS IN PROCESS CONTROL PROCEDURES
REDUCED GENERATION OF WASTE WATER & RAW MATERIAL COSTS

Company: Nakro **Country:** Estonia

Industry: Tannery **City:** Narva

Waste Minimization Demonstration Project: Improve procedure for determining exact pH in order to optimize the chemicals required for the treating and finishing of hides. In addition, reduce the contaminants in the waste water discharged into the Waste Water Treatment Plant.

Project Start Date: **Completion Date:** April 1995

Monetary Benefits				
Investment - US$			Yearly Savings - US$	Payback In Months
U.S. Aid	Plant	Total		
900	0	900	8,000	1.4

Monetary Benefits Result From: Reduction in costs for raw materials and waste water treatment chemicals.

Environmental Benefits			
Pollutant	Yearly Reductions Into		
	Air	Water	Land
Waste Water Contaminants	----	?	----

Health and Safety Benefits: Reduced chemical contaminants discharged into the waste water.

Equipment Supplied By USAID To Company For Project:
Portable pH Meters

Company Profile	
Location:	
Ownership: State Joint Stock	**Year Plant Start-Up:** 1984
Latest Annual Sales: US$	**Number of Employees:** 800

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REVISIONS IN OPERATING PROCEDURES
REDUCED WATER CONSUMPTION AND POLLUTANT EMISSIONS

Company: Perion **Country:** Hungary

Industry: Battery Manufacturing **City:** Budapest

Waste Minimization Demonstration Project: Reduce consumption of potable water, as well as reduce the quantity of waste water and lead discharged into the environment.

Project Start Date: August 1993 **Completion Date:** March 1995

Monetary Benefits				
Investment - US$			Yearly Savings - US$	Payback In Months
U.S. Aid	Plant	Total		
25,977	0	25,977	72,000	4.3

Monetary Benefits Result From: Reduced potable water costs by 38%, plus improved production efficiency.

Environmental Benefits			
Pollutant	Annual Reductions Into		
	Air	Water	Land
Lead	?	0.4 tons	----

Health and Safety Benefits: Significant reduction in employee sick days and improved air quality in plant as well as adjacent residential areas.

Equipment Supplied By USAID To Company For Project:
Automatic Waste Water Samplers
Flow Meters
Toxic Gas Detector

Company Profile	
Location: City of Budapest	
Ownership:	**Year Plant Start-Up:** 1895
Latest Annual Sales:	**Number of Employees:** 650

REVISIONS IN PROCESS EQUIPMENT
REDUCED POLLUTANT EMISSIONS & GENERATION OF WASTE

Company: Petrochema **Country:** Slovakia

Industry: Petrochemical **City:** Dubova

Waste Minimization Demonstration Project: Consists of two projects at the White Oil Facility as follows:

1. Neutralization of the "Goudron" sludge to reduce the discharge of sulfur dioxide, and
2. Optimize the production of sulfur trioxide.

Project Start Date: December 1993 **Completion Date:** July 1994

Monetary Benefits				
Investment - US$			Yearly Savings - US$	Payback In Months
U.S. Aid	Plant	Total		
26,557	0	26,557	35,000	9.1

Monetary Benefits Result From: Reduction in costs for raw materials and waste disposal, plus improved production efficiency.

Environmental Benefits			
Pollutant	Yearly Reductions Into		
	Air	Water	Land
Sulfur Dioxide	70 tons	----	185 tons

Health and Safety Benefits: Reduction of noxious pollutants in plant and adjacent residential areas.

Equipment Supplied By USAID To Company For Project:
SO_2 Analyzer
Heated Stack Filter, w/ Probe & Cooler
Heat Line Hose
Calibration Gas

Company Profile	
Location: Approximately 40 miles northeast of Bratislava	
Ownership:	**Year Plant Start-Up:**
Latest Annual Sales: US$	**Number of Employees:**

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REVISIONS IN MANUFACTURING CONTROL PROCEDURES REDUCED POLLUTION EMISSIONS INTO THE WATER

Company: Pharmacia **Country:** Bulgaria

Industry: Pharmaceutical **City:** Dupnica

Waste Minimization Demonstration Project: At the Vitamin C Manufacturing Facility, reduce acetone content in the waste water.

Project Start Date: February 1994 **Completion Date:** Not determined

Monetary Benefits				
Investment - US$			Yearly Savings - US$	Payback In Months
U.S. Aid	Plant	Total		
15,273	0	15,273	75,000	2.4

Monetary Benefits Result From: Reduction in costs for raw materials and waste disposal, plus improved production efficiency.

Environmental Benefits			
Pollutant	Yearly Reductions Into		
	Air	Water	Land
Acetone in Waste Water	----	170 tons	----

Health and Safety Benefits: Improved water quality in the adjacent streams.

Equipment Supplied By USAID To Company For Project:
Densitometer

Company Profile	
Location: Approximately 70 miles southwest of Sofia	
Ownership: State	**Year Plant Start-Up:** 1954
Latest Annual Sales: US$	**Number of Employees:**

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REVISED EQUIPMENT & REVISIONS IN PROCESS CONTROL PROCEDURES REDUCED WATER CONSUMPTION & GENERATION OF WASTE WATER

Company: Riga Plant of Autoelectroapparatus **Country:** Latvia

Industry: Metal Finishing **City:** Riga

Waste Minimization Demonstration Project: Reduce water consumption and generation of waste water in the rinsing operations, and improve efficiency of the Waste Water Treatment Plant.

Project Start Date: **Completion Date:** May 1995

Monetary Benefits				
Investment - US$			Yearlyl Savings - US$	Payback In Months
U.S. Aid	Plant	Total		
6,750	0	6,750	51,000	1.6

Monetary Benefits Result From: Reduction in costs for fresh water, plus improved production efficiency.

Environmental Benefits			
Pollutant	Yearly Reductions Into		
	Air	Water	Land
Waste Water	----	53,000 m^3	----
Sludge w/Heavy Metals	----	?	?

Health and Safety Benefits: Significantly reduced discharge of heavy metals into waste water and quantity of heavy metal sludge.

Equipment Supplied By USAID To Company For Project:
pH Meter & Controller, w/Spargers
Conductivity Controllers
Sludge Lever Detector

Company Profile	
Location: City of Riga	
Ownership: State	**Year Plant Start-Up:**
Latest Annual Sales: US$	**Number of Employees:** 2,500

Appendix D

Small Project Environmental Review Guidelines

Small plant or factory projects, minor repairs and replacements, or the minor changes to equipment are commonplace activities that can be turned into significant opportunities for environmental improvements and waste reduction. The key is to visualize environmental consequences involved and how this necessary work can be made environmentally beneficial at the same time. A small project environmental review procedure has been developed by Du Pont, similar in purpose to the procedure in Appendix C, but simplified to allow its easier application to small projects.

See five examples from the WEC Waste Minimization Impact Program.

Environmental Screening Review

A Preliminary Review of Pertinent Environmental Issues, Considerations and Needed Actions

Issues:

- Permits
- Groundwater Protection
- Wastewater
- Stormwater
- Air Pollution
- Solid/Hazardous Wastes
- Pollution Prevention
- Remediation
- Other

Pre-Project Environmental Questionnaire

Date____/____/____ Title_____
Site_____

Completed by_____ Sheet____of____ Business Unit_____

Project No._____ Project Team Leader_____ Phone No._____

Environmental Leader_____ C.E.P.? Yes☐ No ☐

Project Objective _____

Flow/Equipment Diagram

Ingredients

Products/By Products

Wastes/Discharges

(Use the back of sheet if necessary.)

Environmental Considerations (Indicate what environmental impacts are expected from this project.)
NOTE: Include all environmental/safety incident information that is relevant.

Air:_____

Water:_____

Ground water: _____

Waste Minimization: _____

Solid/Hazardous Waste: _____

Remediation: _____

Storm water: _____

Discharges/Emissions/Waste Information (Where specific discharges/releases are identified, please describe, quantify and indicate fate of each.)

		Source Type	Routed To
Air (#/hr, tons/yr)			
Water (gpm)			
Solid/Hazardous Waste (#/yr)			

Proactive Considerations: (List any proactive measures of this project to improve the environment.)

_____ _____

_____ _____

_____ _____

Services/Considerations: (List the critical services, steam, soft water, waste water treatment, etc. required.) Delta Impacts:

_____

_____

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FIVE TYPICAL EXAMPLES OF WEC'S WASTE MINIMIZATION IMPACT PROGRAM

I. Petrochemical Plant

Total Plant Investment	$ 10,500
Yearly Savings	$111,000
Payback Period	1.1 months

Problem

Manufacturing carbon black leaves traces of product in the residual gases used for steam generation in the process steam boiler. When the steam boiler is shut down, the residual gases escape into the atmosphere.

Solution

Tie-in the individual steam lines into one common line allowing the residual gases to by-pass any unit's shut down boiler.

Yearly Savings

From improved operating efficiency.

Environmental, Health & Safety Benefits

Improved air quality in plant and adjacent residential areas.

II. Chemical Plant

Total Plant Investment	$15,000
Yearly Savings	$95,000
Payback Period	1.9 months

Problem

Reduce the ammonia content in the waste water from the carbamide production line.

Solution

Recycle the ammonia from the waste gases by absorption.

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Yearly Savings

Reduced cost for raw material.

Environmental, Health & Safety Benefits

Improved quality of the water discharged into the streams.

III. Pharmaceutical Plant

Total Plant Investment	$0
Yearly Savings	$13,000
Payback Period	None

Problem

Eliminate/reduce the extensive analytical testing of raw materials procured from suppliers having varied quality control standards.

Solution

Purchase raw materials only from suppliers that are ISO 9000 certified, and who can furnish a product certificate of analysis for every product.

Yearly Savings

From reduction in costs for analytical testing.

Environmental, Health & Safety Benefits

Reduced generated waste from laboratory and workers' exposure to toxic testing materials.

IV. Chemical Plant

Total Plant Investment	$ 74,000
Yearly Savings	$374,000
Payback Period	2.4 months

Problem

Using the electrolytic method for producing chlorine and sodium/potassium in mercury cells, develop 2,500 tons of sludge per year. The sludge is a product of the impurities in

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the sodium/potassium chloride used in the process. One kilogram of dry sludge contains 50mg of mercury.

Solution

Revise the manufacturing process to use recrystallized salts with a higher purity (99.9%) instead of the natural chlorines presently specified. This process change will minimize the production of mercury contaminated sludge.

Yearly Savings

Eliminating the cost for disposing of 2,500 tons of sludge per year.

Environmental, Health & Safety Benefits

Reduced mercury in sludge deposited in landfill and workers exposure to mercury.

V. Refinery

Total Plant Investment	$0
Yearly Savings	$320,000
Payback Period	None

Problem

To stop the use of landfills for storing of liquid and semi-liquid wastes and presently disposed of in lagoons.

Solution

Utilize storage tank farms for separating the oil and waste water. The oil will be recycled and the contaminated water will be discharged into the waste water system. The plant has made arrangements to sell the recovered oil from the lagoons to another company for use as a fuel. The balance of the semi-liquid will be solidified using a process developed by the plant and will be mixed with coal and used as a fuel by the power plants.

Yearly Savings

From the sale of the recovered oil to another company and the use of waste oil with solidified waste as a fuel by the power plants.

Environmental, Health & Safety Benefits

Reduced VOC emissions and elimination of a potential fire hazard at the oil saturated lagoons.