EXPERIENCE WITH THE EPA MANUAL FOR WASTE MINIMIZATION OPPORTUNITY ASSESSMENTS

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Introduction

The EPA Waste Minimization Opportunity Assessment Manual (EPA/625/7-88/003) was published to assist those responsible for managing waste minimization activities at the waste generating facility and at corporate levels. The Manual sets forth a procedure that incorporates technical and managerial principles and motivates people to develop and implement pollution prevention concepts and ideas. Environmental management has increasingly become one of cooperative endeavor whereby whether in government, industry, or other forms of enterprise, the effectiveness with which people work together toward the attainment of a clean environment is largely determined by the ability of those who hold managerial position. It is recognized that scientific knowledge, engineering skills, technical abilities, or vast amounts of material resources by themselves are limited without high quality management tools and effective coordination of human resources.

This paper offers a description of the EPA Waste Minimization Opportunity Assessment Manual procedure which supports the waste minimization assessment as a systematic planned procedure with the objective of identifying ways to reduce or eliminate waste generation. The Manual is a management tool that blends science and management principles. The practice of managing waste minimization/pollution prevention makes use of the underlying organized science and engineering knowledge and applies it in the light of realities to gain a desired, practical result. Too often science and management disciplines do not complement each other. Since there is no science in which everything is known and all relationships proved, and it is recognized that management is perhaps the most inexact of the social sciences, the descriptive, prescriptive and normative principles have value in gaining effectiveness and efficiency in the day to day decision making of pollution prevention.

The early stages of EPA's Pollution Prevention Research Program centered on the development of the Manual and its use at a number of facilities within the private and public sectors. This paper identifies a number of case studies and waste minimization opportunity assessment reports that demonstrate the value of using the Manual's approach. Several industry-specific waste minimization assessment manuals have resulted from the Manual's generic approach to waste minimization. There were some modifications to the Manual's generic approach when the waste stream has been other than industrial hazardous waste. There are other cases where the Manual requires modification, but the waste minimization incentives and the waste minimization assessment procedure should be adaptable to most situations.

Waste Minimization Opportunity Assessment (WMOA)

The Waste Minimization Opportunity Assessment (WMOA) can best be described by defining the three terms: 1) waste minimization, 2) opportunity, and 3) assessment as used in the context of pollution prevention. First, the working definition of waste minimization consists of source reduction and recycling which are the most desirable steps on the waste management hierarchy before treatment, storage or disposal of the waste. Waste minimization focuses on source reduction or recycling activities that reduce either the volume or the toxicity of waste generated. Terms used which are somewhat synonymous with waste minimization are: waste reduction, clean technologies, pollution prevention, environmental technologies, low- and nonwaste technologies, and green technologies.

The second term, opportunity refers to the compelling incentives for reducing or eliminating the generation of waste. Since top management commitment of time, personnel and financing is essential to the success of a pollution prevention program, the changes for obtaining this commitment are enhanced by outlining the potential incentives for waste minimization. A variety of incentives for minimizing the generation of waste include the following:

- Sound Economics (reducing costs for raw materials, waste treated and disposal)
- Compliance with Regulations (including disposal regulations, reporting and permitting requirements)
- Reduced Liability (including environmental problems and work place safety)
- Improved Public Image and Environmental Concern

The term assessment is a systematic step-by-step review of understanding the process and waste stream, identifying options for reducing waste, and determining which options are technically and economically feasible to justify implementation. The assessment is not an environmental audit or an attempt to determine regulatory compliance.

The waste minimization opportunity assessment is therefore a systematic examination of a waste generating process and its components with the goal of recommending techniques and or technologies that would enhance the cleanliness of a particular process or operation.

Waste Minimization Opportunities

It is quickly recognized that waste minimization is site specific, but a number of generic approaches and techniques have been used successfully across the country to reduce many kinds of industrial wastes.

Generally, waste minimization opportunities can be grouped into four major categories: 1) inventory management and improved operations; 2) modification of equipment; 3) production process changes; and 4) recycling and reuse. Such techniques can have applications across a range of industries and manufacturing processes, and can apply to hazardous as well as nonhazardous waste.

Many of these techniques involve source reduction -- the preferred option on EPA's hierarchy of waste management. Others deal with on- and off-site recycling. The most feasible strategy may be a combination of source reduction and recycling approaches.

The approaches discussed and illustrated in Figure 1 provide waste minimization examples for generic and specific processes.

Figure 1
Waste Minimization Approaches and Techniques

Inventory Management & Improved Operations

- Inventory and trace all raw materials.
- Purchase fewer toxic and more nontoxic production materials.
- Implement employee training and management feedback.
- Improve material receiving, storage, and handling practices.

Modification of Equipment

- Install equipment that produces minimal or no waste.
- Modify equipment to enhance recovery or recycling options.
- Redesign equipment or production lines to produce less waste.
- Improve operating efficiency of equipment.
- Maintain strict preventive maintenance program.

Production Process Changes

- Substitute nonhazardous for hazardous raw materials
- Segregate wastes by type for recovery
- Eliminate sources of leaks and spills.
- Separate hazardous from non-hazardous wastes.
- Redesign or reformulate end products to less hazardous.
- Optimize reactions and raw material use.

Recycling and Reuse

- Install closed-loop systems.
- Recycle onsite for reuse.
- Recycle offsite for reuse.
- Exchange wastes.

The Waste Minimization Assessment Procedure

The waste minimization assessment procedure is outlined in the Manual and in Figure 2. The planning and organizational aspects provide the foundation for the WMOA through setting goals, organizing the WMOA task force and assuring management support. The assessment phase includes data collection, targeting waste generating operations, selecting the WMOA team, and identifying potential waste minimization options. The feasibility analysis phase determines the economic and technical feasibility of the selected options for waste minimization. The final phase of the procedure is the implementation which measures the effectiveness of the selected options and provides the technical and economic justification.

The following sections describe some of the assessment efforts currently being conducted by the EPA.

Figure 2
The Waste Minimization Assessment Procedure

I. Planning and Organization

- Get management commitment
- Set assessment program goals
- Organize assessment program task force

II. Assessment Preparation Step

- Identify and track waste streams
- Compile process and facility data
- Prioritize and select assessment targets
- Select people for assessment teams

III. Assessment Step

- Inspect site
- Generate options
- Screen and rank options
- Select options for feasibility study

IV. Feasibility Analysis Step

- Technical evaluation
- Economic evaluation
- Select options for implementation

V. Implementation

- Justify projects and obtain funding
- Install or modify equipment
- Implement new procedure
- Evaluate performance of projects

DEPARTMENT OF DEFENSE

The greatest quantities of hazardous waste within the Department of Defense (DoD) are generated by plating, cleaning, and stripping operations. To date, the EPA's Waste Reduction Evaluations at Federal Sites (WREAFS) Program support of DoD pollution prevention activities include projects conducted at the Philadelphia Naval Shipyard, Fort Riley (Kansas) Army Forces Command, and the Naval Undersea Warfare Engineering Station in Keyport, Washington. These projects have identified pollution prevention opportunities for a range of industrial and military operations including: metal cleaning, solvent degreasing, spray painting, vehicle and battery repair, ship bilge cleaning, and weapons overhaul. The resultant pollution prevention recommendations and research identification are source reduction methods including technology, process, and procedural changes and recycling methods, which focus on reuse and recycling.

Philadelphia Naval Shipyard Assessment

One of the WREAFS sites chosen for performance of a waste reduction assessment is the Philadelphia Naval Shipyard (PNSY). This Federal facility specializes in revitalizing and repairing operational naval vessels. A wide range of industrial processes are performed at the PNSY, many of which generate wastes. This project focused on the processes and wastes of operations related to aluminum cleaning, spray painting, and bilge cleaning. Seven waste minimization options were evaluated during this project.

An aluminum cleaning operation is performed to remove oil and other materials from the surfaces of aluminum sheets prior to welding. This process is critical in that the welding operation cannot be performed unless the metal surfaces are properly cleaned. The cleaning line consists of four tanks: two process tanks and two rinse tanks. The process tanks contain a proprietary cleaning solution. One of the process tanks is heated (steam coil) and the other is at ambient temperature. The heated tank is used more often since it provides better oil removal. The rinse tanks contain tap water. Both rinse tanks are heated.

The process tanks become diluted after repeated operation due to dragout losses and tap water replenishment. These tanks also collect floating oil, and the solution becomes contaminated with suspended solids. During this project, drag-out reduction methods and an alternative rinsing procedure were evaluated which would reduce the frequency of discharge for these wastestreams.

The spray painting processes are used for small and medium-sized aluminum and steel parts. Aluminum parts are degreased by wiping with rags that have been dipped in xylene. The parts are then spray painted in a water curtain booth. The painting process typically consists of a zinc chromate primer, air drying, a final enamel paint coating, and air drying. A new booth water chemical system was used for the first time during the survey.

The economics of the new booth maintenance system were evaluated during this project. Also, optional dewatering equipment was evaluated which is currently under consideration by PNSY. The dewatering equipment will reduce the volume of paint sludge generated by the maintenance system.

PNSY employs a chemical cleaning process for ships' tanks, bilges and void spaces termed the citric acid process. It is generally performed while ships are in drydock. This process is relatively new (1976) and it replaces the mechanical methods of cleaning and derusting metal surfaces. The procedures involve the use of a citric acid/triethanolamine (TEA) solution to remove the oxides from the metal surfaces, and subsequent neutralization and rinsing with dilute solutions.

The results of the PNSY assessment are summarized in Table 1. The best options in terms of cost savings are the awareness and training program for paint waste reduction and the changes to the aluminum cleaning line including the dragout reduction, bath maintenance, and improved rinsing. These three options offer a combined net savings of $158,680 per year.

TABLE I. PHILADELPHIA NAVAL SHIPYARD SUMMARY OF WM OPTIONS

Location Process and Waste	WM Options	Nature of WM Option	Total Capital Investment $	Savings $/yr	Payback Period yr	Est. Waste Reduction lb/yr
BUILDING 990						
Aluminum Cleaning Spent KRC-7X	Bath Maintenance	Equipment	$12,200	$44,190	0.3	44,035
	Two Stage Rinse	Equipment	3,116	34,590	0.1	190,590
Spray Painting of Aluminum Paint Sludge	Booth Chemicals	Materials	12,190	5,430	2.3	-
	Paint Sludge Dewater.	Equipment	9,550	3,840	2.5	15,012
Used Paint Thinner and Unused Paint	Awareness & Training	Personnel/ Proced.	24,266	79,900	0.3	unknown
BUILDING 1028						
Spray Painting of Steel Paint Sludge	Booth Chemicals	Materials	3,300	5,460	0.6	27,022
	Paint Sludge Dewater.	Equipment	same as bldg 990	-	-	-
DRYDOCKS						
Citric Acid Derusting Conc. Citric Acid/TEA	ED Recovery System	Equipment	76,050	60,720	1.3	124,241

Ft. Riley (Kansas) Army Forces Command

Another WREAFS site was the U.S. Army Forces Command (FORSCOM) located at Ft. Riley, Kansas. This government-owned, government-operated installation provides support and training facilities for the 1st Infantry Division, Non-Divisional Units, and tenant activities. The areas selected for assessment were the Division motor pools. Results of the waste minimization assessment identified two waste reduction opportunities in a multipurpose building used for automotive subassembly rebuilding, lead acid battery repair as well as other maintenance operations.

One opportunity is with the lead acid battery repair shop where battery acid is currently being drained from dead batteries and batteries being repaired. It is proposed that the waste battery acid be collected in a holding tank, filtered to remove particulates, and adjusted in concentration to 37 percent sulfuric acid as needed for reuse in reconditioned or new batteries. Battery acid disposal is currently costing twice as much as new acid procurement. By reusing the spent acid, the cost of disposal and purchase of new acid will be reduced.

The second waste reduction opportunity is in the area of automotive parts cleaning. Currently the dirty aqueous alkaline detergent solution for automotive parts cleaning, which contains trace levels of lead, chromium, and cadmium as well as the oils, grease, and dirt is drained to an on-site evaporation pond. The proposed waste minimization option for this waste stream involves emulsion breaking to remove the tramp oils, filtration to remove particulates, and addition of fresh alkaline detergent as necessary, followed by reuse for automotive parts cleaning. In addition, another pollution prevention practice would be to monitor the types and kinds of parts which require cleaning for repair and determine how to prevent the part from breaking. By extending part life, the need for repair, and therefore cleaning needed prior to repair, would be reduced.

The waste reduction options identified at the Ft. Riley assessment are recycle/reuse options. A net savings in operating costs is anticipated to be $149,400 per year. It is also noted that the options recommended at Ft. Riley may be applied in at least 10 other U.S. Army FORSCOM installations.

INDUSTRY ASSESSMENTS

Simultaneously with the assessments at Federal sites, EPA is conducting WMOA's at industrial facilities. The focus of these efforts has been on locating small and medium-sized facilities which may not have the immediate resources or expertise to do what is necessary to reduce their waste, and would benefit significantly from Agency support. Toward this goal, assessments have been conducted at a mini-photo lab and a truck manufacturing facility. Both hazardous and non-hazardous wastes are included in the assessments.

Details on the two assessments are provided below.

Mini-Photo Lab

After an assessment in August 1989, the assessment team identified five waste minimization options they considered applicable to the wastestreams of interest. Following is a brief description of these options.

Option 1 - Wash Water Control - Wash water is used for color film development and the B&W paper process. The wash water is turned on each production day at approximately 7:00 a.m. and shut off at 7:00 p.m. Water use is therefore continuous during the day, however, production is not. The waste minimization option consists of a simple timer control system consisting of a switch, timer and solenoid valve. The operator would punch a button on the switch to activate the timer. In turn, the activated solenoid would allow water to flow for a preset time period.

Option 2 - Silver Recovery/Metal Replacement Cartridges - Silver is found (as light-sensitive silver halide) in spent photographic chemicals and wash waters as a result of removing the emulsion on films and papers. A metal replacement cartridge is a widely-used device for silver recovery. It can be used alone or in conjunction with other recovery technologies. In this case, the spent process solutions which contain significant amounts of silver would be plumbed to a single pipe. Two cartridges would be used to allow for high capacity while maintaining a high recovery rate.

Option 3 - Silver Recovery/Electrowinning - An electrowinning unit passes a direct current through a concentrated silver solution from anode to cathode causing the silver to plate out onto the cathode in nearly pure metallic form. A wide range of equipment is commercially available for electrowinning. Using manufacturer's literature as a basis, it is expected that up to two batches (4 gallons each) can be treated each day. During the average batch, 1.13 troy oz. of silver would be recovered within 4.5 hours.

Option 4 - Silver Recovery - This option is based on using the electrowinning device in Option 3, with metal replacement cartridges used to polish the effluent. The average effluent will be desilvered from 500 mg/l to approximately 10 mg/l, using only one cartridge.

Option 5 - Bleach Fix Recovery - The recommended method for bleach fix recovery is desilvering with two metal replacement cartridges. This requires three steps: 1) silver recovery, 2) restoring bleaching ability by aerating ferrous-EDTA complex to oxidize back to ferric-EDTA, and 3) replenishment of chemicals lost through carry-over with the film or paper. Approximately 75% of the recovered bleach fix solution can be reused while 25% should be discarded to prevent contaminant build-up.

Total capital investment, net operating cost, and payback period for each option are shown in Table 2. The owner of the lab has received a copy of the final assessment report and is taking the recommended options under advisement.

TABLE 2. SUMMARY OF MINI-PHOTO LAB WASTE MINIMIZATION OPTIONS

WASTE MINIMIZATION OPTION	TOTAL CAP. INVESTMENT, $	NET OP. COST SAVINGS, $/YR	PAYBACK PERIOD, YR
Wash Water Control	$ 675	$1,436	0.47
Silver Recovery Using Metal Replacement Cartridges	1,071	1,325	0.81
Silver Recovery Using Electrowinning	3,510	1,414	2.48
Silver Recovery Using Electrowinning with MRC Tailing	3,667	1,757	2.08
Recycle of Bleach Fix and Silver Using MRCs	1,571	2,508	0.63

Truck Manufacturer

This truck manufacturing facility produces 34 trucks (tractor-trailer) per day. The production processes are primarily assembly and painting. The current quantities of generated wastes and the associated disposal costs for the first three quarters of 1989 are given below:

	Amount (lb)	Cost of Disposal
Waste Paint	184,860	$12,957
Pretreatment Sludge	71,020	$ 9,134
Undercoating	3,375	$ 2,560
Degreasing Solvent (Chlorinated)	13,060	$ 5,431
Used Oil	28,275	$ 105
Paint Sludge	474,960	$15,132
Housekeeping	3,800	$ 1,428

The above figures represent a sharp decrease from recent years. The facility has instituted a number of waste minimization measures and cost reduction methods related to good waste management practices.

A site visit was conducted in January 1990 to begin the assessment. Although this facility has made major strides in waste minimization, the assessment team feels there are additional opportunities which may have significant impact. The following are targeted areas which will be investigated further throughout the assessment and feasibility phases.

Spray Painting - Air-assisted airless spray equipment is used for most spray painting. This method is a distinct improvement over conventional compressed air spray painting, however, alternatives exist which may improve transfer efficiency. Increasing the transfer efficiency reduces the volume of paint used and reduces volatile organic carbon (VOC) emissions.

Phosphating - An automated phosphating (conversion coating) process and electro-coat (E-coat) is used for small and medium-sized parts. This line consists of several processing and rinsing steps. The rinse water is piped to a chemical treatment plant where it is combined with paint booth wastewater. The resultant sludge is disposed as a hazardous waste.

It may be possible to avoid waste treatment of the phosphating rinse water by using an ion exchange recycle system, thereby also reducing water usage. Furthermore, the current wastewater treatment process, which uses large amounts of ferric chloride, may be altered, resulting in reduced sludge generation.

Degreasing of Rail Frames - The rail frame, or chassis, is degreased prior to spray painting using a chlorinated solvent (90% 1,1,1,-trichloroethane/10% methylene chloride). The spent solvent is distilled (350-400 gallons per day) and reused. Waste minimization options may include chemical substitution, procedural changes, or improvements to the recycle process.

NEW JERSEY ASSESSMENTS

A pilot project with the New Jersey Department of Environmental Protection (NJDEP), entitled "Assessment of Reduction and Recycling Opportunities for Hazardous Waste (ARROW)," will allow the State to evaluate waste minimization techniques and conduct assessments at approximately thirty facilities within New Jersey. The objective of the site selection is to cover ten industries (three sites in each) to develop industry-specific information through the assessment activities.

Through a subcontract with NJDEP, the New Jersey Institute of Technology (NJIT) is locating sites and performing the assessments by following the EPA-recommended procedure outlined in the EPA manual. Participation in the program by facilities is on a voluntary basis. To date, response to the program has been enthusiastic and 14 companies are lined up for assessment work. Five site visits have been completed and the assessment reports are being prepared. Brief descriptions of two of the companies visited and potential waste minimization options follow below.

Nuclear Power Generation Facility

Interestingly, the bulk of the wastes from this electrical power generation facility is from construction and maintenance activities when power generation is shut down. Three major sources of waste streams were identified by the assessment team: operations, maintenance, and site services. After analysis of costs and waste generation quantities, the assessment team targeted opportunities for reduction in the levels of off-spec materials and containers of partially used materials which go to waste treatment and disposal. Several waste reduction options were identified, such as improved project estimation and planning of material procurement, dispensing, and stocking; incentives to contractors for waste reduction; and improved security to protect against wastes imported to the site.

Graphic Controls

This facility manufactures pens and markers for automatic recording devices and inks for use in these devices. The waste generation data indicate that the operation for ink formulation and preparation contribute the bulk of the hazardous waste generation. Some options leading to reduced waste generation include reduction in quantities of rinse water used in the cleaning of equipment; improved scheduling of colors and types of batches of inks to reduce cleaning between batches; increased use of mechanical cleaning of tanks to supplement water cleaning; and changes in ink preparation procedure such as the utilization of a large ink base which could be tinted to the appropriate color in smaller batches as the need arose using small amounts of tinting color.

NJIT continues to work with facilities who show a strong interest in waste minimization and have volunteered to participate in the ARROW program. This effort will continue through August 1991.

TECHNICAL ASSISTANCE CENTERS

In 1988, a pilot project to assist small and medium-sized manufacturers in initiating hazardous waste minimization programs was begun through a cooperative agreement with the University City Science Center (UCSC) in Philadelphia, Pennsylvania. The need for these centers is based on the recurring problem, as stated previously, that for many smaller industrial facilities there is a lack of in-house expertise or resources required to start a waste minimization program. However, a small amount of technical assistance in the form of an initial waste minimization assessment can lay the foundation for a permanent program. The pilot project provides such assessments at no out-of-pocket expense to the client manufacturer. Waste Minimization Assessment Centers (WMAC's) were established at the University of Tennessee in Knoxville and at Colorado State University in Fort Collins during the first year of the project. A third WMAC was instituted at the University of Louisville in Kentucky in 1989.

Two examples of completed assessments involve an automobile bumper refinishing plant and a paint and coatings manufacturer. These facilities are described below.

<u>Facility A - Automobile Bumper Refinishing</u>

Refinished automobile bumpers (steel, aluminum, and plastic) are the chief products of this plant, which operates for 52 weeks per year and spends almost $15,000 per year to treat and dispose of its wastes. Those costs would be considerably higher if this plant, which was built only 3-4 years ago, had not incorporated certain features to aid in hazardous waste management into its basic design. The WMAC team therefore faced a more difficult challenge in further reducing hazardous waste emissions. For example, the design of this plant had eliminated direct drains from production areas to the sewer, had surrounded certain chemical tanks with dikes so that any spillage or overflow would be channeled to a central sump pump, and had taken other precautions to reduce migration from spillage, such as locating tanks below ground level.

In general, raw materials (used bumpers) follow one of three possible paths in this plant:

° Steel bumpers are straightened and cleaned before being plated with nickel and chromium.

° Aluminum bumpers are straightened and cleaned before being re-anodized (off-site).

° Urethane bumpers (plastic) are treated to remove paint before being repaired and repainted.

The direct focus of the WMAC team was on the first two because they account for the bulk of the production and virtually all of the hazardous waste generated at this plant. For metal bumpers, the production level averaged almost 16,000 per year, and about 80% of that was steel.

Steel Bumper Refinishing

After being straightened, the steel bumpers are prepared for refinishing by soaking in hydrochloric acid to remove old plating and then rinsed before immersion in metal cleaning solution (caustic and sodium silicate), polishing, and grinding. Then the bumpers are put through the plating line, where they are successively soaked in a dilute cleaning solution and a sodium fluoride acid soap solution with intermediate rinses, before being electrolytically replated with nickel first and then with chromium. A drag-out tank reduces liquid carryover from plating, and deionized water is used for multi-stage countercurrent rinsing.

This sequence of operations includes several steps already adopted by the plant to reduce the quantity of waste generated, such as:

- Air agitation to assure good circulation in the rinse tanks and to lower the volume needed.

- Deionized water for making process solutions and for rinsing, because otherwise the calcium and magnesium in the water supply would add to the amount of sludge formed.

- Less toxic trivalent chromium in the plating solution to lessen the concentration (weight of chromium per unit volume) and reduce treatment costs.

- Drag-out tanks to capture most of the solution carried out of the plating tanks before it reaches the rinse. When metal concentration in the drag-out increases over a period of time, the solution is recycled to the plating tank (for chromium) or sent to a holding tank (for nickel), where it is heated to decrease its volume by evaporation.

- Multi-stage countercurrent rinsing (rather than a continuous flow) so that the bumpers are first placed in the most contaminated stage and then the cleanest stage last.

- Continuous filtration of the chromium and nickel plating solutions to remove solid contaminants and allow the filtrate to be returned to the plating tanks.

Periodically the cleaning solutions and the rinse tanks are dumped into a sump and transferred to a storage and evaporation tank. The metals are flocculated by adding sodium bicarbonate, and the resulting sludge settles to the bottom. The remaining liquid, after pH adjustment, has been hauled offsite for disposal while the sludge, with mixed metals, has been sent to a hazardous waste landfill.

Aluminum Bumper Refinishing

The potential for hazardous waste to be derived from aluminum bumper refinishing at this plant is considerably less than it is for steel. First, the amount of aluminum bumpers among the plant's raw materials is only about one-fourth of the quantity of steel ones. Second, only part of the overall refinishing occurs at this plant, and the operations which are carried out have generated less hazardous waste than refinishing steel.

To remove the anodized coating on the bumpers brought into the plant, they are first soaked in a tank of heated alkaline de-ruster. After rinsing with tap water, the aluminum bumpers are immersed in a de-smut tank and then rinsed again with tap water. Aluminum bumpers are then re-anodized at another location.

Spent solutions and rinse water containing suspended solids are accumulated in a sump, from which they are pumped periodically to a storage and evaporation tank.

Three recommended waste minimization opportunities (WMO's) will, if implemented, save about half the current hazardous waste management costs at this plant. They are summarized in Table 3 with emissions reduction, savings and costs.

TABLE 3. SUMMARY OF WASTE MINIMIZATION OPTIONS - FACILITY A

Present Practice	Proposed Action	Cost Savings
Rinse water and other liquid streams are collected and treated with sodium bicarbonate to precipitate most of metals as sludge. Resulting liquid has nickel content less than 50 mg/l and chromium content below 5 mg/l. POTW requires less than 2.52 mg/l of nickel and less than 2.77 mg/l of chromium. Volume = 84,600 gal/yr.	Use additional filtration and existing deionization systems to reduce chromium and nickel levels to acceptable limits and to assure quality of water for recycle to plant. Add small additional solid collected to hazardous waste going to landfill for disposal.	Est. waste reduction = 84,600 gal/yr Est. cost reduction = $3910/yr Incre. operating cost = $258/yr Incre. cost of solid waste = $27/yr Net cost saving = $3625/yr Simple payback = about 15 mo.
Sludge from precipitation of metals is combined with residue from filtration of plating solutions and sent to hazardous waste landfill. Weight = 5500 lb/yr	Dewater the sludge by heating it. Continuous dewatering is possible by loading the sludge into a hopper and feeding it by an auger to a burner tube fueled by natural gas or LPG. The weight of hazardous waste sent to the landfill will be reduced.	Est. waste reduction = 3874 lb/yr Est. cost reduction = $2964/yr Incre. operating cost = $50/yr Net cost saving = $2914/yr Est. implementation cost = $10,000 Simple payback = 3.4 year
Tap water is used freely to rinse aluminum bumpers after they are stripped of anodized coating. This rinse is combined with other liquids and the total is sent for landfill disposal.	Constrict the flow of tap water from 6 to 3 gal/min. If a higher pressure water stream is needed, substitute a wand spray gun. Then a booster pump will be needed, but the flow can be reduced to about 0.6 gal/min.	Est. waste reduction = 8246 gal/yr Est. cost reduction = $1039/yr (based on cost to haul liquids to landfill) Est. implementation cost = under $10 Simple payback less than 1 month Cost of Booster pump (1/2 hp) = $300 Cost reduction = $1860/yr Est. operating cost = $60/yr Simple payback = 2 months

Facility B - Paints and Coatings Production

This plant produces paints, coatings, stains, and surface-treating products at an overall rate of about 1.1 million gallons per year for regional distribution on a schedule of 2080 hours per year for 52 weeks. Its operations primarily involve blending and mixing of raw materials, followed by product testing and packaging and by cleaning of vessels and lines. Color separation in the product is obviously important, and each lot must meet a variety of other customer specifications.

Individual lots of water-based and solvent-based paints are mixed in tanks from 200 to 1,000 gallons capacity. Ingredients for this initial step include (for water-based) water, latex, resins, extenders, and dispersed pigments. For solvent-based paints the materials are generally similar in type, but obviously solvent replaces water and latex, and the other new ingredients include plasticizers, tints, and thinners.

After batches are made up they are transferred to so-called let-down tanks, where additional water (or solvent), resins, preservatives, anti-foaming agents, thinners, and bactericides are added. Testing of batches encompasses at least color, viscosity, and gloss, and those lots which meet specifications are filtered and charged to cans for labeling, packaging, and shipping.

Hazardous Waste Generation

The principal waste streams are the result of equipment cleaning, especially from water-based paints. For example, rinsing the let-down tanks ordinarily requires 35 gallons of rinse water, but that value increases to 53 gallons if light paint is to be blended after a dark predecessor. The hazardous nature of water rinses is due to mercury from the bactericide in the paint.

In some instances, rinse water from the mixing tanks is held in 500-gallon tanks and used in the let-down tanks (instead of fresh water) to formulate future batches of water-based paint. The rinses are separated according to the color intensity of paint in the tanks from which they were derived. For example, rinses from white paint formulation amount to about 70% of the total and they are invariably used again.

Waste rinses not used again are piped to holding and flocculation tanks. Alum is added to lower the pH and some solid is precipitated by adding flocculent. From this, supernatant liquid is removed for re-use in other paint formulations.

Tanks used for solvent-based paints are rinsed with mineral spirits at a rate of about 5 gallons/400-gallon tank. These washings are sent off-site for recovery, followed by recycling or sale as fuel.

In addition to re-use of rinse water and recovery of solvent, this plant has adopted the following measures to reduce waste generation:

- Cleaning equipment before paint dries and hardens.

- Eliminating hazardous materials, except for mercury in the bactericide added to outdoor water-based paint.

- Avoiding hazardous container waste by purchasing the bactericide in water-soluble bags which dissolve during paint formulation.
- Scheduling batch formulations so that light ones precede dark ones and thereby reduce the total volume of rinses.
- Reducing the inventory of raw materials to avoid degradation and spoilage and to assure high-quality product that can be sold, rather than low-quality paint which adds to the burden of waste disposal.
- Using bag filters to collect dust.

Summary of Recommended Waste Minimization

Table 4 offers a brief description of each recommendation and of current plant practice, together with savings and cost data. Together, the three WMO's recommended could save over $22,000 per year, which represents about 25% of current waste management costs. Each simple payback time is less than one year.

CONCLUSION

This paper describes several waste minimization success stories arising from the EPA's pollution prevention research program in Cincinnati, Ohio. The programmatic approach has been to go to other Federal agencies and industry to determine the manual's implementation and to transfer technical pollution prevention impacts throughout these communities, especially to small and medium-sized businesses which may not otherwise have the resources to pursue pollution prevention initiatives on their own. Furthermore, it is clear that EPA's program has focused on practical approaches to already existing processes and facilities.

EPA's assessment program will continue to aid in the establishment of a knowledge pool of individuals technically-oriented to pollution prevention. The assessment process is becoming an integral part of business management practices, much as safety concerns have become routine. Beyond these assessments, the Agency's pollution prevention research programs must turn to identifying clean practices, clean products and processes. With the cooperation of representatives from the Federal and private sectors, EPA anticipates broad potential for research in alternative technologies and products that lower risks to the environment. Each waste minimization opportunity assessment brings together the science and management required to reduce the generation of wastes.

TABLE 4. SUMMARY OF WASTE MINIMIZATION OPTIONS - FACILITY B

PRESENT PRACTICE	PROPOSED ACTION	COST SAVINGS
Water rinses remove paint from tanks and pipes	Install a pipe-cleaning system consisting of 3 different-sized foam plugs or "pigs" to be sent throughout the pipes by compressed air. Paint is thus forced from the lines and to the canning line filter. The use of water and amount of waste are lower. (This WMO is applicable to non-white paints.)	Est. waste reduction = 1,780 gal/yr Est. cost reduction = $11,110/yr Est. implementation cost = $1,600 Simple payback = 2 months
About 15 gal solvent per batch of paint is drummed and sent off-site for disposal.	Use a solvent recovery system based upon distillation and ship the small amount of remaining solid to a hazardous waste disposal site.	Est. waste reduction = 3,300 gal/yr Est. cost reduction = $5,420/yr Est. implementation cost = $4,950 Simple payback = 11 months
A bactericide containing mercury is being used in water-based paints.	Eliminate the bactericide from water-based interior paints and substitute an organic material. (This WMO is applicable to non-white paints.) There is no cost difference between these additives.	Est. waste reduction = $3,100 gal/yr Est. cost reduction = $5,580/yr Est. implementation cost = none Simple payback = immediate

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