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Waste Minimization

INSTRUCTOR:

HARRY FREEMAN
RISK REDUCTION ENGINEERING LAB
U.S. ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OH 45268
USA

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Waste Minimization Training Courses
1990 Pacific Basin Conference on Hazardous Waste Minimization

November 9-15, 1990 - Honolulu, Hawaii

Agenda

8:30 - 9:00	Introduction of participants formation of work teams, review of text, and overview of workshop goals
9:00 - 9:30	Waste minimization overview: terms, policies, and strategies - good reg. section
9:30 - 10:15	Examples of waste minimization techniques and technologies
10:15 - 10:30	Break
10:30 - 10:45	Excerpts from Pollution Prevention
10:45 - 11:15	Waste minimization assessments
11:15 - 12:00	Classroom Exercise - Advice to Pristine-Enviro
12:00 - 1:00	Lunch
1:00 - 1:30	Waste Minimization Case Studies
1:30 - 2:30	Measuring waste minimization (John Warren, RTI)
2:30 - 2:45	Break
2:45 - 3:15	Economics of waste minimization
3:15 - 4:00	Classroom exercises
4:00 - 4:30	DOD Waste Minimization Efforts in Hawaii (Mr. Leighton Wong, US Navy)

DAY 2

8:30 - 9:30	Establishing a waste minimization program at your facility
9:30 - 10:00	Film, Waste Not
10:00 - 10:15	Break
10:15 - 12:00	Amazing Blitzfn Exercise
12:00 - 1:00	Lunch
1:00 - 1:30	Review of Blitzfn Exercise
1:30 - 2:30	Pollution Prevention: The Bigger Picture
2:30 - 2:45	Break

WASTE MINIMIZATION

SECTION 1:

WASTE MINIMIZATION OVERVIEW

- "Waste Minimization" (from The Safe Disposal of Hazardous Wastes: The Special Needs of Developing Countries - World Bank Technical Paper 93.
- USEPA Pollution Prevention Policy Statement : January 20, 1987.
- Current Waste Minimization Requirements in RCRA.
- California Hazardous Waste Source Reduction and Management Review Act.
- "Hazardous Waste Minimization: A Strategy for Environmental Improvement: JAPCA January, 1988.
- Lecture Overheads.

TABLE 4-1

Working Definitions of Waste Minimization and Related Terms

Waste minimization:	The reduction, to the extent feasible, of hazardous waste that is generated or subsequently treated, stored, or disposed of. It includes any source reduction or recycling activity undertaken by a generator that results in either (1) the reduction of total volume or quantity of hazardous waste or (2) the reduction of toxicity of hazardous waste, or both, so long as such reduction is consistent with the goal of minimizing present and future threats to human health and the environment.
Reduction of total volume or quantity:	The reduction in the total amount of hazardous waste generated, treated, stored, or disposed of, as defined by volume, weight, mass or some other appropriate measure.
Reduction in toxicity:	The reduction or elimination of the toxicity of a hazardous waste by (1) altering the toxic constituent(s) of the waste to less toxic or non-toxic form(s) or (2) lowering the concentration of toxic constituent(s) in the waste by means other than dilution.
Source reduction:	Any activity that reduces or eliminates the generation of a hazardous waste within a process.
Source control:	Any activity classifiable under source reduction with the notable exception of product substitution.
Product substitution:	The replacement of any product intended for an intermediate or final use with another product intended and suitable for the same intermediate or final use.
Recycled:	A material is "recycled" if it used, reused, or reclaimed (40 CFR 261.1 [b] [7]).
Used or reused:	A material is "used or reused" if it is either (1) employed as an ingredient (including its use as an intermediate) in an industrial process to make a product; however, a material will not satisfy this condition if distinct components of the material are recovered as separate end products (as when metals are recovered from metal-containing secondary materials) or (2) employed in a particular function or application as an effective substitute for a commercial product (40 CFR 261.1 [c] [5]).
Reclaimed:	A material is "reclaimed" if it is processed to recover a usable product or if it is regenerated. Examples are recovery of lead values for spent batteries and regeneration of spent solvents (40 CFR 261.1 [c] [4]).

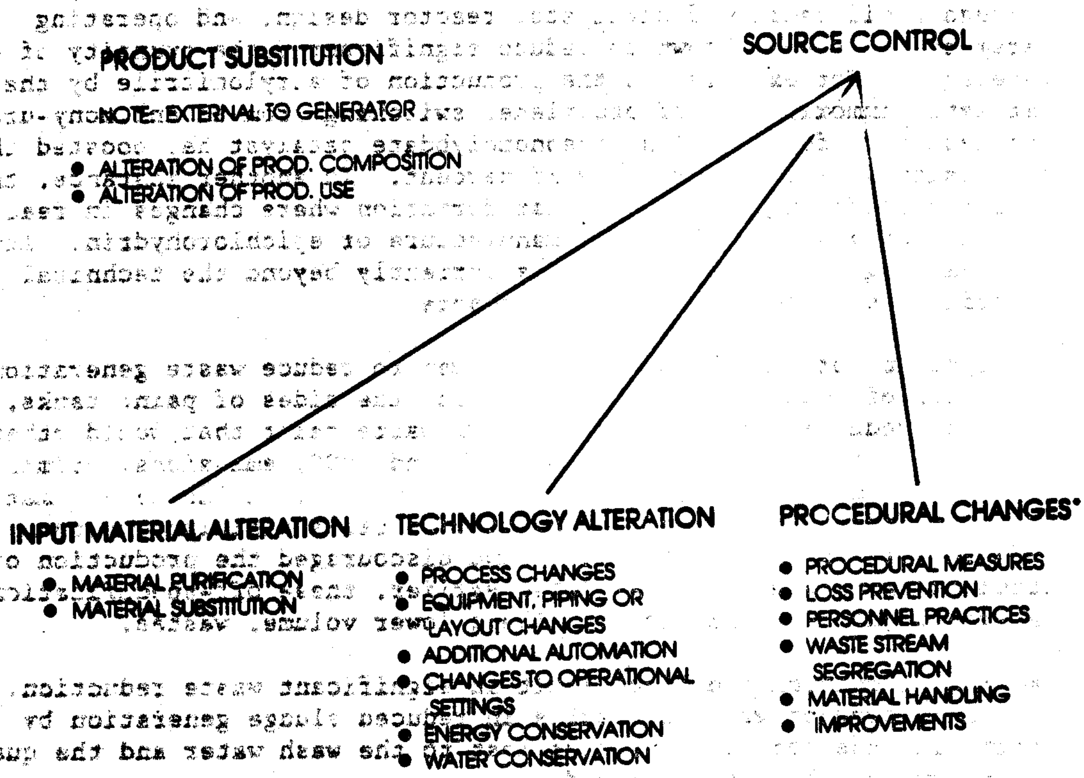
TABLE 4-1 (continued)

Treatment:	(as part of waste minimization) -- Any activity or a series of activities that reduces the volume and/or toxicity of hazardous waste <u>without</u> attendant recovery of valuable material that is subsequently employed in the manufacture of a commercial product (e.g., an incinerator for disposal of spent chlorinated solvent with scrubbing and neutralization of hydrogen chloride from the flue gas);

Source: U.S. Environmental Protection Office. 1986. <u>Minimization of Hazardous Waste</u>. No. 530-SW-86-033 (October). Washington, D.C.

FIGURE 4-2

Concept of Source Reduction As a Component of Waste Minimization



*ALSO REFERRED TO AS "GOOD OPERATING PRACTICES" OR "GOOD HOUSEKEEPING".

Source: Tulman, C.E. Control Through Source Reduction.

compounds in lieu of chromate corrosion inhibitors in cooling towers. Sometimes, however, a manufacturer may substitute a material not because the waste would be less toxic but because the waste is simply not regulated.

(ii) Technology Alterations

In certain instances, technology substitutions are also effective in minimizing waste. A product can sometimes be manufactured by two or more distinct processes. Certain processes, such as the chloride process for producing titanium dioxide, generate considerably less waste than alternative processes, such as the sulfate process. Unfortunately, modification of existing facilities can involve considerable research and development and capital investments, and can require a lengthy implementation period.

Inefficient chemical reactions in a process are a major source of increased waste generation. Improving the efficiency of the process through modification of catalysts, reactor design, and operating parameters has been shown to reduce significantly the quantity of waste generated. For example, in the production of acrylonitrile by the catalytic ammoxidation of propylene, switching from an antimony-uranium catalyst to a ferrobismuth phosphomolybdate catalyst has boosted the conversion of acrylonitrile by 35 percent. In another instance, there has been a significant decrease in tar formation where changes in reactor design improved mixing for the manufacture of epichlorohydrin. Attaining zero waste generation, however, is currently beyond the technical capabilities of most chemical processors.

Modification of equipment is another way to reduce waste generation. The invention of mechanical wipers to scrape the sides of paint tanks, for example, reduces the exposed volume of waste paint that would otherwise produce fugitive volatile organic compound (VOC) emissions. Similarly, process automation, which helps optimize product yields by automatically adjusting process parameters, has in many cases minimized operator error, reduced the likelihood of spills, and discouraged the production of off-specification materials. As noted earlier, these off-specification materials can be highly toxic, albeit lower volume, wastes.

Water conservation can also result in significant waste reduction. Efficient product washing results in reduced sludge generation by minimizing the amount of product lost to the wash water and the quantity of wastewater that is generated.

Technology modification and development of low waste techonologies is currently a central focus of waste minimization. Generally these changes are most cost-effective when implemented during a plant's planning or design period or when a plant is retooling and replacing worn out equipment. Retrofitting plants that have already been designed and/or constructed is often expensive and difficult. Consequently, while technology modification may be of limited effectiveness in reducing waste generation and toxicity from existing sources, it can be effective in limiting future waste generation.

(iii) Procedural Changes

"Good operating practices" or "good housekeeping practices" involve the alteration of existing procedural, organizational, or institutional aspects of a manufacturing process. The goal is to limit unnecessary generation of waste attributable to human intervention (or the lack of it). Employee training, management initiatives, inventory control, waste stream segregation, improvements in materials handling, scheduling improvements, spill and leak prevention, and preventive maintenance are all examples of good operating practices. Others include the scheduling of batch operations to limit the frequency of equipment cleaning and, consequently, waste generation; the segregation of hazardous wastes from non-hazardous wastes to minimize the volume of contaminated wastes; and the reduction of overspray and runoff from spraying by the paint booth operator during paint application.

(iv) Product Substitution

Replacement of an original product with a different product that is intended for the identical use can be an effective method of source reduction. For example, integrated pest management, an alternative to pesticide use in certain applications, reduces pesticide production and, in turn, the waste generated during pesticide production and application. The substitution of concrete pilings for creosote-treated timbers eliminates wastes from the manufacture of the creosote-treated pilings. Substitution of less toxic solvents, such as petroleum solvents for more toxic solvents such as perchloroethylene or trichloroethylene, generates a spent solvent waste that is less toxic.

It is difficult to quantify the current status or effectiveness of these source reduction techniques. Each substitution needs to be evaluated on a case or application-specific basis. The viability of a substitute can be based on:

- o whether the substitute can function adequately as a replacement;
- o whether the economic cost of a substitute justifies its use as a replacement,
- o whether the manufacture and disposal of a substitute reduces environmental consequence;
- o whether the cost/environmental benefit of the substitute is sufficiently attractive; and
- o socio-political factors, such as government action (e.g., procurement policy) to promote the substitute.

Trade-offs have to be weighed prior to the selection of substitutes. For example, water-based inks, sometimes used for engraving and flexographic printing, have the advantage of being less toxic than solvent-based inks, but require more energy to dry, possess a low gloss, can cause paper to curl, and occasionally require brief process stoppages. Petroleum solvents can be used in dry cleaning, but they are much more flammable than the more commonly used but more toxic perchloroethylene.

Available data are insufficient to quantify the current effectiveness of source reduction practices in reducing volume or toxicity. In qualitative terms, data indicate that industry in developed countries have already considerably reduced the volume of their wastes. Most of these source control methods, however, have been employed (1) to reduce costs or improve product quality, and, in turn, increase profits and (2) to respond to existing environmental regulations. Rarely have these practices been used solely for the purpose of waste minimization. Current information suggests that further significant source reduction does appear feasible and practicable.

4.2.3 Recycling

Viewed generically, "recycling" encompasses both re-use and reclamation activities. The discussion in this section on recycling activities pertains to hazardous waste recycling for materials recovery as well as for energy recovery. A recycler's decisions as to how to treat a waste is principally determined by the character of specific waste streams or waste mixtures. Where treatment should take place (either onsite of offsite), however, is a function of a generator's management practices which include:

- proximity to offsite recycling facilities,
- economic costs related to the transportation of wastes,
- the volume of wastes available for processing, and
- costs related to storage of waste onsite compared to offsite.

Recycling is characterized by three major practices: (1) direct use or re-use of a waste in a process, (2) recovery of a secondary material for a separate end use such as the recovery of a metal from a sludge, and (3) removal of impurities from a waste to obtain a relatively pure re-usable substance.

(i) Materials Recovery

Although recycling of selected streams is practiced to a considerable degree by certain industries, only about 4 percent of the hazardous waste generated in the United States was recycled in 1981. Of the waste that was recycled, 81 percent by volume was recycled onsite. Offsite recycling, however, is becoming increasingly common with the advent of commercial recyclers and direct transfer of wastes from generators to others who can re-use the wastes. Table 4-2 summarizes these data for the ten highest volume waste generating industries.

TABLE 4-2
Ten Highest Volume Waste Generating Industries+
Generation and Recycling Volumes during 1981

SIC	Industry	Volume of Waste Generated M gals*	Total Volume Recycled M gals*	Percent**	Volume Recycled Onsite M gals*	Percent**	Volume Recycled Offsite M gals*	Percent**
28	Chemicals and Allied Products	28,000	340	1.2	300	1.1	32	0.1
35	Machinery, Except Electrical	4,200	26	0.6	18	0.4	7.9	0.2
37	Transportation Equipment	2,300	900	39.0	880	38.0	22	0.9
42	Motor Freight Transportation	1,700	NR		NR		NR	
29	Petroleum and Coal Products	1,300	36	2.8	32	2.5	4.2	0.3
33	Primary Metal Industries	1,000	170	17.0	18	1.8	150	15.0
17	Construction: Special Trade Contractors	870	0.2	<0.1	0.1	<0.1	0.1	<0.1
34	Fabricated Metal Products	820	24	2.9	14	1.7	9.6	1.2
36	Electric and Electronic Equipment	670	47	7.0	0.4	<0.1	46	6.9
49	Electric, Gas, and Sanitary Services (includes POTWs)	470	3.3	0.7	0.1	<0.1	3.2	0.7
Total:		40,000	1543.2		1262.5		271.8	

+ These are wastes recycled at the end of the production process.
* Reporting error accounts for onsite and offsite volumes not equalling total volume recycled.
** Percent of total waste generated (by SIC).
NR: No Recycling of this type reported in RIA Generator Survey.
Source: U. S. Environmental Protection Agency. 1984. National Survey of Hazardous Waste Generators and Treatment, Storage, and Disposal Facilities Regulated Under RCRA in 1981. Washington, D.C.: Office of Solid Waste.

Recycled wastes are used as feedstocks in production processes or as substitutes for commercial chemical products. Examples include:

- the re-use of solvents for equipment cleaning;
- the recycling of collected pesticide dusts at pesticide formulators; and
- the re-use of ferric chloride wastes from titanium dioxide manufacturing as a wastewater conditioner in water treatment.

The proportion of waste that is recycled is both industry and waste specific. In general, certain wastes, such as solvents, tend to be recycled more often than others, such as pesticides. Factors that influence whether an industry recycles its waste include (1) the type of waste generation process used; (2) the volume, composition, and uniformity of wastes; (3) whether uses and re-uses of the wastes have been identified, and (4) availability and price of virgin materials relative to the costs of recycling and storing the wastes. Toxicity of the waste does not appear to be a direct factor in the recyclability of a generated waste, although, as noted previously, high volume wastes, which are often less toxic, are more commonly recycled. Based on limited data, some industry-specific observations can be made. See Table 4-2.

Generally, the streams that are recycled in the greatest volumes are dilute waste streams containing a constituent that can be re-used in large-scale applications by a generator. For example, in the chemical and allied products sector, spent acids and alkaline solutions are recycled in the transportation equipment industry; wastewater treatment sludges from electroplating and chromium plating processes are recycled; and in the primary metals industry, spent pickle liquor is recycled. Chronium solutions can be reused and recovered in tanneries. These streams are of varying toxicity, and data are inconclusive as to whether toxicity plays a role in a stream's being recycled.

Solvents tend to be recovered in larger proportion than other wastes. This is because there is both an existing technology to allow recovery and because a market exists for the recycled solvent. The available technology (e.g., distillation) is relatively inexpensive to operate and can attain high purity levels (95 percent or higher). In other cases, however, production processes generate wastes that are not practical for recovery since the recovered wastes themselves would not be useful in production.

(ii) <u>Energy Recovery</u>

In the 1981 U.S. survey, data indicate that recycling for materials recovery and re-use appears to be more popular than fuel use or energy recovery. There are two reasons why this is so. First, some wastes that could be recycled for energy recovery can also be reclaimed and re-used over and over. Energy recovery in contrast destroys the inputs. Only when the waste is too 'dirty' (contaminated from repeated re-use) do generators consider energy recovery a desirable option. The 1981 data may not, however, provide a completely accurate picture of current practices because of recent developments in energy recovery technology. Many technologies were not available in 1981, and others are only beginning to be commercially available today. Solvents tend to be used for energy recovery because they can possess high energy values. Increasing quantities of high calorific wastes are being used by cement plants and lime kilns.

(iii) Other recycling technologies

Wastes that have higher constituent concentrations are usually selected for recovery and reclamation. Data suggest that there are threshold levels that must be reached before wastes can be considered eligible for the recycling process. Halogenated solvent and nonsolvent wastes must be, on average, in the range of 35 to 40 percent before recovery or re-use technologies are practical. For other wastes, such as nonhalogenated solvents and corrosives, the threshold levels are lower for recovery or re-use practices. In any case, the average concentration level for the material being recovered using reclamation technologies is higher than that for any of the other management practices (such as onsite wastewater treatment, surface impoundments, wastewater discharge, land disposal, and treatment of organics).

A number of other typical characteristics are common to waste streams that are recycled. To be economically and technically viable for recycling, a stream usually must be uniform (i.e., it must not contain more than one contaminant). Other factors that must be met in order for recycling to be successful include:

- A market for the recycled material must exist within an economically viable distance; and

- The recycled waste must meet purity requirements for manufacturing processes.

Because recyclable wastes must be economically competitive with the virgin materials they are replacing, the wastes must often be processed prior to re-use. Reclamation processes include chemical, physical, and electrochemical separation. Some of the major technologies include the following:

- Distillation of solvent wastes;

- Dechlorination of halogenated, nonsolvent wastes; and

- Metal concentrating techniques such as leaching, solvents extraction, ion exchange, precipitation, crystallization, and evaporation to treat dilute metal-bearing waste streams.

While not as common as onsite recycling, commercial offsite recycling is becoming increasingly popular. It is, in fact, favored by some industries, most notably primary metals and small quantity generators of lead-acid battery wastes. Offsite recycling usually occurs at mobile plants, centralized recovery facilities, or other commercial recycling plants. An increasingly popular commercial recycling service called batch tolling accepts hazardous wastes from a generator only for treatment and returns the recovered product to the same generator for re-use. The recycler charges a fee to the generator for recovery of the reclaimed material. Some small volume generators have actually pooled their resources and now operate centralized facilities, thereby reducing their capital and operating costs.

Certain wastes that are not useful to a generator may be desired by another industry as a raw material. Waste exchanges are often helpful in facilitating the transfer and recycling of these wastes. They serve as information clearinghouses (listing wastes that are available or desired), and can also act as brokers; occasionally they actually transport wastes from one plant to another. Available information suggests that approximately 20 to 30 percent of all wastes listed by exchanges are eventually recycled. Some of the wastes that are most often recycled include acids, alkalis, solvents, metal wastes, and corrosives.

4.2.4 Treatment

This topic is treated in considerable depth in Chapter 6.

4.3 Incentives and Disincentives for Waste Minimization in Developing Countries

With very limited government enforcement of air and water pollution control regulations (if these have even been promulgated) and with no effective regulations to control hazardous wastes, the costs associated with the disposal of hazardous waste in developing countries tend to be negligible. If the wastes are transported off site the disposal cost may simply amount to the lowest bid received from the local waste hauler who dumps it on uncontrolled waste sites or into swamps, streams or ponds as close as possible to waste generators. Therefore, there is usually little or no economic incentive for the waste generator to engage in waste minimization practices unless the waste contains a valuable material which can be readily recovered, for example: gold and silver.

The most important requisite for waste minimization is active enforcement of air and water pollution control and hazardous waste management regulations. Even without specific regulations requiring waste minimization and utilization of low waste technologies, the increased cost of waste disposal and limitations on certain unacceptable disposal practices will provide some incentives for waste minimization.

Other barriers to an effective waste minimization program at a particular plant may include (Turman):

- lack of awareness of the benefits of waste minimization;
- lack of technical staff;

- a "hands-off-the-process" attitude caused by fear of upsetting a product's quality;
- organizational inertia, for example, an "if-it-isn't-broken-don't-fix--it" attitude;
- internal politics of the organization, for example, an innovator may feel inhibited by a fear of lack of management's support; and
- an "it-can't-be-done" attitude--people may reject an innovative approach merely because it is outside their range of experience.

4.4 Waste Minimization Audits

One procedure which can help overcome some of the above barriers to identification and implementation of waste reduction plans is a Waste Minimization Audit (Fromm and Callahan 1986). The objectives of the audit are:

- to generate a comprehensive list of waste minimization measures or options applicable to a specific industrial process, and
- to rank all identified waste reduction options and to allow management to focus on options deserving further in-depth consideration.

A typical wastes minimization audit may involve some or all of the following steps:

- selection of the audit team,
- compilation by the audit team of a waste stream list for the facility with the associated flowrates,
- generation by the audit team of waste reduction options for each waste stream,
- ranking by the audit team of each compiled option in three categories: effectiveness, extent of current use, and application potential,
- preparation by the audit team of documentation in support of selected options,
- presentation, discussion and joint review with plant personnel of options and their rankings,
- analysis by the audit team of revised rankings, and
- final report preparation.

The above procedure is applicable to all three categories of waste minimization (recycling, treatment and source reduction). However, it originally was developed and tested for source reduction options only. Source reduction measures should be considered even when recycling or treatment options are given priority, because reducing the quantities of waste that are recycled or treated often means an increase in revenues (e.g., due to an increase of product yield and lower cost of treatment). Tables 4-3, 4-4, 4-5 and 4-6 contain checklists of water reduction measures compiled based on many process analyses and on experiences gained with waste minimization audits in a number of industries. Annex 4A gives some examples of cost/benefit analyses of waste minimization projects.

4.5 Evaluating Waste Minimization Project Costs and Benefits

Ideally, the relative worth of any proposed-capital project is developed by identifying and quantifying all project-related costs and savings. However, not all savings need be quantified in practice to demonstrate economic practicability.

In practice, the potential value of most capital projects has been established on the basis of savings in the following areas:

- raw materials costs
- utilities, labor, and maintenance costs, and
- enhanced revenues through creation of marketable by-products

Waste reduction projects can create savings in the same areas. However, the goal of reducing waste focuses attention on waste generation costs which were previously affected but not taken into consideration:

- disposal fees
- fees/taxes on generators per unit of waste(some states)
- transportation costs
- on-site waste storage and handling costs
- predisposal treatment costs
- permitting, reporting, and recordkeeping costs
- pollution and safety liabilities

For the purpose of evaluating a project to reduce waste quantities, some types of costs are larger and more easily quantified. These are disposal fees, transportation costs, predisposal treatment costs, raw materials costs, and operation and maintenance costs. It is suggested that savings in these costs be taken into consideration first because they will have a greater effect on project economics and will involve less effort to estimate reliably.

Disposal fees vary according to whether the wastes are solid or liquid, the type of container in which the waste arrives (drum or in bulk), and

TABLE 4-3

Waste Reduction Methodology Checklist: All Processes

All Waste Streams	1. Use higher purity materials 2. Use less toxic raw materials 3. Use non-corrosive materials 4. Convert from batch to continuous process 5. Tighter equipment inspection and maintenance 6. Better operator training 7. Closer supervision 8. Practice good housekeeping 9. Eliminate or reduce water use for spill cleanup 10. Implement proper equipment cleaning techniques 11. Use improved monitoring systems 12. Use pumps with double mechanical seals
Commodities Produced Continuously Examples:	Acrylonitrile, Epichlorophydrin, Petroleum Refining, 1,1,1-Trichloroethane, Trichloroethylene/Perchloroethylene, Vinyl Chloride Monomer
Heavy and Light Ends	1. Develop more selective catalyst 2. Optimize the reaction variables/reactor design 3. Use alternate process routes 4. Combust with heat (and HCI) recovery
Spent and Lost Catalyst	1. Develop tougher catalyst support 2. Use filter inside reactor freeboard 3. Regenerate and recycle spent catalyst
Equipment Cleaning Waste	1. Increase equipment drainage time 2. Use corrosion resistant materials 3. Agitate and/or insulate storage tanks 4. Re-examine need for chemical cleaning 5. Use nitrogen blanket to reduce oxidation 6. Use in-process HX cleaning devices
Leaks and Spills	1. Use bellow-sealed valves 2. Use canned (seal-less) pumps 3. Maximize use of welded vs. flanged pipe joints

TABLE 4-4

Waste Reduction Methodology Checklist: Commodities Produced in Batches

Examples:	Dyes, Inorganic Pigments, Paint, Agricultural Chemical formulation, Phenolic Resins, Wood Preserving
Material Handling	1. Segregate containers by prior contents 2. Use rinseable/recyclable drums 3. Purchase materials in bulk or in larger containers 4. Purchase materials in pre-weighed packages 5. Use pipeline for intermediate transfer
Reaction/Processing Step	1. Optimize the reaction variables/reactor design 2. Optimize the reaction addition method 3. Eliminate the use of toxic catalysts
Filtration and Washing	1. Employ efficient washing/rinsing methods 2. Eliminate the use of filter aids 3. Use countercurrent washing 4. Recycle spent washwater 5. Maximize sludge dewatering
Baghouse Fines	1. Increase use of dust suppression methods 2. Use wet instead of dry grinding 3. Schedule baghouse emptying
Off-Spec Product	1. Tighter control of reaction temperature 2. Reformulation of off-spec product
Equipment Cleaning	1. Install high pressure spray wash system 2. Alter production schedule 3. Use mechanical wipers on mix tanks 4. Clean mix tanks immediately after use 5. Use countercurrent rinse sequence 6. Recycle spent rinse water 7. Increase spent rinse settling time 8. Re-examine need for chemical cleaning 9. Dewater spent rinse sludge
Leaks and Spills	1. Use bellow-sealed valves 2. Install spill basins 3. Use canned (seal-less) pumps 4. Maximize use of welded vs. flanged pipe joints

TABLE 4-5

Waste Reduction Methodology Checklist: Manufacturing Operations

Examples:	Electroplating, Lithographic Printing, Metal Parts Cleaning, Metal Surface Treatment, Paint Application, Printed circuit Boards
Material Handling	1. Segregate containers by prior contents 2. Use rinseable/recyclable drum 3. Purchase materials in bulk or in larger containers 4. Purchase materials in pre-weighed packages
Solvent Cleaners	1. Install/operate cleaning tanks properly 2. Avoid cross-contamination of solvent 3. Avoid water contamination of solvent 4. Remove sludge continuously 5. Monitor solvent composition 6. Consolidate cold cleaning operations 7. Recycle spent solvent 8. Use plastic bead blasting for paint stripping
Alkaline/Acid Cleaners	1. Install/operate cleaning tanks properly 2. Avoid cross-contamination of solvent 3. Remove sludge frequently
Plating/Etching/ Surface Finishing Solution	1. Increase plating solution bath life 2. Use lower concentration plating bath 3. Use trivalent Cr in place of hexavalent: Cr 4. Use non-cyanide plating solutions 5. use in-line recovery techniques 6. Regenerate spent bath solutions 7. Segregate all waste streams 8. Inspect all parts for proper cleanliness
Rinse Water	1. Install/operate all rinse tanks properly 2. Use multiple rinse tanks 3. Install drain boards and drip tanks 4. Use fog nozzles and spray units 5. Agitate rinse bath 6. Use deionized water for rinsing 7. Recycle and reuse rinse water 8. Segregate all waste streams 9. Reclaim metal from rinse water
Paint Application	1. Use equipment with low overspray 2. Inspect all parts before painting
Leaks and Spills	1. Install splash guards and drip boards 2. Prevent tank overflow

TABLE 4-6

Replace Electroplating Chemicals

Electroplating is a common process used throughout the metals industry. Many electroplating process typically use chemicals containing high levels of cyanide, and hexavalent chromium which are highly toxic and pose disposal problems. Eletroplating chemicals are available which may replace chemicals containing chromium or cyanide.

Traditional Chemical	Substitute Chemical	Comments
Fire Dip (NaCN + H_2O_2)	Muriatic Acid with additives	Slower acting than fire dip.
Heavy copper	Copper Sulphate	Provides excellent throwing power with a bright, smooth, rapid finish. Requires good preplate cleaning. Eliminates carbonate build-up in tanks. Copper Cyanide likely still necessary for steel or tin-based metals.
Chromic Acid Cleaners	Sulphuric Acid and Hydrogen Peroxide	Non-chromium substitution. Non-fuming.
Chrome-based Anti-tarnish	Benzotriazole (0.1-1.0% solution in Methanol)	Non-chromium substitution. Extremely reactive, requires ventilation.
Cyanide Cleaner	Trisodium Phosphate or Ammonia	Good degreasing when hot and in an ultrasonic bath. Highly basic. May complex with soluble metals if used as an intermediate rinse between plating baths where metal ion may be dragged into the cleaner.
Tin cyanide	Acid tin chloride	Works faster and better

the quantity of waste disposed of. Table 4-7 gives some disposal fee ranges for solids and liquids in drum and bulk containers and for "lab packs." In the U.S., the drum prices shown are for larger quantities; disposal of small quantities of drums can cost up to three times as much per drum.

The cost of disposal site lab analysis of the waste is included as a disposal fee and appears in Table 4-7. Each shipment of waste to a management facility undergoes an analysis confirming the constituents of the waste shipment. Therefore, reducing the number of shipments will result in a savings.

Changes in raw materials cost, and operation and maintenance costs are process-specific. Maintenance cost may seem a minor item, but it may be quite substantial.

The remaining elements are usually secondary in their direct impact and should be included on an as-needed basis in fine-tuning the analysis. For example, calculating savings in waste storage and handling requires imputing a value for the waste inventory area and estimating the pre- and post-project costs of containerizing, labelling, and moving the waste. Changes in the administrative costs of regulatory compliance may occur only with a complete or near-complete reduction in waste volume.

Once cost savings have been calculated, the standard profitability measure can be computed. One of the more popular measures among engineers is the payback period. This measure has a strong intuitive appeal, especially for projects intended for reducing costs as opposed to increasing revenues. Capital funding for a project may well hinge on the ability of the project to generate positive margins long after payback and to realize an acceptable return on investment as measured by the internal rate of return.

One way of accounting for a reduction in an identified but not readily quantified risk is to ease the financial performance requirements for the project. The acceptable payback period may be lengthened to five years, or the required internal rate of return may be lowered. Such adjustments reflect recognition of elements which affect the risk exposure of the firm but which cannot be included in the analysis, such as lower potential liabilities. (These adjustments necessarily reflect the individual bias of the persons evaluating the project for capital funding.)

4.6 Requesting Approval for Funding of Waste Management Projects

Unfortunately, suggestions for process improvements are not always sold on their technical merits alone. As anyone involved in selling a product will say, presentation is the most important part of persuasion. A clear depiction of both tangible and intangible benefits may edge a project past its competitors for funding.

Persons willing to sponsor a waste reduction idea should exhibit a strong belief in their idea and confidence that it will work. In the interest of

TABLE 4-7

Typical Costs of Industrial Waste Management

Disposal	
Drum waste	
solids	$50 - $75/drum
liquids	$75 - $160/drum
Bulk waste	
solids	$150/cubic yard
liquids	$0.95 - $2.50/gallon
Lab packs	$100/drum
Analysis (at disposal site)	$200 - $300
Transportation	$65 - $85/hour @45 mph (round trip)

Source: Jacobs Engineering. 1986. Private Survey. Washington, D.C.

implementing their idea, they should be flexible enough to develop alternatives or modifications. They should also be committed to the point of doing substantial background/support work and anticipating possible problems with the idea's implementation. Above all, they should keep in mind that an idea won't sell if the sponsors aren't sold on it themselves.

The first step in securing approval is to call attention to the idea. Identify the problem, noting how long it has persisted and is likely to persist without action. For example, a lack of efficient control at one stage of a process could be the source of a waste quantity associated with a constantly increasing disposal cost. An effective identification of the problem would include an outline of the process step, the method currently used to control it, and the past and present costs to the company (e.g. in terms of excess raw material usage plus waste management costs) attributable to the inefficiency. After summarizing the problem, describe the proposed solution, and spell out the material benefits to the company of underwriting the solution. Also, try to enlist the support of management at this point, especially those with primary profit responsibility in your area. Keep in mind that the greater the organizational authority on the part of an idea's main backer(s), the more likely the idea will be implemented.

Knowing the level within the corporation that has approval authority for capital projects will help in enlisting the appropriate support. For example, smaller projects may be approved at the plant manager level, medium-size projects at the divisional vice-president level, and larger projects at the executive committee level.

While soliciting additional sponsorship of an idea, it is important to assemble solid analytical and documentary support. Evaluate the performance of the project under different sets of assumptions, taking care not to "fix" the results positively but to stay close to realistic expectations of future costs and prices, production quantities, tax laws, etc. Use a number of different performance measures (e.g., internal rate of return, net present value, payback period, the timing and amount of net cash flow, and so on). In presenting the analysis, briefly outline how it was done (i.e., what assumptions have been made, whether they are conservative, and how the project generates net cash flow). For example, if the project meets performance requirements even though current disposal fees were used in calculations covering the entire life of the project, point out that these fees can realistically be expected to rise in the future, resulting in even greater avoided costs than estimated. In summarizing your analysis, present all measures of performance to aid in the making of an informed decision. Also include a qualitative assessment of intangible costs or benefits occurring to the company and their effect on project desirability.

The analysis should include not only how much the project will cost and its expected performance, but also how it will be done. It is important to discuss:

- o whether the technology is established, with brief mention of successful applications;

- o the required resources (e.g., technical expertise and labor time) procurable in-house versus those that must be brought in;
- o estimated production downtime;
- o estimated construction period, and
- o how the performance of the project can be evaluated after it is implemented.

- In addition, think through the project for possible alternatives or modifications. Be flexible, as long as the original goal is not obscured. Discuss your idea in advance with operation and maintenance supervision to verify safety and efficient use of manpower. If your idea is for a change in production methods, be prepared to answer questions about the project's effect on the quality of the final product.

The size of the capital outlay and the level of authority needed for approval determine the extent of the necessary analysis and exploration. Decisions on larger capital outlays generally require a more thorough examination of project economic performance in the face of changing business conditions, increased competition, etc.

The next step is to develop a suggested course of action. Develop a detailed schedule for implementing the project, noting when it is most feasible for production downtime to occur, or suggest that the project be referred to an evaluation team. A team can review the project in the context of:

- o past experience in this area of operations;
- o what the market and the competition are doing;
- o how the implementation program fits into the company's overall business strategy; and
- o advantages of the proposal in relation to competing requests for capital funding.

An evaluation team made up of financial and technical personnel can ensure that a sponsor's enthusiasm is balanced by objectivity. In like manner, it can also serve to quell opposing "can't be done" or "if it isn't broken, don't fix it" attitudes which the idea could encounter in the organizational structure.

<u>Waste reduction projects generally involve improvements in process efficiency and/or reductions in operating costs of waste management</u>. Cost reduction is certainly an objective of any well-run business. However, the firm's capital resources may be prioritized towards enhancing future revenues (e.g., moving into new lines of business, expanding plant capacity, or acquiring other companies, rather than towards cutting

current costs). If this is the case, then a sound waste reduction project could be postponed until the next capital budgeting period. It is then up to the project sponsor to ensure that the project is reconsidered at that time.

4.8 Measurement of Waste Reduction

Having implemented waste minimization alternatives, it is important to document how successful the alternatives are. You may be able to measure your success by real benefits such as savings in the costs of waste disposal or raw materials (see Section 4.7). However, a more analytical approach to monitor waste reduction is to calculate percentage reduction based on production as follows:

$$WR = \left(\left[\frac{W1}{P1} - \frac{W2}{P2}\right] / \frac{W1}{P1}\right) \times 100\%$$

where,

WR= percentage of waste reduction
W1= waste generated in year "1"
P1= production output in year "1"
W2= waste generated in year "2"
P2= production output in year "2".

Example:

During 1985 a process generated 50,000 kilograms of waste and produced 500,000 kilograms of product. During 1986, some process modifications were made to reduce waste and improve efficiency, so that 60,000 kilograms of waste were generated, but the process produced 800,000 kilograms of product.

W1= 50,000 kg P1= 500,000 kg
W2= 60,000 kg P2= 800,000 kg

WR= (((50/60) - (500/800)) / (50/60) X 100%

WR= 25 percent waste reduction

4.9 References 4.1-4.8

Fromm, C. H., and M. Callahan. 1986. Waste reduction audit procedure: A Methodolgy for Assessment and Screening of Waste Minimization Options. Conference Precedings at the Hazardous Materials Control Research Institute, 4-6 March, Atlanta, Georgia.

Turman, C. E. Hazardous Waste Control Through Source Reduction.

4.10 Bibliography 4.1-4.8

Campbell, Monica E., and William M. Glen. 1982. Profit From Pollution Prevention - A Guide to Industrial Waste Reduction and Recycling. Toronto, Ontario, Canada: Pollution Probe Foundation.

Congress of the United States. 1986. Serious Reduction of Hazardous Waste. Washington, D.C.: Office of Technology Assessment.

Huisingh, Donald, et al. 1985. Profits of Pollution Prevention - A Compendium of North Carolina Case Studies in Resource Conversation and Waste Reduction. Pollution Prevention Pays Program. Raleigh, North Carolina: Department of Natural Resources and Community Development.

Huisingh, Donald, et al. 1985. Proven Profits from Pollution Prevention - Case Studies in Resource Conservation and Waste Reduction. Washington, D.C.: Institute for Self-Reliance.

Personal communication with Dr. Bill Bibb, Director of Research and Waste Management Division, Department of Energy, Oak Ridge Operations, Oak Ridge, Tennessee.

Sarokin, David J., et al. 1985. Cutting Chemical Wastes-What 29 Organic Chemical Plants are Doing to Reduce Hazardous Wastes. New York: INFORM.

Shanghai Resource Recovery and Utilization Company. 1984. Resource recovery and utilization in Shanghai, edited by C.G. Gunnerson. Paper presented at the International Resource Recovery and Utilization Seminar, November, Shanghai, Peoples Republic of China.

U.S. Department of Energy. 1986. Waste Minimization: Less is Better. Draft. Oak Ridge, Tennessee: Waste Management Technology Division.

U.S. Environmental Protection Agency. 1986. Meeting hazardous waste requirements for metal finishers. Seminar materials.

ANNEX 4A - Cost/Benefit Analyses of Waste Minimization

The following two examples illustrate how waste generators treat the cost/benefit analysis of waste minimizations strategies. In each case, the treatment of the prospect were developed first, and the analysis focused on the resulting economic feasibility.

Example 1. Secondary Solvent Recovery

A resin compounding operation uses 1,1,1-trichloroethane solvent for equipment cleaning. The present configuration uses a single stage atmosphere still for solvent recovery. The still recovers 92 percent of 3,455 lbs. of spent solvent per day. The still bottoms, which contain 20 percent solids by weight, are sent to a facility for solidification prior to landfilling.

The company is investigating the feasibility of adding a secondary recovery system to produce a nearly solvent-free, "dry" cake consisting of filler solids and polymerized resin.

The current and planned solvent recycling scheme is depicted in the lock flow diagram in Figure 4A-1. For secondary recovery, a scraped-drum evaporator is being investigated. The equipment list with pertinent technical and cost information is presented in Table 4A-1. Important operating cost parameters are presented in Table 4A-2.

A fixed-cost discounted cash-flow analysis, which assumes no inflation and no change in the real relationships among costs, results in an internal rate of return of 28 percent and a payback period of 3.3 years for this project. The present Accelerated Cost Recovery Schedule[1] (ACRS) is assumed to apply for equipment depreciation. The half of the installed cost is assumed to be met with retained earnings; the other half is financed over 5 years at a real cost of capital of 6.67 percent (12 percent nominal rate of interest with 5 percent inflation). The unit has an assumed operating life of 10 years and no salvage value. Project cash flows under these assumptions are displayed in Table 4A-3.

Table 4A-4 shows project cash flows under the same set of assumptions, but with no account taken of savings through avoided disposal costs. The internal rate of return has fallen to 8.7 percent, and the payback period has increased to nearly six years. On the basis of recovered solvent alone, there is apparently little justification for recovering the 8 percent of solvent remaining after distillation. However, the presence of significant avoided

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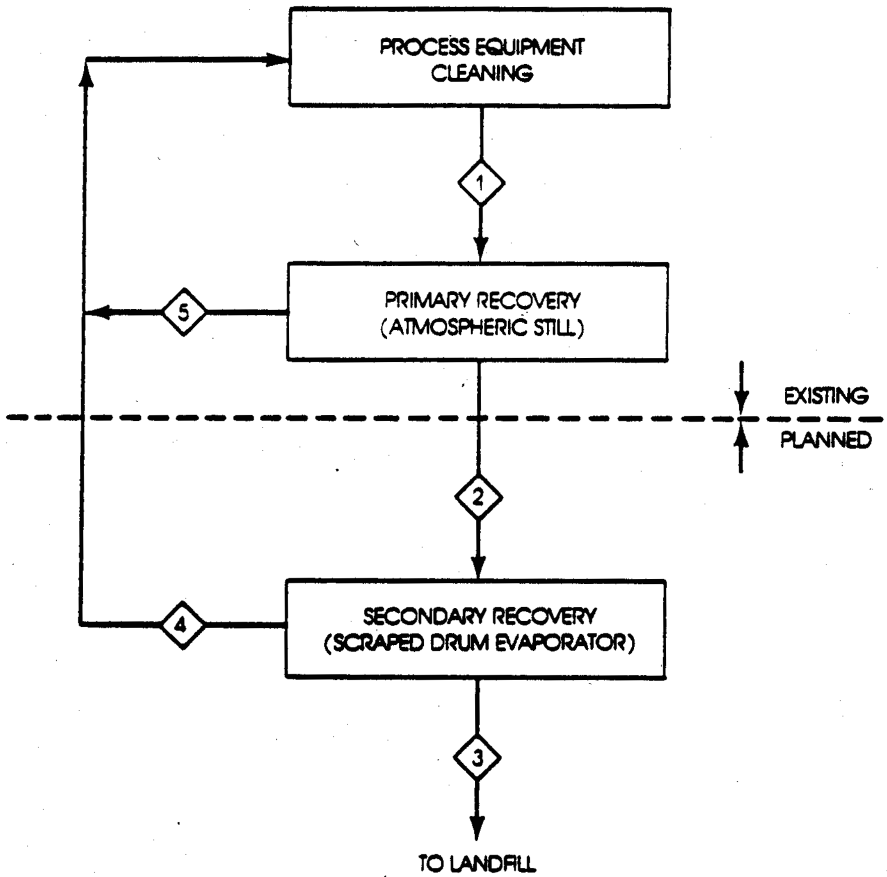
1/ Under ACRS, the equipment portion of a capital investment may be completely depreciated over 5 years beginning with the first (whole or partial) year of operation. The yearly allowable amounts are 15, 21, 21, 21, and 22 percent.

FIGURE 4A-1

Block Flow Diagram and Mass Balance for Solvent Recovery System



Stream	1	2	3	4	5
Solvent	3,455	270	27	243	3,185
Resin	30	30	30	0	0
Filler	76	76	76	0	0
Total, lb/day	3,551	376	133	243	3,185

Source: Butler, D., C.T. Timm, C. Fromm. 1986. Justification of Waste Reduction Projects by Comprehensive Cost-Benefit Analysis. Washington, D.C.: Jacobs Engineering Group, Inc.

TABLE 4A-1

Secondary Solvent Recovery System
Equipment Data and Cost Information

Service	Description	Delivered Cost
Feed Pump	10 gph, gear type 1/4 HP, Hastelloy C casing, Teflon gears	$ 620
Scraped Drum Evaporator	10,000 BTU/hr, steam heated 1 HP drive, double 6"Ø x 8" drums (titanium), Teflon coated housing	$34,000
Condenser	10,000 BTU/hr, 3.5 ft^2 graphite block	$ 3,000
Receiver Tank	100 gal capacity	$ 1,800
Mixer	1/4 HP	$ 600
Discharge Pump	10 gpm, 3/4 HP, Teflon-coated casing and impeller magnetic-coupled	$ 950
		$40,970
Piping and Instrumentation		$ 2,000
Engineering, Design and Procurement (in-house)		8,600
Installation Labor and Materials		12,000
DEPRECIABLE FIXED CAPITAL INVESTMENT		$63,570
Allowance for Unforseen/Cash Requirements		6,000
TOTAL CAPITAL COST		$69,570

Source: Butler, D., C. Timm, and C. Fromm. 1986. Justification of Waste Reduction Projects by Comprehensive Cost-Benefit Analysis. Washington, D.C.: Jacobs Engineering Group, Inc.

TABLE 4A-2

Secondary Solvent Recovery System
Summary of Operating Parameters and Costs

Element	Rate	Unit Cost	Annual Cost
Solvent Recovered	60,750 lb/yr	$ 0.38/lb	$23,085
Inhibitor Makeup	1,814 lb/yr	$ 1.02/lb	1,850
Utilities (includes steam, cooling water and electricity)			240
Operating Labor and Supervision	1.5 hr/day	$16,00/hr (burdened)	6,000
Maintenance and Spare Parts	6.0% of capital cost		4,250
Waste Disposal			
without secondary recovery	94,000 lb/yr	$ 0.15/lb	$14,100
with secondary recovery	33,250 lb/yr	$ 0.04/lb	$ 1,330

Source: Butler, D., C. Timm, and C. Fromm. 1986. Justification of Waste Reduction Projects by Comprehensive Cost-Benefit Analysis. Washington, D.C.: Jacobs Engineering Group, Inc.

TABLE 4A-3

<u>Scraped-drum Evaporator</u>

	1986 (1)	1987 (2)	1988 (3)	1989 (4)	1990 (5)	1991 (6)	1992 (7)	1993 (8)	1994 (9)	1995 (10)
Gross savings:										
Solvent recovered	$ 11538	$ 23075	$ 23075	$ 23075	$ 23075	$ 23075	$ 23075	$ 23075	$ 23075	$23075
Avoided disposal	6388	12775	12775	12775	12775	12775	12775	12775	12775	12775
Total savings	$ 17925	$ 35850	$ 35850	$ 35850	$ 35850	$ 35850	$ 35850	$ 35850	$ 35850	$ 35850
Operating costs:										
Feedstock/power	$ 100	$ 200	$ 200	$ 200	$ 200	$ 200	$ 200	$ 200	$ 200	$ 200
Feedstock/steam	20	40	40	40	40	40	40	40	40	40
Inhibitor	925	1850	1850	1850	1850	1850	1850	1850	1850	1850
Labor	3000	6000	6000	6000	6000	6000	6000	6000	6000	6000
Maintenance	2125	4250	4250	4250	4250	4250	4250	4250	4250	4250
Total cost	$ 6170	$ 12340	$ 12340	$ 12340	$ 12340	$ 12340	$ 12340	$ 12340	$ 12340	$ 12340
Operating income	$ 11755	$ 23510	$ 23510	$ 23510	$ 23510	$ 23510	$ 23510	$ 23510	$ 23510	$ 23510
Less:										
Cost of working capital	179	359	359	359	[illegible]	359	359	359	359	359
Depreciation	9359	13102	13102	13102	13726	0	[illegible]	0	0	0
Interest expense	2131	1710	1267	789	281	0	0	0	0	0
Taxable income	$ 86	$ 8340	$ 8783	$ 9261	$ 9145	$ 23152	$ 23152	$ 23152	$ 23152	$ 23152
Less:										
Tax liability	43	4170	4391	4630	4672	11576	11576	11576	11576	11576
Post tax income	$ 43	$ 4170	$ 4391	$ 4630	$ 4572	$ 11576	$ 11576	$ 11576	$ 11576	11576
Add back depreciation	9359	13102	13102	13102	13726	0	0	0	0	0
Add back tax credits	6567	0	0	0	0	0	0	0	0	0
Post tax cash flow	$ 15969	$ 17272	$ 17493	$ 17732	$ 18298	$ 11576	$ 11576	$ 11576	$ 11576	$ 11576
Cumulative cash flow	$ 15969	$ 33241	$ 50734	$ 68466	$ 86764	$ 98340	$109916	$121492	$133067	$144643

TABLE 4A-3 (continued)

	1986 (1)	1987 (2)	1988 (3)	1989 (4)	1990 (5)	1991 (6)	1992 (7)	1993 (8)	1994 (9)	1995 (10)
Less:										
Equity payment	34785	0	0	0	0	0	0	0	0	0
Principal repayment	6070	6491	6[illegible]34	7412	7920	0	0	0	0	0
Net cash flow	$-24885	$ 10781	$ 10560	$ 10321	$ 10379	$ 11576	$ 11576	$ 11576	$ 11576	$ 11576
Real cumulative cash flow	$-24885	$-14104	$ -3545	$ 6776	$ 17155	$ 28731	$ 40306	$ 51882	$ 63458	$ 75034
For the internal rate of return (IRR)										
Operating income	$ 11755	$ 23510	$ 23510	$ 23510	$ 23510	$ 23510	$ 23510	$ 23510	$ 23510	$ 23510
Cost of working capital	179	359	359	359	359	359	359	359	359	359
Depreciation	9359	13102	13102	13102	13726	0	0	0	0	0
Taxable income	$ 2217	$ 10050	$ 10050	$ 10050	$ 9426	$ 23152	$ 23152	$ 23152	$ 23152	$ 23152
Less tax liability	1109	5025	5025	5025	4713	11576	11576	11576	11576	11576
After tax income	$ 1109	$ 5025	$ 5025	$ 5025	$ 4713	$ 11576	$ 11576	$ 11576	$ 11576	$ 11576
Add back depreciation	9359	13102	13102	13102	13726	0	0	0	0	0
Add back tax credits	6567	0	0	0	0	0	0	0	0	
Post tax net cash flow	$ 17035	$ 18127	$ 18127	$ 18127	$ 18439	$ 11576	$ 11576	$ 11576	$ 11576	$ 11576

Internal rate of return = 28.48%
Payback period = 3.3 years

Source: Butler, D., C. Timm, and C. Fromm. 1986. Justification of Waste Reduction Projects by Comprehensive Cost-Benefit Analysis. Washington, D.C.: Jacobs Engineering Group, Inc.

TABLE 4A-4

Evaporator w/o Disposal Savings

	1986 (1)	1987 (2)	1988 (3)	1989 (4)	1990 (5)	1991 (6)	1992 (7)	1993 (8)	1994 (9)	1995 (10)
Gross savings:										
Solvent recovered	$ 11538	$ 23075	$ 23075	$ 23075	$ 23075	$ 23075	$ 23075	$ 23075	$ 23075	$ 23075
Avoided disposal	0	0	0	0	0	0	0	0	0	0
Total savings	$ 11538	$ 23075	$ 23075	$ 23075	$ 23075	$ 23075	$ 23075	$ 23075	$ 23075	$ 23075
Operating costs:										
Feedstock/power	$ 100	$ 200	$ 200	$ 200	$ 200	$ 200	$ 200	$ 200	$ 200	$ 200
Feedstock/steam	20	40	40	40	40	40	40	40	40	40
Inhibitor	925	1850	1850	1850	1850	1850	1850	1850	1850	1850
Labor	3000	6000	6000	6000	6000	6000	6000	6000	6000	6000
Maintenance	2125	4250	4250	4250	4250	4250	4250	4250	4250	4250
Total cost	$ 6170	$ 12340	$ 12340	$ 12340	$ 12340	$ 12340	$ 12340	$ 12340	$12340	$ 12340
Operating income	$ 5368	$ 10735	$ 10735	$ 10735	$ 10735	$ 10735	$ 10735	$ 10735	$10735	$10735
Less:										
Cost of working capital	115	231	231	231	231	231	231	231	231	231
Depreciation	9359	13102	13102	13102	13726	0	0	0	0	0
Interest expense	2131	1710	1267	789	281	0	0	0	0	0
Taxable income	$ -6237	$ -4308	$ -3865	$ -3387	$ -3503	$ 10504	$ 10504	$ 10504	$ 10504	$ 10504
Less:										
Tax liability	-3119	-2154	-1932	-1693	-1761	5252	5252	5252	5252	5252
Post tax income	$ -3119	$ -2154	$ -1932	$ -1693	$ -1761	$ 5252	$ 5252	$ 5252	$ 5252	$ 5252
Add back depreciation	9359	13102	13102	13102	13726	0	0	0	0	0
Add back tax credits	6567	0	0	0	0	0	0	0	0	0
Post tax cash flow	$ 12807	$ 10948	$ 11170	$ 11409	$ 11975	$ 5252	$ 5252	$ 5252	$ 5252	$ 5252
Cumulative cash flow	$ 12807	$ 23755	$ 34925	$ 46334	$ 58308	$ 63560	$ 68812	$ 74065	$ 79317	$ 84569

TABLE 4A-4 (continued)

	1986 (1)	1987 (2)	1988 (3)	1989 (4)	1990 (5)	1991 (6)	1992 (7)	1993 (8)	1994 (9)	1995 (10)
Less:										
Equity payment	34785	0	0	0	0	0	0	0	0	0
Principal repayment	6070	6491	6934	7412	7920	0	0	0	0	0
New cash flow	$-28047	$ 4458	$ 4236	$ 3997	$ 4055	$ 5252	$ 5252	$ 5252	$ 5252	$ 5252
Real cumulative cash flow	$-28047	$-23590	$-19354	$-15357	$-11302	$ -6049	$ -797	$ 4455	$ 9707	$ 14959
For the internal rate of return (IRR)										
Operating income	$ 5368	$ 10735	$ 10735	$ 10735	$ 10735	$ 10735	$ 10735	$ 10735	$ 107535	$ 10735
Cost of working capital	115	231	231	231	231	231	231	231	231	231
Depreciation	9359	13102	13102	13102	13726	0	0	0	0	0
Taxable income	$ -4106	$ -2598	$ -2598	$ -2598	$ -3222	$ 10504	$ 10504	$ 10504	$ 10504	$ 10504
Less tax liability	-2053	-1299	-1299	-1299	-1611	5252	5252	5252	5252	5252
After tax income	$ -2053	$ -1299	$ -1299	$ -1299	$ -1611	$ 5252	$ 5252	$ 5252	$ 5252	$ 5252
Add back drepreciation	9359	13102	13102	13102	13726	0	0	0	0	0
Add back tax credits	6567	0	0	0	0	0	0	0	0	0
Post tax net cash flow	$ 13873	$ 11803	$ 11803	$ 11803	$ 12115	$ 5252	$ 5252	$ 5252	$ 5252	$ 5252

Internal rate of return = 8.66%
Payback period = 5.9 years

Source: Butler, D., C. Timm, and C. Fromm. 1986. Justification of Waste Reduction Projects by Comprehensive Cost-Benefit Analysis. Washington, D.C.: Jacobs Engineering Group, Inc.

disposal costs makes the difference between a marginal (probably unacceptable) project and a project that can compete with other projects for capital funding.

Example 2. Retubing of Heat Exchanger

A paper mill facility is using a 8200-ft2 tubular-exchanger as an evaporator for the forced circulation black liquor evaporator service. Severe fouling conditions dictate daily water washings and an average of four shutdowns a year for a hydroblasting (high pressure water jet cleaning) of tubes.

The company has tested electropolished tubes in this service. The test data indicate that while daily washings may still be necessary, the cleaning frequency can be reduced to once a year. The company is now set to evaluate the economic feasibility of retubing. Initial analyses are based on cleaning cost savings alone (i.e., they ignore savings in steam and pumping costs). Since there is a spare unit, there is no loss of production. Basic parameters are summarized in Table 4A-5.

As in Example 1, a fixed-cost discounted cash-flow analysis is conducted to determine the internal rate of return and payback period for this project. Assumptions about project financing are the same: half of the money is borrowed over 5 years at a real rate of interest of 6.67% and the other half is covered by the company's retained earnings. Again, the Accelerated Cost Recovery Schedule (ACRS) is assumed in effect for equipment depreciation, and the investment tax credit is taken. The new tubes are assumed to last 15 years before requiring replacements. Salvage value is assumed to be zero.

The cash flows generated by the proposed retubing project are found in Figure 3. Under the stated assumptions, the project has an internal rate of return of 9.94% and a payback period of 6.3 years. The real cumulative cash flow does not become positive until the ninth year. These are indications of a marginal project. Based on this analysis the acceptability of retubing the heat exchanger would to some degree depend on the ability of the facility to absorb the deficit cash generation until the project's later years. However, inclusion of avoided steam and pumping costs should enhance the project economics considerably. In addition, intangibles such as reduced worker exposure have not been evaluated. On the basis of avoided cleaning costs alone, this project comes close to being feasible. (See Table 4A-4, Table 4A-5 and Table 4A-6).

Source for Annex 4A: Butler, D., C. Timm, and C. Fromm. 1986. Justification of Waste Reduction Projects by Comprehensive Cost-Benefit Analysis. Washington, D.C.: Jacobs Engineering Group, Inc.

TABLE 4A-5

Retubing of Heat Exchanger
Summary of Technical and Economic Parameters

Parameter	Description
Heat Exchanger	Long tube vertical evaporator, 8200 ft^2, fixed tubesheet, 800 tubes, 1.5" OD X 0.059" wall, 26 ft-long bundle, 316 SS.
Cost to Retube	$80,000 Includes cost of material (316 stainless electropolished tubes: Tubec tubes - Avesta Stainless Co.), shop and field labor, freight.
Cost of Cleaning (single occurrence)	$4,200 Includes shutdown, disassembly and setup, hydroblasting, re-assembly and cleanup, waste handling and general/administrative indirect costs. The wastes are incinerated on-site using a conventional kraft mill recovery furnace.
Savings in Steam	See Note
Savings in Pumping Costs	See Note

Note: These costs were not included in the analysis in order to isolate the effect of cleanup costs. Energy cost savings can be substantial and must be included in a comprehensive project analysis.

Source: Butler, D., C. Timm, and C. Fromm. 1986. Justification of Waste Reduction Projects by Comprehensive Cost-Benefit Analysis. Washington, D.C.: Jacobs Engineering Group, Inc.

TABLE 4A-6

Retubing with Electropolished Tubes

	1986 (1)	1987 (2)	1988 (3)	1989 (4)	1990 (5)	1991 (6)	1992 (7)	1993 (8)	1994 (9)	1995 (10)
Gross savings:										
Disassembly	$ 638	$ 2550	$ 2550	$ 2550	$ 2550	$ 2550	$ 2550	$ 2550	$ 2550	$ 2550
Hydroblasting	1200	4800	4800	4800	4800	4800	4800	4800	4800	4800
Assembly	563	2250	2250	2250	2250	2250	2250	2250	2250	2250
Filtration	188	750	750	750	750	750	750	750	750	750
Disposal	0	0	0	0	0	0	0	0	0	0
Indirects	563	2250	2250	2250	2250	2250	2250	2250	2250	2250
Total Savings	$ 3150	$ 12600	$ 12600	$ 12600	$ 12600	$ 12600	$ 12600	$ 12600	$ 12600	$ 12600
Operating income	$ 3150	$ 12600	$ 12600	$ 12600	$ 12600	$ 12600	$ 12600	$12600	$ 12600	$ 12600
Less:										
Cost of working capital	32	126	126	126	126	126	126	126	126	126
Depreciation	11748	16448	16448	16448	17231	0	0	0	0	0
Interest expense	1464	2526	1963	1366	709	99	0	0	0	0
Taxable income	$-10094	$ -6500	$ -5937	$ -5330	$ -5466	$ 12375	$ 12474	$ 12474	$ 12474	$ 12474
Less:										
Tax liability	-5047	-3250	-2968	-2665	-2733	6188	6237	6237	6237	6237
Post tax income	$ -5047	$ -3250	$ -2968	$ -2665	$ -2733	$ 6188	$ 6237	$ 6237	$ 6237	$ 6237
Add back depreciation	11748	16448	16448	16448	17231	0	0	0	0	0
Add back tax credits	8244	0	0	0	0	0	0	0	0	0
Post tax cash flow	$ 14946	$ 13198	$ 13479	$ 13783	$ 14498	$ 6188	$ 6237	$ 6237	$ 6237	$6237
Cumulative cash flow	$ 14946	$ 28144	$ 41623	$ 55406	$ 69903	$ 76091	$ 82328	$ 88565	$ 94802	$101039
Less:										
Equity payment	45600	0	0	0	0	0	0	0	0	0
Principal repayment	3911	8224	8787	9394	10041	5276	0	0	0	0
Net cash flow	$-34565	$ 4974	$ 4692	$ 4389	$ 4457	$ 911	$ 6237	$ 6237	$ 6237	$ 6237

TABLE 4A-6 (continued)

	1986 (1)	1987 (2)	1988 (3)	1989 (4)	1990 (5)	1991 (6)	1992 (7)	1993 (8)	1994 (9)	1995 (10)
Real cumulative cash flow	$-34565	$-29591	$-24899	$-20510	$-16053	$-15142	$ -8905	$ -2668	$ 3569	$ 9806
For the internal rate of return (IRR)										
Operating income	$ 3150	$ 12600	$ 126000	$ 126000	$ 12600	$ 12600	$ 12600	$ 12600	$ 12600	$ 12600
Cost of working capital	32	126	126	126	126	126	126	126	126	126
Depreciation	11748	16448	16448	16448	17231	0	0	0	0	0
Taxable income	$ -8630	$ -3974	$ -3974	$ -3974	$ -4757	$ 12474	$ 12474	$ 12474	$ 12474	$ 12474
Less tax liability	-4315	-1987	-1987	-1987	-2378	6237	6237	6237	6237	6237
After tax income	$ -4315	$ -1987	$ -1987	$ -1987	$ -2378	$ 6237	$ 6237	$ 6237	$ 6237	$ 6237
Add back depreciation	11748	16448	16448	16448	17231	0	0	0	0	0
Add back tax credits	8244	0	0	0	0	0	0	0	0	0
Post tax net cash flow	$ 15678	$ 14461	$ 14461	$ 14461	$ 14852	$ 6237	$ 6237	$ 6237	$ 6237	$ 6237

Internal rate of return = 9.94%
Payback period = 6.3 years

Source: Butler, D., C. Timm, and C. Fromm. 1986. Justification of Waste Reduction Projects by Comprehensive Cost-Benefit Analysis. Washington, D.C.: Jacobs Engineering Group, Inc.

ANNEX 4B - Examples of Successful Waste Minimization Programs

Examples of Successful Waste Minimization Programs

- Allied Chemical Corporation of Metropolis, Illinois, recycled its waste calcium fluoride into the production of anhydrous hydrofluoric acid at another facility. The project required a capital outlay of $4.3 million and resulted in the recycling of 1,000 cubic yards per month. Annual cost savings came to $1.0 million, giving a project payback of about 4.5 years (Huisingh et al. 1985).

- Borden Chemical Co. of Fremont, California, was able to reduce its phenolic resin waste by 95 percent through filter rinse and reuse of phenolic resin from the rinsate. The company also implemented tank rinsing in 2 stages and set up a program to instruct operating personnel about the importance of waste reduction. Capital outlay was minimal (Huisingh et al. 1985).

- Texagulf of Saltville, Virginia, makers of defluorinated phosphate, installed a closed-loop recycling system to remove inorganic fluorides from its process water discharge stream. The system reduced wastewater volume by 280,000 gallons per day, resulting in an annual [illegible]t savings of $2 million and a payback in one year (Huisingh et al. 198[illegible]

- Intel Corporation of Albuquerque, New Mexico, installed an in-line acid neutralization unit for their hydrofluoric acid waste. The company realized a payback in 8 months by avoiding the generation of 601 tons of hydrofluoric acid waste which they had previously shipped to California for treatment and disposal (Jacobs Engineering 1986).

- Monsanto Corp. in Baxley, Georgia, was able to find a market for their sodium hydroxide waste as a chemical neutralizer. No longer burdened with the cost disposal, the company is saving $400,000 annually (Sobrino 1985).

- United Globe Corporation, a furniture manufacturer in Lexington, North Carolina, turned in 1982 to incineration of process wastewater solids and solvent wastes to produce process steam. The project involved an outlay of $1.5 million and paid back in less than 3 years on an annual savings of $905,000 (Huisingh et al. 1985).

- Lumberton Dyeing and Finishing Co., a textile firm in Lumberton, North Carolina, modified their process by installing a counterflow heat recovery system to heat process water with exhaust and to precipitate out hydrocarbon pollutants. The system had a payback of five months (Campbell and Glenn 1982).

- Numerous solvent-using companies have installed distillation units and carbon adsorption systems to reduce solvent waste and vapor emissions. Some also burn spent solvents for heat recovery. In all, 22 of the 116 companies examined practiced a form of solvent recovery/reuse. Riker Laboratories of Northridge, California, a pharmaceuticals division of 3M Corporation, was able to eliminate 24 tons of their organic-based solvent waste per year by modifying their process to accept water-based solvent for tablet coating (Garrison 1985). Companies such as Fisher Body of Lansing, Michigan, and Caterpillar Tractor Co. in Mossville, Illinois, have significantly reduced solvent waste by switching to electrocoating and water-borne paints (Campbell and Glenn 1982).

- At DuPont's petrochemicals facility in Victoria, Texas, the use of a new process to produce adiponitrile (ADN) eliminated one intermediate. Wastewater was reduced by 50 percent (400 gallons per minute).

- DuPont's petrochemicals facility in Sabine, Texas, practices distillation of waste for recovery of chemical inputs to other processes and subsequently incinerates the distillation residues to achieve an 80 percent reduction in hazardous waste. The facility also recovers and sells alumina instead of disposing of it off site.

- At DuPont's Cape Fear plant, cobalt is recovered from one process for reformulation as a catalyst in the dimethyl terephthalate (DMT) manufacturing process. In addition, raw materials are recovered out of by-product streams from DMT production, and off-gases are burned to generate heat. The facility has also switched to the use of safer solvents.

  - Other measures taken by DuPont include (League of Women Voters of Massachusetts 1985):

  - Sale of waste ferric chloride instead of ocean dumping

  - Pre-treatment of waste aluminum oxide for sale to recycler

  - Conversion of waste HCl into chlorine

- Type of industry - Automobile Mirror Manufacturer
  Name - Dominion Automotive Industries, Inc.
  Location - Sevierville, Tennessee

  Description - Dominion Automotive Industries manufactures mirrors for automobiles and small trucks. Prior to an analysis of their production process and subsequent modifications, they were prohibited from disposing of their waste water in the local publicly owned waste water treatment plant because of the hazardous constituents (organics and heavy metals). The company was spending approximately $60,000 US per year to transport and dispose of waste water.

  Waste Reduction Methods - House-keeping methods were improved to keep the organic contaminants out of the waste water stream. Organic solvents, primarily methylene chloride are shipped offsite for solvent reprocessing. An ultrafiltration unit and ion exchange unit were installed to remove metals and other contaminants.

  Waste Reduction Costs - $30,000 US

  Payback period - 2 years

Annual Savings - $50,000

Other benefits - Dominion has segregated its hazardous waste from other non-hazardous waste streams. The threat of environmental contamination is significantly lowered and the long term liability to the company is all but eliminated.

Source - Personal Communication Mr. Fred Valentich, Environmental Manager, Dominion Automotive (Garrison 1985).

o Type of Industry - Dye and Epoxy Resin
Name - CIBA-GEIGY
Location - Toms River, New Jersey

Description - The Toms River CIBA-GEIGY Plant has the capacity to produce about 500 different products including dyes and epoxy resins. The plant has the capacity to produce 220,000 and 105,000 pounds per day of dyes and resin respectively. The plant used a significant number of organic solvents in its manufacturing process as evidenced by over 100 air permits filed with the New Jersey Department of Environmental Protection. In its anthraquinone dyes manufacturing process the company used a standard process which relied on mercury as a catalyst. About 2,280 pounds of mercury catalyst ended up in waste streams, the most significant of which was 39,500 lbs of contaminated material.

Waste Reduction Methods - The Toms River Plant has instituted many waste reduction projects but one stands out as superior. In 1983 a new process was instituted at the plant which eliminated the need for mercury as a catalyst in the manufacturing process. This process was developed by the corporation's research staff in Switzerland.

Waste Reduction Costs - Not Reported

Payback Period - Not Reported

Annual Savings - Not Reported

Other Benefits - Mercury is a particularly toxic and persistent chemical in the environment. Elimination of the use of the chemical is a major benefit to the environment and public health.

Source - INFORM (Campbell and Glenn 1982).

o Type of Industry - Power Tool Manufacturer
Name - Emerson Electric Company
Location - Murphy, North Carolina

Description - The Emerson Electric Company produces stationary power tools. Key steps in the finishing of the products are painting and metal finishing. Manufacturing lines of interest include: an electrostatic paint line, zinc electroplating, a paint stripping line and parts washing.

Waste Reduction Methods - Emerson Electric installed a modern automated electroplating process and replaced their organic solvent-based paint system with an aqueous-based anodic electrostatic immersion system. Because they installed the water-based system, Emerson has been able to recover and reuse paint. Cost for raw materials has decreased $600,000 US per year. The company has also improved its house-keeping and general waste management practices.

Waste Reduction Costs - $1,254,000

Payback Period - 1.2 years

Annual Savings - $998,000

Other Benefits - Emerson has implemented a wide variety of waste reduction methods. Invested costs are recovered in little over a year and the financial benefits will continue to accrue thereafter.

Source - North Carolina Pollution Prevention Pays Program (Kohl, Moses, and Triplett 1984).

- Type of Industry - U.S. Government-Owned Research and Production Facility Name - Department of Energy/Oak Ridge Operations (DOE/ORO) Location - Oak Ridge, Tennessee.

Description - The Department of Energy Facilities at Oak Ridge historically have produced large volumes of both radioactive and mixed radioactive and hazardous wastes. Rather than continuing to ignore waste production as had always been the case in the past, the DOE site managers recently instituted a waste reduction program which penalized generating organizations for producing waste.

Waste Reduction Methods - In 1985 a cost recovery system was instituted by charging the manufacturing and research organization $1.50 per gallon of waste. This fee increased to $3.00 in October 1986. The facility has implemented numerous waste reduction techniques but the results of only two are reported here. In 1982 a process was developed to recover silver from used photographic chemicals. The process has been refined and scaled up to production level. Second, at one of the machining facilities a non-hazardous water-based coolant (propylene glycol and borax) was substituted for an organic solvent-based coolant (tetrachloroethylene and mineral oil).

Waste Reduction Costs - unavailable

Payback Period - unavailable

Annual Savings - $60,000 (for silver recovery only)

Other Benefits - The recent emphasis by this US Government Department on waste reduction is an indication that the government is willing to set an example particularly for small and medium-sized industries which are still unaware of the economic and environmental benefits.

Source - Waste Management Technology Document (Draft) (Huisingh, et al. 1985) and personal communication with Dr. Bill Bibb, Director of Research and Waste Management Division DOE/ORO (Kohl, Moses, and Triplett 1984).

o Type of Industry - Leather Tanning
Name - Not Reported
Location - Italy

Description - Leather tanning is an age-old process which has continued to improve. The application of new treatment technologies has improved the efficiency of tanning even more. In summary, the tanning process involves:

1. soaking with salt to prevent bacterial degradation;
2. fleshing to remove unwanted remaining flesh and fat;
3. unhairing using a line and sodium sulphide solution; and
4. tanning using either the vegetable, chrome, or alum process.

Waste Reduction Method - This relates only to the unhairing operation and recovery of salt and sulphide. Ultrafiltration is the technology selected to recover the make-up materials in this bath. The s[illegible] and sulphides pass through a membrane while the contaminants such as solids, proteins and oils do not. The membrane has a projected useful life of about three years.

Waste Reduction Costs - $80,000 (1979)

Payback Period - 2.93 years (including accelerated equipment depreciation)

Annual Savings - New uses are being developed for the waste proteins and solids generated in the tanning process. Use for these materials range from foodstuffs to cosmetics.

Source - Pollution Probe Foundation (League of Women Voters of Massachusetts 1985)

o Type of Industry - Auto Engine Remanufacture
Name - Vulcan Automotive Equipment Ltd
Location - Vancouver, B.C., Canada

Description - Vulcan Automotive remanufactures used auto engines. As part of the remanufacturing process, they clean the old block and parts prior to reconstruction. The old cleaning process which they used involved the wet application of caustic soda followed by scrubbing and rinsing. The caustic sludge was stored on-site in tanks prior to off-site disposal. Costs for disposal ranged from $15,000 to $18,000 per year.

Waste Reduction Methods - The company installed a new parts-cleaning system. The two step process involves heating the metal parts to remove the volatile organic oil and greases. Second, the parts are sprayed with a high velocity stream of aluminum shot. The new process is more efficient and less costly than the alkaline-based process.

Waste Reduction Costs - $75,000 US

Payback Period - 2 years

Annual Savings - $41,000 US

Other Benefits - The installation of the new dry washing process has eliminated the need for approximately 48,000 gal/yr of water as well as reduced the manpower requirements for the washing process.

Source - Institute for Local Self-Reliance (Huisingh, et al. 1985).

o Type of Industry - Electroplating
Name of Process - Providence Method
Location - Many

Problem - The majority of contaminated waste from electro-plating facilities is caused by drag out. This leads to the generation of large quantities of hazardous waste, but also to high treatment costs and high raw materials cost. Typically in a batch system, drag-out can account for between 50 per cent and 90 per cent of the chemical raw material use.

Solution - Process modification designed to remove the majority of the drag-out in one or two counter-flow tanks not connected to the final flowing rinse tank resulted in final effluent which required at most pH adjustment and which could then be discharged to sewer. Volume of waste requiring batch treatment was reduced by up to 99 per cent.

Reduction in waste treatment costs - US $60,000 assuming conventional treatment method water flow of 36,000 gpd reduced to 10,000 gpd.

Other benefits - up to 50 per cent saving in process chemicals.

Source - USEPA - Meeting Hazardous Waste Requirement for Metal Finishers (1986).

The cases cited here may now be taken for granted by experienced chemical engineers as common yield-improvement measures, but each one has contributed to significant waste reduction while improving profitability.

Of the more than 115 cases of waste reduction which were examined, 29 included data on payback period. This information is summarized in Table 4B-1. As seen in the table, more than 80 percent of the 29 cases had payback periods of less than 3 years, which indicates fairly rapid capital recovery and suggests solid profitability. Of course, waste reduction could be an unprofitable undertaking. One case was found where a process modification resulted in a net annual cost to the company. However, because the modification helped the company achieve regulatory compliance and improve its community relations, management indicated that the cost was warranted.

TABLE 4B-1

Waste Reduction Project Payback Periods

Payback Period (Years)	Cases	Percent
Under 1	16	55
1-2	6	21
2-3	2	7
3-4	3	10
Over 4	2	7
Total	29	100

Source: Jacobs Engineering. 1986. Washington, D.C.

References for Annex 4B

Huisingh, D. et al.. 1985. Proven Profit from Pollution Prevention. Washington, D.C.: Institute for Local Self-Reliance.

Jacobs Engineering. 1986. Private survey. Washington, D.C.

Sobrino, F. 1985. Resource recovery attracts attention of waste generators. Chemical Market Reporter (November 18).

Campbell, M., and W. Glenn. 1982. Profit from Pollution Prevention, p.298. Toranto: Pollution Probe Foundation.

Garrison, L. S.. 1985. Dupont News 14(9): 1.

Kohl, J., P. Moses, and B. Triplet. 1984. Managing and Recycling Solvents: North Carolina Practices, Facilities and Regulations, Releigh, North Carolina: North Carolina State University, Industrial Extension Service.

League of Women Voters of Massachusetts. 1985. Waste Reduction: The Untold Story. Proceedings of conference at the National Academy of Sciences Conference Center, June 19-21, Woods Hole, Massachusetts.

Fromm, C. H., and M. Callahan. 1986. Waste reduction audit procedure: A methodology for identification, assessment and screening of waste minimization options. Hazardous Materials Control Research Institute, Paper from the 3rd National Conference Proceedings, March 4-6, Atlanta, Georgia.

ANNEX 4C - Bringing About Change in Hazardous Waste Management

Written by Jerome Kohl, North Carolina State University, Raleigh, North Carolina

Introduction

This chapter provides information on North Carolina generators and some United States experience in working with hazardous waste. Most of the experience is North Carolina experience; however, some information is presented on California, Massachusetts, and New York practices.

The basic thesis is: (1) We have developed a hierarchy covering waste management options, in this hierarchy eliminating generation of the wastes is our first choice and land disposal (burial) is last. Other disposal options fall in between; (2) As a result of problems with land disposal we recognize that we need to bring about a change in the waste handling practices of our waste generators; and (3) To bring about this change requires that we educate the generators on alternatives available to them and the pros and cons of each alternative and that we motivate them to make a change. This chapter describes the options, North Carolina educational mechanisms, and efforts at motivation and our recommendations.

First, a little background on North Carolina, our hazardous wastes and their regulation; and our hazardous waste treatment, storage, and disposal facilities.

North Carolina, which is shown in perspective to Spain in Table 4C-1, manages generation, treatment, storage, and disposal of its wastes under permits from the United States Environmental Protection Agency (USEPA). North Carolina Regulations cannot be less strict than those of EPA by EPA rule and cannot be more strict by State Law. So the State Regulations parallel those of the EPA. Enforcement is by a Solid and Hazardous Waste Management Branch of the Department of Human Resources. We also have a Pollution Prevention Pays (PPP) group in the Environmental Management Division of the Department of Natural Resources and Community Development (NRCD). NRCD enforces air and water pollution regulations.

North Carolina has a "Governor's Waste Management Board" which fosters public education and has certain authority in case a company seeking to set up a new treating or disposal facility is in disagreement with a local authority on local charges (this situation has not yet arisen). A two-year-old "Waste Management Commission" overseas is the establishment of the needed facilities. This multiplicity of interested agencies in different departments leads to confusion and competition.

North Carolina generators comprise private industries often owned out of state (and out of country); Federal installations including many military bases; state and local institutions, including schools, prisons, and hospitals.

TABLE 4C-1

A Perspective

	Area in Sq. Miles	Population
Spain	195,000	34,000,000
USA	3,000,000	226,545,000
Vizcaya	853	1,200,000
North Carolina	49,000	6,000,000
Bilbao		433,000
Raleigh		300,000

Bringing About Change

Psychological Factors Involved in Change

The purpose of this Annex is to provide information on how we in North Carolina have helped people and organizations to improve their operations in regard to production and disposal of their hazardous wastes through better management and recycling. Improving here meant getting individuals and organizations to do things differently. It is well known that such changes do not occur easily or naturally. People and organizations have a strong tendency to continue doing things the way they are used to doing them. If changes are to be made, it is necessary that persons and groups be well-informed, be well-motivated, be cooperative and have a positive attitude toward the new ideas. These are all psychological factors. Changes are not likely to be brought about by giving orders or by an appeal to the good intentions of people. Changing the behavior of people in work organizations is a difficult task that requires considerable thought and planning even though it seems perfectly clear that such changes will benefit everyone. Creating change in an organization requires a change agent, that is, a person who will see to it that the conditions necessary for change are established. That person cannot bring about change directly. He or she must do it through people.

Change Agent -----> Supervisors -----> Workers -----> nge

Here are some suggestions that should help in bringing about desired changes.

(1) In influencing people to change their attitudes and behavior, we should keep in mind the following:

(a) The way people perform or behave results from two major factors -- motivation and ability. They not only must want to do something, they must know how, if things are to happen. Neither motivation nor ability by itself is enough. If we wrote this idea in mathematical form, it might look like this:

$$\underline{P = M \times A}.$$

P is performance, M is motivation and A is ability. Note that the relationship between M and A is multiplicative. If either M or A is zero, nothing will happen. Neither high ability with low motivation nor low ability with high motivation is likely to be very productive.

(b) People are goal oriented in their behavior. They do things because it will make them better off in some sense. The fact that you may not understand or approve of that reason does not matter except that if you do not understand their goals, you will probably not be effective in influencing them. It is also worth remembering that personal goals are often different from organizational goals.

(c) While we tend to think of people as individuals, the social forces in their behavior are extremely important. People do things because of what other people think or do. Hence, we have to plan our operations so as to affect people as groups and not just individuals. A working organization is not merely a collection of individuals; it is a social system. That means that any change in operation that one person makes will affect many other persons and they will react to that change.

(2) The following are some ways of influencing or changing behavior with brief comments on their effectiveness:

(a) Giving orders for desired behavior often causes resentment. This procedure overlooks levels of motivation and ability and usually deals with people as individuals and ignores social factors.

(b) The use of incentives or rewards is a necessary condition. Usually we think of financial incentives only, but other important incentives are promotion, praise, and social approval. An incentive will be of no value if it is not desired by the person. Giving awards to a few only may result in animosity toward management and other workers.

(c) Procedural changes based on social and group factors are usually more effective than those directed at individuals only.

(d) Involving the employee in the decision to make changes and in the process of making changes increases the chance that he will be cooperative and will contribute effectively to improving the process. People like to have control over their own behavior even at work.

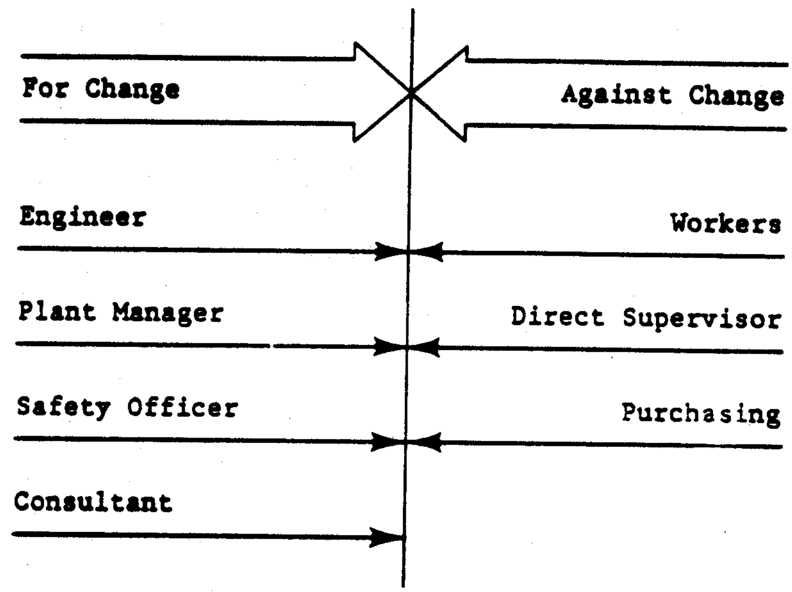
(e) Make full use of the employee's knowledge and his ability to think; treating employees like mental incompetents leads to resentment. Employees usually are the source of the best ideas.

(f) The cooperation and support of all levels of management is important and necessary, if changes are to be made. Make sure management is informed and supportive.

(3) In planning change it is a good idea to make some assessment of the forces in your organization that are for the change and those likely to be opposed to it. We call this "Force Field Analysis." Examine all the forces in your organization; try to determine whether they are for or against the new procedure and the amount of their support or opposition. As an example, these forces might include -- Plant Manager, Safety Officer, Direct Supervisor, Workers, Engineering, Purchasing. You might diagram these forces as follows in Figure 4C-1:

FIGURE 4C-1

Force Field Analisis Diagram



You can see from this balance of forces, pro and con, that you will have some problems in bringing about your change. While you seem to have power and reason on your side, the forces against you might defeat you in the long run. A careful analysis of all forces will give you guidance on how to proceed and what tactics to use in achieving your change.

<u>Economics</u>

One important factor motivating change in the manner of handling wastes is the economic factor. In the case studies included in this paper, the motivation is often economic. For each proposed change, an estimate of costs and savings will need to be made so a payout can be determined.

Some of the lesser-known incentives involve actions by the State of North Carolina and by the Federal Government to encourage companies to do something to reduce hazards and to reduce the danger of groundwater pollution.

Incentives are offered by the Federal and State governments for the following reasons:

(i) To encourage compliance with state and federal pollution abatement requirements

(ii) To avoid or mitigate economic harm to industries forced to comply with pollution clean-up requirements

(iii) To help ensure that complying companies are not at a competitive disadvantage to non-complying companies

The incentives offered by our governments include:

(i) Rapid amortization of investments

(ii) Investment tax credit

(iii) Deduction against franchise tax liability

(iv) Tax-exempt Industrial Development and Pollution Control Bonds

(v) Penalties as incentives:

(a) RCRA legislation and EPA policies prohibit the EPA from approving or recommending to private parties any facilities that have Category 1 violations.

(b) RCRA legislation and EPA policies require that penalties be large enough to offset any economic gain from non-compliance.

(c) Normal business expenses through compliance are tax deductible but penalty expenses are not tax deductible. For example, the cost of buying new drums for a leaky drums penalty is not tax deductible.

(d) The cost of lost goodwill is immeasurable in terms of lost customers, etc.

The North Carolina state incentives currently in existence are:

(i) Tax Exempt Industrial Development and Pollution Control Bonds (N.C. General Statute 159c-2) must meet certain criteria and be approved by appropriate local and state authorities.

(ii) Exclusion from local property tax (N.C. General Statute 105-275) of property used to abate water pollution or to recycle or provide resource recovery of solid waste.

iii) Reduction of franchise tax (N.C. General Statute 102-122) for costs of property used as in (ii) above.

(iv) Sixty-month amortization (N.C. General Statute 105-122b) on costs of property used as in (ii) above.

Federal incentives are:

(i) Tax-exempt bonds for water pollution control facilities and solid waste disposal facilities.

Other economic incentives to change include:

(i) The need to maintain and enhance the status of the company in the eyes of the community and its customers.

(ii) Early payback of investment or a satisfactory return on the investment.

Hierarchy

There are a variety of options for managing any hazardous waste. As an example this chapter uses electroplating sludge. To reduce sludge production three are options such as recycling, solidifying or otherwise disposing of the sludge. The factors determining the hierarchy include:

(i) Liability

Liability may be the most important consideration in a decision on how to handle sludges. The RCRA "cradle to grave" philosophy and the lawsuits being carried out under Superfund against electroplaters, who in the past legally disposed of waste that must now be pulled out of a landfill and reburied, are strong factors motivating minimizing the use of landfills -- even hazardous waste landfills. While it is difficult to assess a per day cost of this future liability, it must be considered in making decisions regarding disposition of sludges.

(ii) Regulations

Any actions are desirable that can be taken to minimize applicable regulations, reduce the paperwork and record keeping.

(iii) Costs

In trying to assess the costs, for example, of paying someone to reuse a spent solution or a sludge, one must balance this cost against the total disposal cost and liability. A factor often not included in cost consideration is that of liability insurance. This insurance cost should be factored in when the waste is stored or disposed of in such a way that future liability could be incurred.

(iv) Conservation of Resources

Chromium, nickel, and copper are all elements of limited supply. It is foolish to take solids with high concentrations of these metals and to mix these solids with many other types of waste materials and then bury the mixture in a manner that makes it difficult to ultimately retrieve the metals. From the long-term point of view, it is in the best interest of electroplaters to minimize their purchase of newly mined metals.

In light of the factors described above, we suggest that a hierarchy for handling electroplating sludge can be developed which will resemble Figure 4C-2. Note that we indicate that the most desirable option with the least liability is changing the process and/or housekeeping to reduce or eliminate sludge generation. We suggest that the poorest option with the greatest long-term liability is the placement of solidified waste in a landfill. Table 4C-2 summarizes the liability and economics of the various sludge handling methods.

Education - Spreading the Word

Due to its lack of treatment facilities and inability to overcome local opposition to siting new facilities, North Carolina is trying to move its hazardous waste generators up the hierarchy shown in Figure 4C-2. Table 4C-3 lists the techniques used in North Carolina for informing generators of the options available to them and the pros and cons of each option. An Advisory Committee of Generators is used to help develop workshops and manuals and a Consulting Behavioral Psychologist provides counsel on motivation. Table 4C-4 lists New York techniques. California uses the above ideas and has set up a program to review manifests. If the manifest indicates that sludge was buried that could have been recycled, the generator is told of his error and instructed to change his ways to a new technique for which he is given information. Massachusetts offers a phone-in-for-help system.

For example, working with S.E. chapters of the Electroplating and Surface Finishing Society, two one-day meetings were organized on "Reducing Metal Losses and Sludge Production in the Electroplating Industry." For and from these meetings a manual, "Managing and Minimizing Hazardous Waste Metal Sludges," (December 1984, J. Kohl. and B. Triplett) was developed. Funding for the workshops and manual came from the N.C. Legislature (via the Governor's Waste Management Board). The Table of Contents of this manual is shown in Tables 4C-5, and 4C-6, and 4C-7 are case studies taken from the manual. Exhibitors (vendors of equipment to electroplaters) were encouraged to participate in the workshops. The manual includes a list of equipment suppliers and a list of companies accepting electroplating sludges and spent or

FIGURE 4C-2

Options for Managing Electroplating Sludges

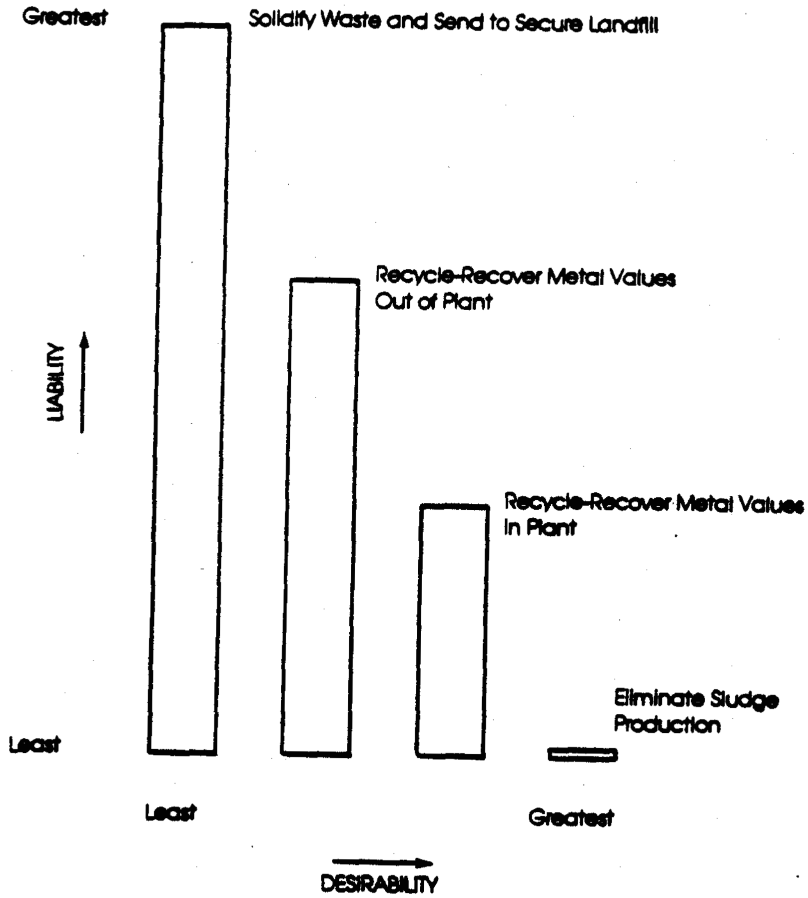


TABLE 4C-2

Overview of Various Handling Alternatives for Metal-Containing Wastes

Option	Limitations	Liability	Economics
Improve housekeeping practices to minimize waste generation	Management must be amenable to procedural changes	Reduced	Little or not capital investment
Change process to minimize or eliminate waste genera-	Process and management must be amenable to change	Greatly reduced or eliminated	Depends on particular situation
Recycle in-plant	Capital for equipment, operating and maintenance problems and expenses	Greatly reduced or eliminated	Depends on particular situation
Recycle out-of-plant	Concentration levels of contaminants in solutions and sludges, modification of process may be necessary	Greatly reduced, but: transportation, failure of recycler, disposal of residue	Process modification expense, transportation, usually cheaper than landfilling
Solidify - place in secure landfill	Expense for solidification process as well as for secure landfill	Reduced, but: transportation, future site problems	\$25-\$250 per ton for solidification, \$85-\$100 per barrel for secure landfilling
Secure landfill	No free liquids	Transportation; future site problems	\$85-\$100 per barrel
Solidify - place in non-secure landfill		Delisting may be withdrawn; site problems	\$25-\$250 per ton

TABLE 4C-3

Generator Motivation

Motivating Action in North Carolina

Governor's Award for Excellence in Waste Management

Pollution Prevention Pays Matching Grants ($5,000)

Regulations Limiting Placement of Electroplating Sludge in Landfills

Enforcement of Regulations - Fines

Other Motivating Factors

Rising Costs of Metals and Land Filling

Lack of Nearby Disposal Facilities

Concern over Liability from Land Filled Wastes

Fear by Employees of Hazards, Waste Responsibilities

Note: New York taxes generators on a per ton basis according to the mode of waste disposal employed.

TABLE 4C-4

Generator Education

New York

Environmental Facilities Corp. - Not a regulatory agency

Information Services

Waste Exchange (particularly underwrites costs)

Assistance with understanding regulations

Waste Stream Evaluation and Analysis - identification of most economical options, evaluation of alternatives

Referral to outside consultants

Assistance with tax free financing options for industrial pollution control project

TABLE 4C-5

Managing and Minimizing Hazardous Waste Metal Sludge Manual, December 1984

Table of Contents

TABLE 4C-5 (continued)

TABLE 4C-6

Evaporator Case Study

Company:	Eastern Plating
Location:	Newport, Tennessee
Contact:	Roger Woods
Phone:	(615) 623-0062
Purpose:	Recover Ni, Cr^{+3}, Cr^{+6}
Motivation:	(1) Economic - less expensive to operator than any other system (2) The evaporator can put every thing back in tank (3) Eliminates necessi for landfilling or sewering waste
Equipment Supplier:	Techmatic, Inc.
Payback:	6 weeks - 6 months
Comments:	Almost maintenance free; inexpensive to operator
Reported:	Personal communications, August 1984

Source: Kohl, J., and B. Triplett. 1984. Managing and Minimizing Hazardous Waste Metal Sludges Manual. Prepared for workshop on "Reducing Metal Losses and Sludge Production in the Electroplating Industry," December, Raleigh, North Carolina.

TABLE 4C-7

Reverse Osmosis Case Study

Company:	Stanley Tools
Location:	100 Stanley Road Cheraw, South Carolina 29520
Contact:	Mike Vannest
Phone:	(803) 537-9311
Purpose:	Nickel salts recovery
Motivation:	Cost reduction
Equipment Supplier:	Osmonics
Payback:	1.3 years
Comments:	Low maintenance, very positive experience
Reported:	Personal communication, August 1984 to B. Triplett

Source: Kohl, J., and B. Triplett. 1984. Managing and Minimizing Hazardous Waste Metal Sludges Manual. Prepared for workshop on "Reducing Metal Losses and Sludge Production in the Electroplating Industry," December, Raleigh, North Carolina.

surplus solutions. Tables 4C-8 and 4C-9 show a section of such a list and a complementary table.

Similar meetings have been developed and presented on Managing and Recycling Solvents, Managing Used Oils, Managing and Recycling Solvents in the Furniture Industry. Over 100 workshops have been developed and presented to hazardous waste generators and small generators throughout North Carolina. For these workshops, manuals and video tapes were developed. Industry specific programs and video tapes have been developed for dry cleaners, pesticide applicators, and vehicle repair facilities.

We lack an objective, quantitative evaluation of the results of applying the techniques described in this Annex. Based on experience, small workshops (30-40 participants) are recommended with generators presenting case studies as speakers, and with plenty of time for discussion. Exhibition of equipment is encouraged and exhibitors are offered 5 minutes on the program to explain their product and its uses. Manuals should include case studies. The more "local" the case study, the better. "In-plant" visits are arranged to enable generators to see first hand good housekeeping and advanced recovery techniques.

For an in-plant workshop we use a company practicing a good waste management technique and willing to "show-off" their practice to other companies. This provides an opportunity for a prospect for change to see for himself what works, to ask questions, to get pay back information. U.S. experience with bringing about change in agricultural processes has demonstrated that trial plots by farmers open for inspection by their neighbors is the number one means of bringing about change. Our feedback says that bibliographies are not much used and if prepared, should only list readily available publications. Recommendations for a successful workshop and manual are shown in Figures 11 and Tables 4C-10 and 4C-11.

Conclusion

We strongly believe that education of generators on available options is not enough. Indeed some of our experiences, indicate that knowledge of an option such as sludge drying with a pay off under two years still will not lead to the purchase of a sludge dryer. An additional boost is often needed beyond economic advantage or good pay off.

From our discussions with generators and with suppliers we have found that a waste generator is most likely to change his ways when he knows of a better option, know that it will pay out in one or two years and when he is convinced that his present practice could lead to a clash with the regulators or to a possible liability. Figure 4C-3 illustrates this point. When enforcement of regulations is consistent, when there are indeed fines and prison sentences, pollution abatement equipment sales rise. With faltering uncertain enforcement, we experience a reluctance to change.

TABLE 4C-8

Equipment Suppliers

The following list was compiled through personal interviews, telephone conversations and sales literature. The preparers of this list take no responsibility for the list's completeness nor for the quality of services offered by these firms.

Baker Brother/Systems
Post Office Box 707
Raeford, North Carolina 28376
Phone: (919) 875-4169
Contact: David Gibson, Manager
Equipment: Electrodialysis

Barnett-Hormberg, Inc.
1709 East Boulevard
Charlotte, North Carolina 28203
Phone: (704) 332-1597
Contact: H. C. Martin
Equipment: Corrosion control linings, air pollution control systems, fiber glass tanks, portable and fixed agitators, FRP grating, structural members, heat exchangers (steam and electric)

Corning Glass Works
Corning Process Systems
BF Plant
Big Flats, New York 14814
Phone: (607) 974-0280
Contact: Raymond Baker
Equipment: Corning Evaporator

ECO-TEC
925 Brock Road South
Toronto, Ontario, Canada L1W 2X9
Phone: (416) 831-3400
Contact: Mike Dejak
Equipment: Ion exchanger

Filtration Technology, Inc.
Post Office Box 31442
Raleigh, North Carolina 27622
Phone: (919) 787-3988
Contact: Jim Grantham
Equipment: Fluid filtration

Frederick Gumm Chemical Company
1280 Wall Street, West Lyndhurst
New Jersey 07071
Phone: (201) 460-7900
Contact: Joe Cahill, Product Mgr.
Equipment and Supplies: Full line of equipment and chemicals for electro and electroless plating

Harshaw/Filtrol
3915 D Valley Court
Winston-Salem, North Carolina 27106
Phone: (1-800) 321-4802
Contact: Louis Gianelos
Equipment: Evaporators

Innova Technology, Inc.
5170 126th Avenue,
Noth Clearwater, Florida 33520
Phone: (813) 577-3888
Contact: Ted Nohren
Equipment: Chrome Napper

JWI, Inc.
2155 112th Avenue
Holland, MI 49423
Phone: (616) 772-9011
Equipment: Sludge Dryers

Lancy International, Inc.
Post Office Box 490
Zelienople, Pennsylvania 16063
Phone: (412) 452-9360
Contact: James Knight
Equipment: Electrolytic metal, electrodialysis, ultrafilters, evaporators, etc.

TABLE 4C-9

Desirable Characteristics of Electroplating Metal Wastes from the Recyler's Point-of-View

	Amlon Metals	Atomergic Chemicals	Capital Assay Labs Ltd.	Gowan Chemical	Macdermid Inc.	Madison Industries	Northland Chemical Company	World Resources Company
Wastes Accepted	Sludges	Sludges and solns, copper stripping solns and and cyanides	Sludges, solutions, cyanides	Reclaim Al etchants, acids, ferric chlorides aluminum materials	Reclaim spent solutions: Cu etchants., Cr solns., Sn and Pb strippers, solder conditioner	Sludges, etchants	Copper etchants from circuit board industry	Sludges
Metals Recovered	Cu, Cr, Sn, Ni, precious metals	Cu, most base metals, precious metals	Cu, precious metals, cyanide	Same as Wastes Accepted above	Same as Wastes Accepted above	Cu, Zn	Cu	Cu, Sn, Ni, precious metals
Required Metal Content	Generally 20% or higher of Cu; 2-20% other metals	Item basis, higher % better isolated waste streams a plus	No % requirement for Cu bearing materials; mixtures OK	High Al content, individually based material content	Metal content not applicable	Metal content not applicable; accept various amounts of waste	14 oz Cu/gal., low level parts of other metals (100 ppm)	No % requirement; mixture OK
Other Special Requirements	Sample size; 2 oz	Low amounts of As, Be, Pb	Sample size 2 oz sludge, 100 ml liquid	Sample size; 1 pint	Prefer to deal with [illegible] customers but will consider outside sources	Wastes only from circuit board industry; sample size: 1 qt.	Prefer low Fe, As, Pb	Sample: 2 lbs dry cake or 1 gal. liquid sludge
$	Payment for metals, precious metals, penalty for undesirable compounds	$ decisions based on profit, cost factors	Payment for Rh, Pt, Au, Ag, Pd precious metals	Payment based on Al content	Payment 28 cents/gal. for Cu, etchants, etc.	Payment for Cu, Zn	Payment only for Cu etchants with low concentration of Fe, As, and Pb	Payment for metals and precious metals

TABLE 4C-9 (continued)

	Amlon Metals	Atomergic Chemicals	Capital Assay Labs Ltd.	Gowan Chemical	Macdermid Inc.	Madison Industries	Northland Chemical Company	World Resources Company
Transport		Seller pays	Seller or recycler pays	Depends on location and quantity of material	Seller pays	Seller pays	Charges for own trucking allowing credit for Cu	"Variable" as to who transport and 8 factors
Product	Ship to overseas refineries	Resalable technical grade metal	Solid metal	Basic chemicals	Rejuvenated spent solutions, reclaimed metals used in new plating solutions	Copper and zinc chemicals	Copper chemicals	
Permits	None (Broker)	Part B	Hazard Permit, seeking a delisted status	None	Part B	No RCRA permits	Interim status	Part B

TABLE 4C-10

Formula for a Successful Workshop on Minimizing Electroplating Sludge

Work with a 10-20 member advisory committee, comprised of suppliers and prospective attendees or speakers

Include exhibitors: give each 5 minutes on program

Help speakers develop good visuals and handouts

Limit presentations to 10-20 minutes

Encourage and don't limit discussion and questions

Provide hourly breaks with fruit, juices, etc.

Emphasize case studies - preferably local

Include information on motivating factors and pay back

TABLE 4C-11

Formula for a Successful Manual on Minimizing Electroplating Sludge

Work with an Advisory Committee of generators, treaters, etc.

Emphasize Case Studies, preferably local

Include accurate, up-to-date information on:

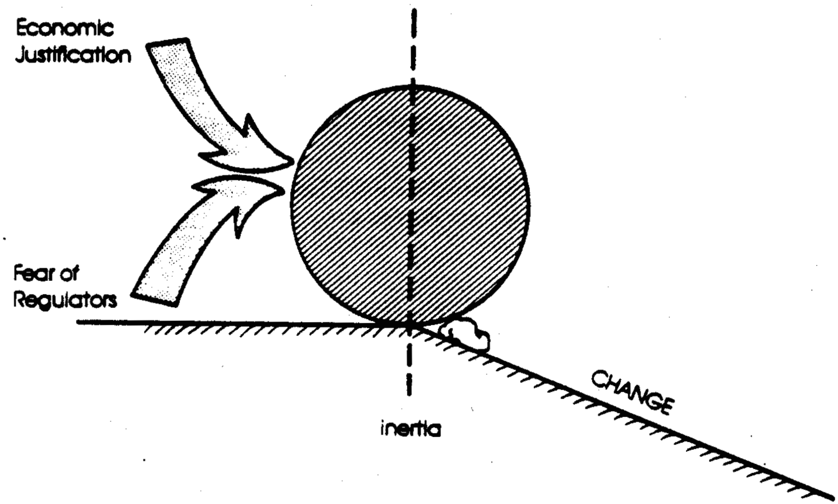
suppliers, transporters, recylers, incinerators, buyers, landfills, services

Provide contacts for information on regulations

Provide a complete, clear Table of Contents

FIGURE 4C-3

Implementing Change



References Annex 4C

N.C. General Statute 159C-2.

N.C. General Statute 105-275.

N.C. General Statute 102-122.

N.C. General Statute 105-122(b).

For reference material on tax and other incentives for pollution abatement equipment, contact Dr. Linda W. Little, Executive Director, Governor's Waste Management Board, 513 Albermarle Building, 325 N. Salisbury St., Raleigh, N.E., 27611, USA, (919) 733-9020.

Note: The N.C. Pollution Prevention Pays (PPP) Program offers assistance to small businesses and communities to find ways to reduce, recycle, and prevent wastes before they become pollutants. The program offers the following publications: 1) Pollution Prevention Bibliography by Industrial Classification; 2) Directory of N.C. Resource Recovery Firms; 3) Environmental Auditing Information Package; 4) Accomplishments of N.C. Industries; and 5) United nations Compendium of Low and Non-Waste Technologies. For access to the PPP program contact:

Mr. Roger Schector, Director - PPP Program
Division of Environmental Management
Department of natural Resources and Community Development
Post Office Box 27687
Raleigh, North Carolina 27611
(919) 733-5083

CHAPTER 5 - Infrastructure of Hazardous Waste Management Systems

5.1 Introduction

The need for a hazardous waste management system begins directly upon generation of waste and continues through all subsequent stages to final treatment and disposal. This system is really a series of management actions to control and contain the waste coordination among various persons and groups of persons. In this simplest form, a hazardous waste management system consists of three units:

- o storage upon generation;
- o collection/transportation; and
- o final treatment/disposal.

This chapter reviews the elements of an overall management system that are applicable to onsite and offsite management of hazardous waste.

5.2 Storage upon Generation

The first stage in this infrastructure is storing waste after it is generated. The waste generator needs to have a system to safely store waste until it can be transferred for further storage, treatment, or disposal. Typically, this storage is done in containers or bulk tanks. Methods like surface impoundments are discussed in Chapter 7.3.1 on disposal technologies. Which is used depends largely on how and where the waste is generated and the physical state of the waste.

5.2.1 Containers

Containers offer the advantages of being very portable, suitable for any physical state of waste, and flexible as to mean. filing. They can be kept next to the waste generating process until full, then easily moved to a waste storage area awaiting further transfer.

Most containers are suitable for many types of waste, form liquids, sludges to bulky solids. Containers may be filled by any available method, for example, pumping, shovelling, or tipping. Empty containers which had contained raw material may be suitable for storing waste, depending on the compatibility of waste with the container and with any residues which may be left in the container. Compatibility with the container is important so that the container's integrity is not impaired. For example, a plastic container should not be used to store solvent waste. Care must be taken that residues from the container's previous contents will not react with the waste; example, a container which had contained cyanide salts should not be used for waste acid.

Disadvantages of containers are:

(1) they are easily damaged and toppled;

United States
Environmental Protection Agency

Office of
Public Affairs (A-107)
Washington DC 20460

EPA

Note to Correspondents

THURSDAY, JANUARY 26, 1989

The U.S. Environmental Protection Agency today issued a policy statement on its pollution prevention program (see attachment).

Pollution prevention -- i.e., reduction and recycling to reduce the amount and toxicity of contaminants and thus the need for pollution controls -- is now a major agency priority. The policy commits EPA to instituting pollution prevention throughout all of its programs (air, water, land, etc.). EPA has established a Pollution Prevention Office that will oversee the agency's efforts; the office has begun to develop a comprehensive agency-wide pollution prevention strategy.

Reporters can call Robin Woods at 202-382-4377 for further information.

Dave Cohen, Director
Press Services Division

-17

ENVIRONMENTAL PROTECTION AGENCY

(OSWER-FRL-xxxx-x)

Pollution Prevention Policy Statement

Agency: Environmental Protection Agency (EPA)

Action: Proposed Policy Statement

Summary:

The Environmental Protection Agency's progress over the last 18 years in improving environmental quality through its media-specific pollution control programs has been substantial. However, EPA realizes that there are limits as to how much environmental improvement can be achieved under these programs, which emphasize management after pollutants have been generated. EPA believes that further improvements in environmental quality can be achieved by reducing or eliminating discharges and/or emissions to the environment through the implementation of source reduction and environmentally-sound recycling practices.

EPA's proposed policy encourages organizations, facilities and individuals to fully utilize source reduction techniques in order to reduce risk to public health, safety, welfare and the environment, and as a second priority to use environmentally sound recycling to achieve these same goals. Industrial source reduction can be accomplished though input substitution, product reformulation, process modification, improved housekeeping, and on-site, closed loop recycling. Although source reduction is preferred to other management practices, the Agency recognizes the value of environmentally sound recycling, and is committed to promoting recycling as a second priority, above treatment, control and disposal.

Since not all pollution can be reduced or recycled, safe treatment, control and disposal will continue to be important components of an environmental protection strategy. Source reduction and recycling will not totally obviate the need for or the importance of these processes. Individuals as well as industrial facilities or organizations can practice source reduction and recycling through changing their consumption or disposal habits, their driving patterns and their on-the-job practices.

EPA firmly believes that all sectors of our society must work together to ensure continued environmental protection. Today's notice commits EPA to a preventive program to reduce or eliminate the generation of potentially harmful pollutants. The Agency has established an Office of Pollution Prevention which together with EPA's media-specific offices will develop and implement this program. An Advisory Committee of senior Agency managers will help direct EPA's pollution prevention program and will assure the participation of the entire Agency in this important mission. EPA also believes that State and local government must play a primary role in encouraging this shift in the environmental priorities of all sectors of industry and the public.

Today's notice also commits EPA to working with States to develop and implement specific strategies and technical assistance programs to encourage commercial and manufacturing industries, the agricultural sector and the general public to reduce the amount of pollution generated.

There are varying views among representatives of industry, public interest groups, state and local governments and others over the role of recyling in pollution prevention. The Agency believes that source reduction (including closed-loop, in-plant recycling) is generally preferred over other management approaches. The Agency also believes that out-of-loop and off-site recycling, when properly conducted, also offers the potential for significant economic benefits and reduced risk. With the publication of this proposed pollution prevention policy, the Agency would like to specifically request comment on the role of environmentally sound recycling in the pollution prevention program. Other comments on this policy, and on the steps necessary to implement it effectively are invited.

Dates: EPA urges interested parties to comment on this notice in writing. The deadline for submitting written comments is (90 days after publication in the Federal Register.

Addressees: All comments must be submitted in triplicate (original and two copies) to: EPA RCRA Docket (room SE-201) (mail code OS-305), 401 M Street, S.W., Washington, D.C. 20460 Place the docket number, # F-88-SRRP-FFFFF, on your comments. For further information, contact:

Gerald Kotas, Director, Pollution Prevention Office, Office of Policy, Planning and Evaluation, 401 M Street, S.W., Washington, D.C. 20460, (202) 382-4335; or

James Lounsbury, Office of Solid Waste (OS-302), 401 M Street, S.W., Washington D.C. 20460, (202) 382-4807.

Supplementary Information:

POLLUTION PREVENTION POLICY STATEMENT

Outline:

This policy statement is organized as follows:

I. Background

EPA has made substantial progress over the last 18 years in improving the quality of the environment through implementation of media-specific pollution control programs. Notwithstanding past progress, there are economic, technological, and institutional limits on how much improvement can be achieved under these programs, which emphasize management after pollutants have been generated. As early as 1976, EPA believed the nation could not continue to reduce threats to human health and the environment while utilizing only better methods of control, treatment or disposal.

In the development of its hazardous waste management program, EPA recognized the importance of a hierarchy with source reduction at the top and recycling above treatment and disposal.[1] The emphasis of EPA's hazardous waste program over the past twelve years, however, has been primarily on implementing statutorily-mandated requirements concerning waste identification, treatment, storage, and disposal. In spite of the significant progress which has been made using this approach, the sheer volume of hazardous waste generated each year poses a continuing and serious environmental problem.

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[1] See 41 FR 35050, August 18, 1976. This notice provides a discussion of EPA's preferred hierarchy of environmentally sound hazardous waste management practices.

another attempt to reduce pollution at the source. Nevertheless, much of the past focus in these programs has been on pollution control rather than pollution prevention. It is necessary at this time to reassess EPA's programs in light of today's policy statement and redirect them accordingly.

The term "waste minimization", which EPA has previously used in reference to source reduction and recycling activities in its hazardous waste program, has been replaced in today's policy statement by the phase "pollution prevention". Through eliminating a term that may be perceived as closely tied to RCRA, EPA is emphasizing that the policy has applicability beyond the RCRA hazardous waste context. EPA stresses that the policy focuses primarily on the prevention of pollution through the multi-media reduction of pollutants at the source. In addition, in order to obtain additional benefits of avoiding releases to the environment, EPA's pollution prevention program secondarily promotes environmentally sound recycling.

II. EPA's Pollution Prevention Policy

EPA's proposed policy encourages organizations, facilities and individuals to fully utilize source reduction techniques in order to reduce risk to public health, safety, welfare and the environment and as a second priority to use environmentally sound recycling to achieve these same goals. Industrial source reduction can be accomplished though input substitution, product reformulation, process modification, improved housekeeping, and on-site, closed loop recycling. Although source reduction is preferred to other management practices, the Agency recognizes the value of environmentally sound recycling, and is committed to promoting recycling as a second priority, above treatment, control and disposal.

Since not all pollution can be reduced or recycled, safe treatment, control and disposal will continue to be important components of an environmental protection strategy. Source reduction and recycling will not totally obviate the need for or the importance of these processes. Individuals as well as industrial facilities or organizations can practice source reduction and recycling through changing their consumption or disposal habits, their driving patterns and their on-the-job practices. EPA believes that developing and implementing a new multi-media prevention strategy, focused primarily on source reduction and secondarily on environmentally sound recycling, offers enormous promise for improvements in human health protection and environmental quality and significant economic benefits.

Section 1030(b) of the Solid Waste Disposal Act, as amended by both the Resource Conservation Recovery Act (RCRA) of 1976 and the Hazardous and Solid Waste Amendments of 1984, established a national policy, initially referred to as the "Waste Minimization Policy", that expressed a clear priority for reducing or eliminating the generation of hazardous waste over managing wastes that were nevertheless generated. Specifically, it stated that:

> "The Congress hereby declares it to be a national policy of the United States that, wherever feasible, the generation of hazardous waste is to be reduced or eliminated as expeditiously as possible. Waste that is nevertheless generated should be treated, stored or disposed of so as to minimize the present and future threat to human health and the environment."

Today's policy statement commits EPA to a program that extends beyond minimization of hazardous waste to reducing all environmentally harmful releases. EPA's experience with its current programs has shown that, notwithstanding the substantial gains that have been made in limiting environmental pollution, media-specific programs have some inherent limitations. Efforts to control or treat pollutants subsequent to their generation or production can sometimes result in transfers of these pollutants from one environmental medium to another, where they may continue to present a hazard. In addition, once these pollutants have been produced or generated, some proportion of those releases will have an impact on the environment, however effective the control or management techniques. The preventive approach of today's policy statement provides a way to more effectively respond to these remaining problems.

EPA believes that all sectors of our society must work together to ensure continued environmental protection. EPA is committed to working with individuals and organizations (both public and private) to make source reduction and as a second priority, environmentally sound recycling, the major focus of future environmental protection strategies. In particular, EPA believes that State and local governments must play a primary role in encouraging this shift in the environmental priorities of all sectors of industry and the public.

Some programs within EPA have already adopted measures to promote source reduction and recycling. For example, the Office of Water has adopted effluent guidelines that have resulted in flow reductions and product substitutions. The rapid phasing down of lead in gasoline by EPA's Office of Air and Radiation is

III. Development of EPA's Multi-Media Pollution Prevention Program

EPA has initiated development of a comprehensive pollution prevention program to implement this pollution prevention policy throughout the Agency programs, whether they affect air, land, surface water, or ground water. EPA has established an Office of Pollution Prevention which together with the Agency's media-specific offices will develop and implement this program. EPA will develop an overall Agency pollution prevention strategy, as well as coordinate strategies among EPA's program and regional offices. An important emphasis of these strategies will be on educational, technical assistance and funding support to make it easier to build these programs into the public and private sectors. An Advisory Committee of senior Agency managers will help direct EPA's pollution prevention program and will assure the participation of the entire Agency in this important mission.

As part of this program, EPA will establish mechanisms for avoiding or mitigating the generation and cross-media transfer of pollutants. Development of EPA's multi-media pollution prevention program will focus on several key components. These include:

- the development of institutional structures within each of EPA's media-specific and regional offices to ensure that the pollution prevention philosophy is incorporated into every feasible aspect of internal EPA decision-making and planning;

- the support of State and local pollution prevention programs. EPA believes that State and local agencies are more aware of the problems facing the commercial or manufacturing industries, or consumers, than the federal government. Indeed, a few States have already formally recognized the importance of multi-media pollution prevention. One of EPA's primary goals is to help States develop their own pollution prevention programs;

- the development of an outreach program targeted at State and local governments, industry and consumers, designed to effect a cultural change emphasizing the opportunities and benefits of pollution prevention;

- the creation of incentives and elimination of barriers to pollution prevention;

- the development of a multi-media clearinghouse to provide educational and technical information. This includes the support of research, development and demonstrations necessary to provide relevant data; and

- the collection, dissemination and analysis of data for the purpose of evaluating national progress in multi-media pollution prevention.

EPA believes that the development of a comprehensive multi-media pollution prevention policy offers enormous promise for improvements in human health protection and environmental quality. Because the focus of pollution prevention is on greater efficiency in the use of materials and processing of products, its implementation could additionally result in significant economic benefits.

There are varying views among representatives of industry, public interest groups, state and local governments and others over the role of recyling in pollution prevention. The Agency believes that source reduction (including closed-loop, in-plant recycling) is generally preferred over other management approaches. The Agency also believes that out-of-loop and off-site recycling, when properly conducted, also offers the potential for significant economic benefits and reduced risk. With the publication of this proposed pollution prevention policy, the Agency would like to specifically request comment on the role of environmentally sound recycling in the pollution prevention program. Other comments on this policy, and on the steps necessary to implement it effectively are invited.

Lee M. Thomas
[insert date]

CURRENT WASTE MINIMIZATION REQUIREMENTS

At present, there are three formal statutory requirements relating to waste minimization. Those sections enacted as part of the 1984 HSWA amendments include:

- Section 3002(a)(6) of HSWA requires, as part of any generator's biennial report to EPA, that the generator describe "*the efforts undertaken during the year to reduce the volume and toxicity of waste generated*" as well as "*changes in volume and toxicity of waste actually achieved during the year in question in comparison with previous years, to the extent such information is available for years prior to enactment of (HSWA).*" This report applies to EPA classed large quantity generators;

- Section 3002(b) of HSWA requires generators to certify on their waste manifests (mandated under Section 3002(a)) that they have in place a program "*to reduce the volume or quantity and toxicity of such waste to the degree determined by the generator to be economically practicable*"; and

- Section 3005(h) of HSWA requires the same certification in relation to any new permit issued for treatment, storage, or disposal of hazardous waste.

The following Generator's Certification statement, included on the Uniform Hazardous Waste Manifest required by Section 3002(a) of HSWA, must be signed by all hazardous waste generators who ship hazardous wastes off-site for treatment, storage, or disposal:

> *"If I am a large quantity generator, I certify that I have a program in place to reduce the volume and toxicity of waste generated to the degree I have determined to be economically practicable and that I have selected the practicable method of treatment, storage, or disposal currently available to me which minimizes the present and future threat to human health and the environment, OR, if I am a small quantity generator, I have made a good faith effort to minimize my waste generation and select the best waste management method that is available to me and that I can afford."*

These requirements should increase the awareness of generators and facility owners and operators of the importance of minimizing hazardous wastes, and might serve as the basis for more specific and farther reaching requirements. However, the present requirements are not overly restrictive. The generators determine whether any particular waste minimization approach that might apply to their processes is economically practicable. And although the biennial reports should provide useful insight into what generators are actually doing to reduce wastes, they are not likely to provide definitive information.

DEFINITION OF WASTE MINIMIZATION

Before proceeding, you should become familiar with some important terms. The following definitions set early parameters for waste minimization programs. They include:

- Waste minimization means the reduction, to the extent feasible, of hazardous waste that is generated or subsequently treated, stored, or disposed of. It includes any source reduction or recycling activity undertaken by a generator that results in either (1) the reduction of total volume or quantity of hazardous waste, or (2) the reduction of toxicity of hazardous waste, or both, so long as the reduction is consistent with the goal of minimizing present and future threats to human health and the environment;

- Source reduction refers to the reduction or elimination of waste generation at the source, usually within a process. Source reduction measures include process modifications, feedstock substitutions or improvements in feedstock purity, various housekeeping and management practices, increases in the efficiency of machinery, and even recycling within a process. Source reduction implies any action that reduces the amount

- Recycling refers to the use or reuse of a waste as an effective substitute for a commercial product, or as an ingredient or feedstock in an industrial process. It also refers to the reclamation of useful constituent fractions within a waste material, or removal of contaminants from a waste to allow it to be reused. Recycling implies use, reuse, or reclamation of a waste, either on-site or off-site, after it is generated by a particular process.

Hazardous waste minimization involves volume or toxicity reduction through either a source reduction or recycling technique and results in the reduction of risks to human health and the environment. The transfer of hazardous constituents from one environmental medium to another does not constitute waste minimization. Neither would concentration conducted solely for reducing volume unless, for example, concentration of the waste allowed for recovery of useful constituents prior to treatment and disposal. Likewise, dilution as a means of toxicity reduction would not be considered waste minimization, unless later recycling steps were involved. Finally, EPA does not consider treatment, e.g., incineration solely for the purpose of management or land disposal, as a valid waste minimization practice.

Draft 2

OhioEPA

State of Ohio Environmental Protection Agency

O. Box 1049, 1800 WaterMark Dr.
Columbus, Ohio 43266-0149
(614) 644-3020 Fax (614) 644-2329

Richard F. Celeste
Governor

FACILITY POLLUTION PREVENTION PLANNING:

A Matrix

of the

Provisions of Twelve State Laws

September 5, 1990

Prepared by Robin M. Sullivan

Division of Solid & Hazardous Waste Management
Pollution Prevention Section

INTRODUCTION

This is a matrix of the provisions of twelve state facility pollution prevention planning statutes. The matrix is intended to provide a comparative analysis of state facility planning laws, which may be particularly useful to states that are currently considering such legislation.

This matrix was developed as part of my Master of Science thesis in environmental policy analysis at The Ohio State University, School of Natural Resources. My thesis will assess the statutory structure of twelve mandatory facility pollution prevention planning statutes, and, based on models of the factors which contribute to successful policy implementation, will evaluate the extent to which each statute structures the policy implementation process.

Statutory variables have been divided into two dimensions: specificity and enforceability (i.e., How specific is each statute? and How stringent are enforcement provisions in each statute?). Seven specificity variables and eight enforceability variables have been developed. These variables comprise the matrix rows and the twelve states comprise matrix columns. Each cell contains the provisions of a state's law corresponding to the respective variable. Funding mechanisms for facility planning programs are also included in a separate matrix.

To make the matrix more concise and readable, language in the matrix may be, in some cases, abbreviated from statutory language. These provisions are derived from explicit language in the statute. Provisions of subsequently drafted administrative rules or policy guidelines are not incorporated.

A draft version of the matrix was sent for review to a key implementer of the facility planning program in each state. Revisions were then made from the comments received.

Any comments or questions regarding the matrix may be addressed to me at (614) 644-3503.

Robin M. Sullivan

OUTLINE

The matrix is organized as follows:

FACILITY POLLUTION PREVENTION PLANNING STATUTES ANALYZED IN ' Ǝ MATRIX

SPECIFICITY

Persons Required to Prepare a Plan

S1) Clarity of Statutory Objectives

S2) Waste Management Hierarchy

S3) Guidelines for Facility Plans

S4) Performance Goals of Facility Plans

S5) Requirements of Facility Progress Reports

S6) Conditions Where Pollution Prevention May Not Be Practicable

S7) Exemptions From Completing Facility Plan

ENFORCEABILITY

E1) Agency Review of Facility Plans

E2) Agency Review of Facility Progress Reports

E3) Frequency of Facility Progress Report Submission to Agency

E4) Administrative Penalties for Noncompliance

E5) Public Access to Facility Plans

E6) Public Access to Facility Progress Reports

E7) Plan Approval Criteria

E8) External Checks on Administrative Actions

FUNDING

FACILITY POLLUTION PREVENTION PLANNING STATUTES

ANALYZED IN THE MATRIX

STATE	STATUTORY AUTHORIZATION	DATE	IMPLEMENTING AGENCY
California	S.B. 14 Hazardous Waste Source Reduction Management and Review Act	1989	Department of Health Services (DHS)
Georgia	S.B. 519 Amendment to the Hazardous Waste Management Act	1990	Department of Natural Resources (DNR)
Maine	S.P. 1011 - L.D. 2507 An Act to Clean the Environment by the Reduction of Toxics Use, Waste and Release	1990	Department of Environmental Protection (DEP)
Massachusetts	H. 6161 Toxics Use Reduction Act	1989	Department of Environmental Protection (DEP)
Minnesota	Toxic Pollution Prevention Act	1990	Pollution Control Agency (PCA)
Mississippi	S.B. 2568 Comprehensive Multimedia Waste Minimization Act	1990	Department of Environmental Quality (DEQ)
New York	S. 5276 - B An Act to amend the environmental conservation law, in relation to the management of hazardous waste	1990	Department of Environmental Conservation (DEC)
North Carolina	S.B. 324 Hazardous Waste Management Commission Act	1989	Department of Natural Resources and Community Development (DNRCD)
Oregon	H.B. 3515 Toxics Use Reduction and Hazardous Waste Reduction Act	1989	Department of Environmental Quality (DEQ)
Tennessee	H.B. 2217 Hazardous Waste Reduction Act	1990	Department of Health and Environment (DHE)
Vermont	H. 733 An Act Relating to the Management of Hazardous Waste	1990	Agency of Natural Resources (ANR)
Washington	H.B. 2390 (sub.)	1990	Department of Ecology (DE)

SPECIFICITY

VARIABLES	CALIFORNIA	GEORGIA	MAINE	MASSACHUSETTS	MINNESOTA	MISSISSIPPI
Persons Required to Prepare a Plan	Generators who, by site, routinely generate, through ongoing processes and operations, more than 12,000 kg of hazardous waste per year or more than 12 kg of extremely hazardous waste per year	Large quantity hazardous waste generators Out-of-state large quantity hazardous waste generators who use Georgia's hazardous waste treatment, storage and disposal facilities	Large quantity hazardous waste generators Small quantity hazardous waste generators Facility owners or operators required to report under SARA, Title III, Section 313 (toxics releasers) Persons required to report the presence of extremely hazardous substances under SARA, Title III, Section 312 (toxics users)	Initially facility owners or operators required to report under SARA, Title III, Section 313, then expanding by 1995 to include other SIC groups and facilities which use chemicals on the CERCLA list (large quantity toxics users)	Facility owners or operators required to report under SARA, Title III, Section 313	Large quantity hazardous waste generators Small quantity hazardous waste generators Facility owners or operators required to report under SARA, Title III, Section 313
S1) Clarity of Statutory Objectives	To reduce the generation of hazardous waste; to reduce chemical contaminant releases	To provide for the preparation of hazardous waste reduction plans and biennial progress reports	To reduce the volume of toxic substances used, toxics released and hazardous waste generation: 10% by 1993, 20% by 1995, 30% by 1997	To reduce toxic waste generated by 50% by 1997 using toxics use reduction as the means for meeting this goal	To protect public health, welfare and the environment; to encourage toxic pollution prevention	To reduce or minimize the generation and toxicity of waste by a minimum of 25% by January 1, 1998
S2) Waste Management Hierarchy	1) Source reduction 2) Recycling 3) Treatment	Not mentioned in this amendment, but specified in the original act: 1) Source reduction 2) Recycling 3) Treatment 4) Disposal	1) Toxics use reduction, toxics release reduction and hazardous waste reduction	1) Toxics use reduction	1) Source reduction and processes that minimize cross-media pollutant transfers	1) Source reduction 2) Recycling 3) Treatment 4) Disposal

SPECIFICITY (continued)

VARIABLES	NEW YORK	NORTH CAROLINA	OREGON	TENNESSEE	VERMONT	WASHINGTON
Persons Required to Prepare a Plan	Generators of equal to or greater than 25 tons of hazardous waste per year Generators required to hold a hazardous waste treatment, storage or disposal facility permit	Hazardous waste generators and operators of hazardous waste treatment facilities which treat waste on-site who are required to pay an annual fee under North Carolina law Persons required to hold a water quality permit Persons required to hold an air quality permit	Large quantity hazardous waste generators Small quantity hazardous waste generators Facility owners or operators required to report under the SARA, Title III, Section 313 (large users)	Large quantity hazardous waste generators Small quantity hazardous waste generators	Persons who routinely generate, through ongoing process and operation, more than 1200 kg of hazardous waste per year or more than 12 kg acutely hazardous waste per year	Persons who generate more than 2640 pounds of hazardous waste per year Facility owners or operators required to report under SARA, Title III, Section 313 except those facilities that are primarily permitted treatment, storage and disposal facilities or recycling facilities (hazardous substance users)
S1) Clarity of Statutory Objectives	To reduce hazardous waste generation and release by 50% over the next 10 years	To encourage voluntary waste and pollution reduction efforts	To encourage toxic substance use and hazardous waste generation reduction without shifting risks from one environmental medium to another	To reduce the aggregate level of hazardous waste generated by 25% by June 30, 1995	To safeguard public health, promote worker safety and protect the environment by establishing toxics use reduction as the top priority for hazardous waste and toxics management	To reduce hazardous waste generation by 50% by 1995 through hazardous substance use reduction and waste reduction techniques
S2) Waste Management Hierarchy	1) Source reduction 2) Recycling 3) Treatment 4) Disposal	Not mentioned in this statute, but specified in an earlier law: 1) Source reduction 2) Recycling 3) Treatment 4) Disposal	1) Toxics use reduction 2) Hazardous waste reduction	1) Reduce or prevent hazardous waste generation 2) Storage, treatment and disposal	1) Source reduction 2) Recycling 3) Treatment	1) Hazardous substance use reduction 2) Hazardous waste reduction 3) Recycling 4) Treatment

SPECIFICITY (continued)

VARIABLES	CALIFORNIA	GEORGIA	MAINE	MASSACHUSETTS	MINNESOTA	MISSISSIPPI
S3) Guidelines for Facility Plans	Name, location, SIC code of site Identification of hazardous waste streams which result from ongoing processes or operations that have an annual volume > 5% total annual volume; or extremely hazardous waste > 5% total annual volume Estimate of quantity of hazardous waste generated Evaluation of viable source reduction options Specification of, and rationale for, source reduction measures which will be taken for each waste stream; rationale for rejecting any available source reduction approach Evaluation and quantification of effects of chosen source reduction measures on emissions and discharges to air, water or land Timetable for making reasonable and measurable progress towards implementing source reduction measures Certification by a professional engineer; process or operations personnel on-site; or an environmental assessor with expertise in hazardous waste management	Policy statement of upper management and corporate support for the plan and commitment to implement plan goals Plan scope and objectives, including the evaluation of technologies, procedures and personnel training programs to ensure unnecessary hazardous waste is not generated; specific goals for hazardous waste reduction, based on what is economically practical Analysis of hazardous waste streams; identification of opportunities for hazardous waste reduction; evaluation of where and why waste was generated; potential reduction and recycling techniques Accounting systems which identify waste management costs and factor in liability, compliance and oversight costs Employee awareness and training programs to involve employees in hazardous waste reduction planning and implementation Incorporation of plan into management practice and procedure to institutionalize plan Plan for implementing reduction options	Statement of facility-wide management policy for toxics use, toxics release and hazardous waste reduction Identification and characterization of types and amounts of all toxics used, toxics released and hazardous waste generated Evaluation of any appropriate technologies, procedures, processes, equipment or production changes that may be utilized to reduce the amount or toxicity of toxics used, toxics released or hazardous waste generated Strategy and schedule for implementing reduction options for each production process Identification of available markets or recycling opportunities for hazardous waste Program for maintaining records on toxics use, toxics release and hazardous waste generation rates and management costs; Employee awareness and training program to involve employees in toxics use, toxics reduction and hazardous waste reduction planning and implementation	Statement of facility-wide management policy for toxics use reduction Plan scope and objectives, including planned reductions in facility-wide use and byproduct generation from the relevant base year for each toxic or hazardous substance during the next 2 years and 5 years Economic and technical evaluation of technologies, procedures and training programs for achieving toxics use reduction Analysis of current and projected toxics use, byproduct generation and emissions Economic impacts of toxics use, including costs of raw material and byproduct storage, potential liability and regulatory compliance Plan implementation schedule 2 year and 5 year goals for the byproduct reduction index for each toxic or hazardous substance Plan certification by a toxics use reduction planner	Policy statement of upper management support for toxics reduction Description of current processes generating or releasing toxics, describing types, sources and quantities of toxics currently being generated or released Description of current and past toxics reduction practices and evaluation of their effectiveness Assessment of technically and economically practicable options available to eliminate or reduce the generation or release of toxics, which may include cost-benefit analysis Plan objectives and schedule for achieving objectives Explanation of the rationale for each objective List of options considered to be economically or technically impracticable Certification by facility manager and a company officer attesting the plan's accuracy	Policy statement of management support for waste minimization and plan implementation Plan scope and objectives, including evaluation of technologies, procedures and personnel training programs to ensure waste minimization Explanation and documentation of previous waste minimization efforts Analysis of waste streams and identification of opportunities to eliminate waste generation, including review of waste generating processes, evaluation of data on types, amounts and hazardous constituents of waste generated and potential waste minimization techniques Identification of waste management costs Employee awareness and training programs to involve employees in waste minimization planning and implementation Performance goals which shall be expressed in numeric terms wherever pr

SPECIFICITY (continued)

VARIABLES	NEW YORK	NORTH CAROLINA	OREGON	TENNESSEE	VERMONT	WASHINGTON
S3) Guidelines for Facility Plans	Identification of amounts and types of acute hazardous waste Identification of amounts and types of hazardous wastes generated during previous year Description of the process that resulted in such waste Calculation of the amount of waste generated per unit of production output, raw material used or other appropriate index Estimate of waste management costs, including storage, treatment, transportation, disposal and regulatory fees Evaluation of feasibility of implementing waste reduction processes for each waste Program to implement feasible waste reduction alternatives Evaluation of anticipated reduction in amount of hazardous waste produced as a result of implementing each waste reduction option Evaluation of cross-media transfers of waste reduction options	For hazardous waste permits: - written description of any program to minimize or reduce the volume and quantity or toxicity of waste For water quality permits: - written description of current and projected plans to reduce the discharge of waste and pollutants by source reduction or recycling For air quality permits: - written description of current and projected plans to reduce the emission of air contaminants by source reduction or recycling	Policy statement of upper management and corporate support for the plan and commitment to implement plan goals Plan scope and objectives, including evaluation of technologies, procedures and personnel training programs Internal analysis of toxics usage and hazardous waste streams, including evaluation of types and amounts of toxics used and waste generated, where and why toxics were used and waste was generated, potential reduction and recycling techniques Accounting systems that identify toxic use and waste management costs and factor in liability, compliance and oversight costs Employee awareness and training programs Institutionalization of plan by incorporation of plan into management practice and procedure Plan for implementing technically and economically practicable toxics use and hazardous waste reduction options	Policy statement of management support for the plan Plan scope and objectives, including evaluation of technologies, procedures and personnel training programs to ensure that unnecessary waste is not generated Description of hazardous waste reduction options and an implementation schedule. Options must be based on internal analysis of waste streams, including evaluation of types and amounts of waste generated, where and why waste was generated and potential reduction and recycling techniques Accounting systems that identify waste management costs and factor in liability, compliance and oversight costs Employee awareness and training programs Description of how plan has been or will be incorporated into management practices and procedures to insure an ongoing effort	Name, location, SIC code of site Identification of each routinely generated hazardous waste resulting from ongoing processes or operations that have a yearly weight > 5% of total yearly weight of hazardous waste or hazardous materials released into the environment; or acutely hazardous waste > 5% of total yearly weight Estimate of quantity of hazardous waste generated Evaluation of feasible source reduction methods Specification of, and rationale for, feasible source reduction methods which will be taken for each waste stream; rationale for rejecting any available source reduction method Evaluation of effects of chosen source reduction methods so as not to adversely affect compliance with applicable laws and regulations on emissions and discharges to air, water or land Timetable for making reasonable and measurable progress towards implementing selected source reduction methods	Policy statement of corporate support for plan Analysis of current hazardous substance use and waste generation and current reduction, recycling and treatment activities Identification and selection of further reduction, recycling and treatment options Analysis of impediments to implementing options Policy stating that in implementing selected options risks will not be shifted from one process, environmental media or product to another Hazardous waste accounting systems which factor in liability, compliance and oversight costs Financial description of plan Employee training and involvement programs 5 year plan implementation schedule Documentation of previous waste reduction efforts Executive summary of plan

SPECIFICITY (continued)

VARIABLES	CALIFORNIA	GEORGIA	MAINE	MASSACHUSETTS	MINNESOTA	MISSISSIPPI
S4) Performance Goals of Facility Plans	Specific numeric performance goals are not required, however, plan must include a timetable for making reasonable and measurable progress toward implementing selected source reduction methods	Specific performance goals for hazardous waste reduction must be expressed in numeric terms wherever technically and economically practicable. If numeric terms are not practical, plan must include a statement of objectives designed to lead to the establishment of numeric goals as soon as practicable. Rationale for each performance goal must be explained, including any impediments to hazardous waste reduction.	Facilities must achieve toxics release and hazardous waste reduction goals of 10% by 1993; 20% by 1995; 30% by 1997	If a majority of toxics users in a priority user segment fall significantly below standard achievements of byproduct generated per unit of product, DEP may require priority user segments to achieve a specified level of byproduct generated per unit of product, within a specified time frame	Wherever technically and economically practicable, objectives for eliminating or reducing the generation or release of each toxic pollutant must be expressed in numeric terms. Otherwise objectives must include a clearly stated list of actions designed to lead to the establishment of numeric goals as soon as practicable	Performance goals for waste minimization must be set in numeric terms to the extent practical

SPECIFICITY (continued)

VARIABLES	NEW YORK	NORTH CAROLINA	OREGON	TENNESSEE	VERMONT	WASHINGTON
S4) *Performance Goals of Facility Plans*	Evaluation of the anticipated reduction, in tons or other appropriate measurement, in the amount of hazardous wastes produced as a result of the implementation of each of the technically feasible and economically practicable waste reduction options	Not specified	Establish specific numeric performance goals for the following categories of toxic substances and hazardous wastes: Any toxic substance used in quantities in excess of 10,000 pounds a year; Any toxic substance used in quantities in excess of 1,000 pounds a year that constitutes 10% or more of the total toxics used; and For large quantity generators, any waste representing 10% or more by weight of the cumulative waste stream generated per year.	Specific performance goals shall be quantitative goals, expressed in numeric terms, established for the source reduction of each waste stream. When possible, units of measurement should be in pounds (or tons) of waste generated per standard unit of production, as defined by the generator. If numeric performance goals are not practical, performance goals shall include a clearly stated list of actions designed to lead to the establishment of numeric goals as soon as practical	Specific performance goals are not required, however, plan must include a timetable for making reasonable and measurable progress toward implementing selected source reduction methods	Specific performance goals must be expressed in numeric terms for each of the following categories: - hazardous substance use reduction or elimination - waste elimination or reduction - recycled materials or wastes - treated wastes If the establishment of numeric performance goals is not practical, goals shall include a clearly stated list of objectives designed to lead to numeric goals as soon as practical

SPECIFICITY (continued)

VARIABLES	CALIFORNIA	GEORGIA	MAINE	MASSACHUSETTS	MINNESOTA	MISSISSIPPI
S5) Requirements of Facility Progress Report	Name, location, SIC code of site Estimate of quantity of hazardous waste generated and managed, onsite and offsite, during the current reporting year and baseline reporting year Assessment of the effect, during the current year, of each hazardous waste management measure implemented since the baseline year, upon onsite and offsite hazardous waste generation, including source reduction, recycling and treatment measures Description of factors during the current year that have affected onsite and offsite hazardous waste generation since the baseline year Certification by a professional engineer; process or operations personnel onsite; environmental assessor with expertise in hazardous waste management	Analyze and quantify progress made, if any, in hazardous waste reduction, relative to each performance goal established in the plan Set forth amendments to the plan and explain the need for the amendments	Toxics use and toxics release reports must state progress toward meeting toxics use and toxics release goals, respectively Hazardous waste generators are not required to complete a progress report	Quantities of toxic or hazardous substances which are manufactured, processed, otherwise used, generated as byproduct, or shipped in product Indication of whether the substance was used in the production unit in amounts: - less than or equal to 5000 pounds; - greater than 5000 pounds but less than or equal to 10,000 pounds; and - greater than 10,000 lbs. Reporting base year Byproduct reduction index Emissions reduction index Matrix form of methods by which byproduct reduction index was achieved for each production operation	Summary of each objective established in the plan, including schedule for meeting objectives Summary of progress made during past year, if any, toward meeting each plan objective, including quantity of each toxic pollutant eliminated or reduced Statement of methods through which elimination or reduction has been achieved Explanation of reasons objectives were not achieved (if applicable), including identification of any technical, economic or other impediments Certification by facility manager and a company officer attesting the report's accuracy	Annual plan updates are required in lieu of progress reports, and must include: Analysis and quantification of progress made, if any, in waste minimization, relative to each performance goal Amendments, if any, to the plan and an explanation of the need for amendments

SPECIFICITY (continued)

VARIABLES	NEW YORK	NORTH CAROLINA	OREGON	TENNESSEE	VERMONT	WASHINGTON
S5) Requirements of Facility Progress Reports	Progress in achieving time schedule for implementing waste reduction alternatives Reasons for not implementing any waste reduction technology, process or operational change identified in the plan Explanation of why any waste reduction method chosen and implemented did not achieve anticipated waste reduction	Progress reports are not required	Analyze progress made, if any, in toxics use reduction and hazardous waste reduction, relative to each performance goal established in the plan Set forth amendments to the plan and explain the need for amendments Submit report to DEQ on quantities of toxics used and wastes generated that meet performance goal criteria, and a narrative explaining the data	Analyze and quantify progress made, if any, in hazardous waste reduction, relative to each performance goal established in the plan Set forth amendments, if needed, to the plan and explain the need for amendments The following summary information must be submitted to DHE as an element of the annual generator report: - For each hazardous waste stream, one of the following as appropriate: a) a statement of specific performance goals and a report on progress made in achieving these goals. Results should be in numeric terms. b) a report on the actions taken toward establishing numeric goals - A narrative explaining the reported data - A description of any impediments to reducing hazardous waste generation	Name, location, SIC code of site Quantity of hazardous waste generated and managed, onsite and offsite, during the current reporting year and baseline reporting year Assessment of the effect, during the current year, of each hazardous materials management measure implemented since the baseline year, upon onsite and offsite hazardous waste generation Description of factors during the current year that have affected hazardous waste generation, hazardous materials releases and onsite and offsite hazardous waste management since the baseline year Certification by a professional engineer; or a process or operations personnel onsite	Description of progress made toward achieving the specific performance goals established in the plan

SPECIFICITY (continued)

VARIABLES	CALIFORNIA	GEORGIA	MAINE	MASSACHUSETTS	MINNESOTA	MISSISSIPPI
S8) Conditions Where Pollution Prevention May Not Be Practicable	Selected measure is not technically feasible or economically practicable Attempts to implement the measure reveal that it would result in: 1) increased hazardous waste generation; 2) increased hazardous chemical releases to other environmental media; 3) adverse impacts on product quality; or 4) significant increase in risks of an adverse impact to human health or environment	For valid reasons of priority, a company chooses to address other more serious hazardous waste reduction concerns Necessary steps to reduce hazardous waste will likely have significant adverse impacts on product quality Legal or existing contractual obligations interfere with the necessary steps that would lead to hazardous waste reduction	Practicable hazardous waste reduction methods do not exist All practicable reductions or actions have been previously implemented or are currently being implemented Practicable steps necessary to reduce hazardous waste would have an unreasonable adverse impact on product quality Legal or contractual obligations prohibit steps necessary to reduce hazardous waste generation	Not specified	Not specified	Not specified

SPECIFICITY (continued)

VARIABLES	NEW YORK	NORTH CAROLINA	OREGON	TENNESSEE	VERMONT	WASHINGTON
S6) Conditions Where Pollution Prevention May Not Be Practicable	Not specified	Not specified	Impediments may include the availability of technically practicable toxics use reduction and hazardous waste reduction methods, and the economic practicability of available toxics use reduction and hazardous waste reduction methods, including any anticipated changes in the future. Examples of situations where reduction may not be economically practicable may include: For valid reasons of priority, a company chooses to first address other more serious toxics use reduction or hazardous waste reduction concerns Necessary steps to reduce toxics use and hazardous waste will likely have significant adverse impacts on product quality Legal or contractual obligations interfere with the necessary steps that would lead to toxics use reduction or hazardous waste reduction	For valid reasons of priority, a company chooses to first address other more serious hazardous waste reduction concerns Necessary steps to reduce hazardous waste will likely have significant adverse impacts on product quality Legal or contractual obligations interfere with the necessary steps that would lead to hazardous waste reduction	Not specified	Not specified

SPECIFICITY (continued)

VARIABLES	CALIFORNIA	GEORGIA	MAINE	MASSACHUSETTS	MINNESOTA	MISSISSIPPI
S7) Exemptions From Completing Facility Plan	DHS shall adopt regulations to establish procedures for exempting generators where the department determines no source reduction opportunities exist	Waste resulting from remediation or cleanup programs Commercial hazardous waste treatment, storage and disposal facilities upon certification to DNR that because of the nature of its business operation or process, the facility cannot meet the waste reduction requirements	<u>Hazardous waste reduction exemptions</u>: - Commercial hazardous waste treatment or storage facilities - Pilot plants or pilot production units - Hazardous waste transporters - Hazardous waste generated as a result of remedial or corrective actions or facility closures - Households - Agricultural operations <u>Toxics release reduction exemptions</u>: - Water supply treatment facilities - Municipal wastewater treatment facilities - Retail and wholesale motor fuel and heating oil distributors - Agricultural operations	Pilot plants and pilot production units Start-up production units for a specified time period	Toxic pollutants resulting solely from research and development activities	Commission of Environmental Quality is authorized to make exceptions to and grant exemptions and variances from rules and regulations implementing the statute

SPECIFICITY (continued)

VARIABLES	NEW YORK	NORTH CAROLINA	OREGON	TENNESSEE	VERMONT	WASHINGTON
S7) Exemptions From Completing Facility Plan	Hazardous waste generated by: - Corrective action for a release from a hazardous waste treatment, storage or disposal facility - Remediation of inactive disposal sites - Cleanup of environmental releases - Demolition and construction debris	Not specified	The definition of toxic substance does not include a substance used a pesticide or herbicide in routine commercial agricultural applications Conditionally exempt small quantity generators are not required to develop plans The law does not apply to hazardous waste generated by remedial activities taken in response to environmental contamination	Not specified	ANR shall adopt rules for exempting from facility planning requirements generators for whom the secretary determines no source reduction opportunities exist	The definition of hazardous substance user does not include those facilities which only distribute or use fertilizers or pesticides intended for commercial agricultural applications Persons required to prepare a plan may petition the DE to be excused from planning requirements, because of the quantity of hazardous waste generated Persons must demonstrate to the director's satisfaction that the quantity of hazardous waste generated was due to unique circumstances not likely to be repeated and that the person is unlikely to generate sufficient hazardous waste to require a plan in the next 5 years

ENFORCEABILITY

VARIABLES	CALIFORNIA	GEORGIA	MAINE	MASSACHUSETTS	MINNESOTA	MISSISSIPPI
E1) Agency Review of Facility Plans	Every two years, beginning 9/15/91, DHS shall select at least 2 categories of generators by SIC code with potential for source reduction and must examine those source reduction evaluation reviews and plans to assure compliance with statutory requirements Beginning 9/15/91, DHS may request a copy of a source reduction evaluation review and plan or plan summary from any generator and may evaluate any document to determine whether it satisfies statutory requirements Generators must retain a copy of the current review and plan and plan summary at each site (or a central location) and upon request shall make it available during any DHS inspection	All plans must be completed and submitted to DNR on or before 3/1/92 Plans shall be updated and submitted to DNR on a biennial basis	After 1/1/93, DEP may require a toxics releaser/hazardous waste generator to submit a summary of the toxics release/hazardous waste reduction plan when: - a facility fails to meet reduction goals - an exempted facility fails to meet alternate reduction goals established by DEP - toxics release rates or hazardous waste generation in a new facility is significantly greater per production unit than in similar facilities of the same SIC code	Plans are kept at the facility and must be made available to DEP upon request	Plans must be kept at the facility PCA shall be given access to a facility plan if the progress report does not meet statutory requirements	A generator or facility operator shall permit any designee of DEQ to review the waste minimization plan
E2) Agency Review of Facility Progress Reports	Beginning 9/15/91, DHS may request a copy of a hazardous waste management performance report or report summary from any generator and may evaluate any of these documents to determine whether it satisfies statutory requirements	Progress shall be reported on a biennial basis First updated biennial reports must be submitted to DNR in 1994	Toxics users and toxics releasers must report their progress toward meeting toxics use/release reduction goals as part of the reporting requirements to the State Emergency Response Commission	Annual toxic or hazardous substance reports must be submitted to DEP DEP must annually compile, analyze and summarize reports and plan summaries	PCA shall review all progress reports to determine if they meet statutory requirements	From the waste minimization plan and each annual update, the generator or facility operator shall submit a certified report of the types and quantities of wastes [illegible] and minimized

ENFORCEABILITY (continued)

VARIABLES	NEW YORK	NORTH CAROLINA	OREGON	TENNESSEE	VERMONT	WASHINGTON
E1) Agency Review of Facility Plans	DEC must review each plan according to a schedule established by statute	All written descriptions of current and projected plans to reduce hazardous wastes, waste water and pollutant discharges and air contaminant emissions shall be transmitted to the Solid Waste Management Division for review and analysis	Upon completing a plan, the user must notify DEQ in writing on a form supplied by DEQ Plans shall be retained at the facility Toxics users shall permit any DEQ employee to inspect the plan	Upon completing a plan, the generator shall maintain a current copy of the plan at the facility Generators shall permit the commissioner's designee to inspect the plan. Generators shall permit any officer, employee or DHE representative to have access to the plan Generators shall furnish a copy of the plan upon request to DHE	Every 2 years, beginning 7/1/92, ANR shall select at least 2 categories of generators by SIC code with potential for source reduction and must examine their source reduction review and plans to determine whether generators have complied with statutory requirements On or after 7/1/92, ANR may request a copy of the source reduction review and plan from any generator and may evaluate any document to determine whether it satisfies statutory requirements	Upon completing a plan, executive summaries of the plan shall be submitted to DE DE may review a plan or executive summary to determine whether the document is adequate pursuant to rules developed under statute and with statutory provisions Plans shall be retained at the facility Generators shall permit a DE representative to review the plan to determine its adequacy
E2) Agency Review of Facility Progress Reports	Annual status reports, describing a generator's progress in achieving its waste reduction implementation schedule, are required as part of hazardous waste generator reports	Progress reports are not required, however, plans are required annually	DEQ may review any progress report Progress reports shall remain at the facility except for the information specified in S5 above	Progress reports shall be retained at the facility, except for the information specified by statute to be reported to DHS Generators shall permit any officer, employee or DHS representative at all reasonable times to have access to the progress report	Hazardous materials management performance reports, documenting hazardous materials management approaches implemented by the generator, must be prepared by generators and submitted as part of the generator's hazardous waste annual report	Progress reports shall be prepared and submitted to DE in accordance with rules developed under statute DE may review an annual progress report to determine whether it is adequate pursuant to rules developed under statute and with statutory provisions

ENFORCEABILITY (continued)

VARIABLES	CALIFORNIA	GEORGIA	MAINE	MASSACHUSETTS	MINNESOTA	MISSISSIPPI
E3) Frequency of Facility Progress Report Submission to Agency	Every 4 years, beginning 9/1/91, generators must prepare a hazardous waste management performance report and summary	Generators must biennially complete a hazardous waste reduction progress report	Toxics users and toxics releasers must annually report progress toward meeting reduction goals Hazardous waste generators are not required to report progress	Toxic or hazardous substance reports must be submitted to DEP annually	Annual progress reports must be submitted to PCA	Annual plan updates must be prepared and must include quantification of progress in achieving performance goals
E4) Administrative Penalties for Noncompliance	Civil penalties in an amount not greater than $1000 may be imposed if a generator fails to submit a revised source reduction evaluation review and plan, plan summary, hazardous waste management performance report or report summary	No penalties	Fees for noncompliance with reduction requirements: Hazardous waste transported offsite for disposal: $0.18/lb. Hazardous waste transported offsite for treatment, storage or other handling, including beneficial reuse, reclamation or recycling: $0.135/lb.	Any individual or toxics user who violates the requirements of toxics use reduction planning or annual toxics and hazardous substance reporting shall be punished by a fine in an amount between $2500 and $25,000, or by imprisonment for not more than one year, or by both	If a modified progress report does not meet statutory requirements, a public meeting will be held in the county where the facility is located	No penalties

ENFORCEABILITY (continued)

VARIABLES	NEW YORK	NORTH CAROLINA	OREGON	TENNESSEE	VERMONT	WASHINGTON
E3) Frequency of Facility Progress Report Submission to Agency	Annual status reports must be submitted to DEC	Progress reports are not required, however, plans are required annually	All toxics users shall annually complete a toxics use reduction and hazardous waste reduction progress report	Based on their annual progress report, generators shall annually submit to DHE summary information on waste reduction activities	Hazardous materials management performance reports must be submitted annually	Annual progress reports must be submitted to DE
E4) Administrative Penalties for Noncompliance	Any generator whose plan has been rejected by DEC is not allowed to make the hazardous waste manifest certification	Fine or permit revocation, depending on whether air, water or hazardous waste	If a toxics user fails to develop an adequate plan or progress report according to DEQ's required modifications, DEQ may issue an administrative order requiring the user to submit a plan or progress report. If the user fails to submit an adequate plan or progress reports within the time specified, DEQ shall conduct a public hearing on the plan or progress report. In any hearing, the relevant plan or progress report shall be considered public record, except for trade secret information	Civil penalties of up to $10,000 shall be imposed on any generator or person who: - fails to file any required reports, records or documents - fails, neglects or refuses to comply with any statutory provisions or orders issued pursuant to the statute - knowingly gives false information in any required report, record or document	No penalties	A penalty fee of either $1000 or 3 times the amount of the generator's previous year's fee or current year's fee, whichever is greater, shall be charged if a generator fails to complete plan, executive summary or progress report modifications required by DE

ENFORCEABILITY (continued)

VARIABLES	CALIFORNIA	GEORGIA	MAINE	MASSACHUSETTS	MINNESOTA	MISSISSIPPI
E5) Public Access to Facility Plans	Any person may request DHS to certify that a generator is in compliance with statutory requirements by having DHS certify that the generator has properly completed the source reduction evaluation review and plan, plan summary, hazardous waste management performance report and summary. DHS shall request a copy of such documents from the generator and shall forward a copy to the person requesting certification. Any person may directly request from a generator a copy of the review and plan, plan summary, report or report summary	DNR shall maintain a copy of each hazardous waste reduction plan and biennial progress report received. This information shall be available to the public at the director's office.	Not specified	Any 10 residents living within 10 miles of a facility required to prepare a toxics use reduction plan may petition DEP to examine the plan, plan summary and any required back up data and determine their adequacy. DEP shall report its determination to the petitioners and the toxics user within a reasonable time. DEP shall make available for resident review all toxics use reduction plan summaries, provided that trade secret information is protected	Plans are nonpublic data 25 or more persons living within 10 miles of the facility may submit a petition that identifies specific deficiencies in the progress report and requests PCA to review the facility plan. Within 30 days after receipt of the petition, PCA shall respond in writing. If the commissioner agrees that the progress report does not meet statutory requirements, PCA shall be given access to the facility plan.	A waste minimization plan and any updates shall be retained at the facility and shall not be subject to inspection, examination, copying or reproduction
E6) Public Access to Facility Progress Reports	Same as provisions for Public Access to Facility Plans	Same as provisions for Public Access to Facility Plans	Not specified	DEP shall make available for resident review all annual toxic or hazardous substance reports provided that trade secret information is protected	Progress reports are public data	Same as plan updates under provisions for Public Access to Facility Plans

ENFORCEABILITY (continued)

VARIABLES	NEW YORK	NORTH CAROLINA	OREGON	TENNESSEE	VERMONT	WASHINGTON
E5) Public Access to Facility Plans	Not specified	Not specified in statute, however, pollution prevention plans become part of the facility permit and compliance files, and are available for public review	DEQ shall maintain a log of each plan or progress report it reviews, a list of all plans or progress reports that have been found to be inadequate and descriptions of corrective actions taken. This information shall be available to the public at DEQ. If a public hearing is held on any plan or progress report, the relevant plan or progress report, excepting trade secret information, shall be considered a public record	Plans shall not be considered public record	Not specified	DE shall make available for public inspection any submitted executive plan summary, protecting confidential information Any 10 persons residing within 10 miles of a facility required to prepare a plan may file a petition requesting DE to examine a plan to determine its adequacy DE shall maintain and make available to the public, a record of each plan, executive summary or progress report it reviews, determines to be inadequate, or for which corrective action is taken.
E6) Public Access to Facility Progress Reports	Not specified	Progress reports are not required	See provisions of Public Access to Facility Plans	Progress reports shall not be considered public record	Not specified	DE shall make available for public inspection any submitted annual progress report, protecting confidential information See provisions for Public Access to Facility Plans

ENFORCEABILITY (continued)

VARIABLES	CALIFORNIA	GEORGIA	MAINE	MASSACHUSETTS	MINNESOTA	MISSISSIPPI
E7) Plan Approval Criteria	DHS shall not judge the appropriateness of any decision or proposed measures contained in a review and plan, plan summary, report or report summary, but shall only determine whether the document is complete, prepared and implemented in according with the statute	Not specified	In reviewing the adequacy of any plan summary, the commissioner shall base a determination on whether the plan summary is complete and prepared in accordance with the goals and guidelines established by statute	DEP shall specify criteria for acceptable plans according to statutory requirements Plans must be certified by a toxics use reduction planner as meeting the department's criteria for acceptable plans	After reviewing the plan and progress report with any modifications submitted, the commissioner shall state in writing whether the progress report meets statutory requirements	Not specified

ENFORCEABILITY (continued)

VARIABLES	NEW YORK	NORTH CAROLINA	OREGON	TENNESSEE	VERMONT	WASHINGTON
E7) Plan Approval Criteria	Review of hazardous waste reduction plans shall be subject to the following standards. DEC may reject any plan or biennial update which: - fails to contain all components required by statute - fails to apply generally accepted engineering, scientific or economic principles and practices - accomplishes waste reduction by transfers to other environmental media without an environmental benefit from such transfers - is inconsistent with the preferred hazardous waste management practices hierarchy - involves conduct prohibited by any applicable law or regulation - fails to provide a basis for charting waste reduction trends over time - beginning with the 1st biennial update, fails to demonstrate reasonable progress in implementing chosen waste reduction alternatives according to the established time schedule; or fails to reevaluate alternatives	Not specified	In reviewing the adequacy of any plan or progress report, DEQ shall base its determination solely on whether the document is complete and prepared in accordance with planning guidelines	DHS may review a plan or annual progress report to determine whether the document reasonably contains the elements specified by statute	ANR may evaluate any of the documents submitted to determine whether they satisfy statutory requirements	In determining the adequacy of any plan, executive summary or annual progress report, DE shall base its determination solely on whether the document is complete and prepared in accordance with statutory provisions

ENFORCEABILITY (continued)

VARIABLES	CALIFORNIA	GEORGIA	MAINE	MASSACHUSETTS	MINNESOTA	MISSISSIPPI
E8) External Checks on Administrative Actions	Every other year, beginning 7/1/93, the director shall prepare and submit to the governor and legislature a report of DHS's operations and activities in carrying out the statute By 12/1/93, the auditor general shall submit a report to the legislature assessing the performance of DHS in carrying out the statute	Not specified	The Toxics Use Advisory Committee shall serve as a review body to assess the progress in implementation of the statute and shall advise DEP in carrying out the policies and purposes of the statute	DEP annually shall submit a report to the Administrative Council and the legislature on actual and expected progress in toxics use reduction and emissions reduction Administrative Council shall annually make policy recommendations in a report to the governor regarding toxics use reduction and the implementation of the statute Advisory Board on Toxics Use Reduction shall provide a forum for discussion and deliberation on matters pertaining to the statute's implementation The superior court has jurisdiction to enforce statutory requirements in an action brought by any 10 state residents against a toxics user, or a department official for failure to perform a nondiscretionary act	Not specified	Not specified

ENFORCEABILITY (continued)

VARIABLES	NEW YORK	NORTH CAROLINA	OREGON	TENNESSEE	VERMONT	WASHINGTON
E8) External Checks on Administrative Actions	Not specified	The department shall report to the Environmental Review Commission as to the progress in implementing the pollution prevention planning program	An advisory committee, consisting of representatives of the public and affected industries, shall assist DEQ in establishing rules and may advise on any matter related to toxics use reduction and hazardous waste reduction By 1/1/91 and 1/1/93, the Environmental Quality Commission shall report to the legislature on the status of implementing the toxics use reduction and hazardous waste reduction program. The report shall include information regarding the status of the technical assistance program, progress toward reducing the quantities of toxic substances used and hazardous wastes generated in Oregon, and an analysis and recommendations for changes to the program including but not limited to the need for any additional enforcement provisions.	Not specified	Every other year, beginning 1/1/94, the secretary shall prepare and submit to the legislature a report of ANR's operation and activities in carrying out the program	Not specified

FUNDING

CALIFORNIA	GEORGIA	MAINE	MASSACHUSETTS	MINNESOTA	MISSISSIPPI
By 1/1/91, DHS must adopt, by regulation, a fair and equitable system of charging and collecting a fee from hazardous waste generators. The fee must be in an amount sufficient to produce revenues to efficiently and effectively implement the Hazardous Waste Reduction and Management Review Act	No funding established	The following fees will be charged annually and deposited in a separate account within the Hazardous Waste Fund to cover implementation of the toxics and hazardous waste reduction program: Hazardous waste generators: $50 Toxics users: $25 Toxics releasers: $25 4 staff positions and $142,238 will be authorized from the hazardous waste fund to the toxics and hazardous waste reduction program All monies received in fees will be deposited in a separate account in the hazardous waste fund to cover costs of administering the toxics and hazardous waste reduction program	A toxics use fee is initially established as follows: # Employees / Base Fee / Max Fee 10 - 49 / 500 / 50 - 99 / 750 / 1500 100-499 / 1250 / 4000 >500 / 2500 / 8500 The base fee is increased by $300 for each toxic or hazardous substance provided that the fee does not exceed the maximum fee The administrative council will adjust the toxics use fees by regulation, based on a survey of all toxics users, to ensure that the projected aggregate fee is between $4 million and $5.5 million. The council may adjust base fees, amount per chemical reported and maximum fees.	PCA is appropriated $45,000 and authorized 1 staff position Office of Waste Management is appropriated $87,000 and authorized 3 staff positions. Department of Public Safety is appropriated $48,000 and authorized 1 staff position to ensure timely and accurate submittal of TRI forms and annual progress reports TRI facilities must pay a pollution prevention fee of $150 for each toxic pollutant reported released, plus a fee based on the total pounds of toxic pollutants released per facility. Facilities reporting annual releases of toxic pollutants less than 25,000 pounds will be assessed a $500 fee. Facilities reporting more than 25,000 pounds will be assessed a graduated fee of $0.02/pound of toxic pollutants reported, not to exceed a total of $30,000 per facility.	An annual waste minimization tax will be charged to all large and small quantity generators and TRI facility operators. Tons Generated/Released / Tax ($) .01 - 9.99 / 250 10 - 99.99 / 500 100-999.99 / 1500 1000-9999.99 / 2500 10,000-49,999.99 / 10,000 50,000 and above / 50,000 The generator or facility operator is liable for a penalty equal to 3 times the amount of the tax due and payable for failure to pay the tax on or before the due date, plus the amount necessary to reimburse the cost of collection.

FUNDING (continued)

NEW YORK	NORTH CAROLINA	OREGON	TENNESSEE	VERMONT	WASHINGTON
No funding established	No funding established	No funding established	No funding established	Generators are required to pay a tax based on the volume and destination of manifested hazardous waste: Destination / Cents/Gallon / Cents/Pound reclaimed, recycle, recovery: 11 / 1.4 * treatment: 22 / 2.8 long-term storage: 33 / 4.2 land disposal or land treatment: 44 / 5.6 This tax rate has a three year sunset provision * (other than land treatment)	An annual fee of $35, first due 7/31/90, will be imposed on every known hazardous waste generator or potential generator. Funds collected will be used to support the Office of Waste Reduction. Generators and hazardous substance users required to prepare plans must pay an additional fee to support implementation of pollution prevention planning requirements. The annual facility fee shall not exceed $10,000/year. Facilities generating less than 2640 pounds/year are exempt from this fee. Facilities generating at least 2640 pounds/year but not more than 4000 pounds/year shall pay a fee of not more than $50. DE shall adopt a fee schedule, by rule, after consulting with affected businesses. Hazardous waste generated and recycled for beneficial use, including initial amounts of hazardous substances introduced into a process and subsequently recycled for beneficial use, shall not be used in the calculations of hazardous waste generated for purposes of determining fees. These fees are to be used by DE for plan review, technical assistance to facilities that are required to prepare plans, other activities related to plan development and implementation and associated indirect costs.

Waste Reduction Institute for
Training and Applications Research
1313 5th St. SE
Minneapolis, MN 55414

Final

Senate Bill No. 14

CHAPTER 1218

An act to add Article 11.9 (commencing with Section 25244.12) to Chapter 6.5 of Division 20 of the Health and Safety Code, relating to hazardous waste.

[Approved by Governor October 1, 1989. Filed with Secretary of State October 1, 1989.]

LEGISLATIVE COUNSEL'S DIGEST

SB 14, Roberti. Hazardous waste: reduction.

(1) Under existing law, every generator of hazardous wastes is required to submit a report to the State Department of Health Services at least once every 2 years concerning changes in waste volume and toxicity achieved through waste reduction. Under existing law, the money in the Hazardous Waste Control Account in the General Fund may be expended by the department, upon appropriation by the Legislature, to carry out the hazardous waste control law.

This bill would enact the Hazardous Waste Reduction and Management Review Act of 1989, which would require the department to adopt a format to be used by generators by January 1, 1991, and to establish a technical and research assistance program to assist hazardous waste generators in reducing hazardous waste.

The bill would require each generator of hazardous waste, as specified, on or before September 1, 1991, and every 4 years thereafter, to complete and conduct a source evaluation review and plan and a source evaluation review and plan summary specifying source reduction measures which will be implemented by the generator. The bill would require each generator to certify that the plan will be implemented. The bill would also require each generator of hazardous waste, on or before September 1, 1991, and every 4 years thereafter, to prepare a hazardous waste management performance report and a hazardous waste management performance report summary concerning the hazardous waste management approaches implemented by the generator.

The bill would require the department to select at least 2 categories of generators on or before September 1, 1992, and every 2 years thereafter, for specified enforcement activities. The bill would also authorize the department, on and after September 15, 1991, to require a generator to provide the department with a copy of the generator's review and plan, plan summary, report, or report summary, within 30 days after the request of the department. The department would be required to take specified enforcement actions to require the completion of the review and plan, plan summary, report, or report summary and would be authorized to take

certain

enforcement actions to require the implementation of the review and plan or plan summary.

The bill would require the State Director of Health Services to submit a report to the Governor and the Legislature commencing July 1, 1993, and once every other year thereafter, concerning the implementation of the act and would require the Auditor General to submit a report by December 1, 1993, assessing the department's performance in the implementation of the act. The bill would also establish procedures for the protection of trade secrets.

The bill would require the department to adopt, by regulation, on or before January 1, 1991, a system for charging and collecting a fee from generators subject to the act, set in an amount sufficient to produce revenues to implement the act and would authorize the department to set the fees at a level to repay the Hazardous Waste Control Account for the initial costs of implementing the act. The fees would be required to be paid by September 1, 1991, and to be deposited in the Hazardous Waste Control Account in the General Fund, for expenditure by the department, upon appropriation by the Legislature, to carry out the act.

(2) The California Constitution requires the state to reimburse local agencies and school districts for certain costs mandated by the state. Statutory provisions establish procedures for making that reimbursement.

This bill would impose a state-mandated local program by creating new crimes concerning the generation of hazardous waste.

The bill would provide that no reimbursement is required by this act for a specified reason.

The people of the State of California do enact as follows:

SECTION 1. Article 11.9 (commencing with Section 25244.12) is added to Chapter 6.5 of Division 20 of the Health and Safety Code, to read:

Article 11.9. Hazardous Waste Source Reduction and Management Review Act of 1989

25244.12. This article shall be known and may be cited as the Hazardous Waste Source Reduction and Management Review Act of 1989.

25244.13. The Legislature finds and declares as follows:

(a) Existing law requires the department and the State Water Resources Control Board to promote the reduction of generated hazardous waste. This policy, in combination with hazardous waste land disposal bans, requires the rapid development of new programs and incentives for achieving the goal of optimal minimization of the generation of hazardous wastes. Substantial improvements and additions to the state's hazardous waste reduction program are

required to be made if these goals are to be achieved.

(b) It is the goal of this article to do all of the following:

(1) Reduce the generation of hazardous waste.

(2) Reduce the release into the environment of chemical contaminants which have adverse and serious health or environmental effects.

(3) Document hazardous waste management information and make that information available to state and local government.

(c) It is the intent of this article to promote the reduction of hazardous waste at its source, and wherever source reduction is not feasible or practicable, to encourage recycling. Where it is not feasible to reduce or recycle hazardous waste, the waste should be treated in an environmentally safe manner to minimize the present and future threat to health and the environment.

(d) It is the intent of the Legislature not to preclude the regulation of environmentally harmful releases to all media, including air, land, surface water, and groundwater, and to encourage and promote the reduction of these releases to air, land, surface water, and groundwater.

(e) It is the intent of the Legislature to encourage all state departments and agencies, especially the State Water Resources Control Board, the California regional water quality control boards, the State Air Resources Board, the air pollution control districts, and the air quality management districts, to promote the reduction of environmentally harmful releases to all media.

25244.14. For purposes of this article, the following definitions apply:

(a) "Appropriate local agency" means a county, city, or regional association which has adopted a hazardous waste management plan pursuant to Article 3.5 (commencing with Section 25135).

(b) "Hazardous waste management approaches" means approaches, methods, and techniques of managing the generation and handling of hazardous waste, including source reduction, recycling, and the treatment of hazardous waste.

(c) "Hazardous waste management performance report" or "report" means the report required by subdivision (b) of Section 25244.20 to document and evaluate the results of hazardous waste management practices.

(d) "Hazardous waste management performance report summary" or "report summary" means the summary required by subdivision (c) of Section 25244.20.

(e) (1) "Source reduction" means one of the following:

(A) Any action which causes a net reduction in the generation of hazardous waste.

(B) Any action taken before the hazardous waste is generated that results in a lessening of the properties which cause it to be classified as a hazardous waste.

(2) "Source reduction" includes, but is not limited to, all of the

following:

(A) "Input change" which means a change in raw materials or feedstocks used in a production process or operation so as to reduce, avoid, or eliminate the generation of hazardous waste.

(B) "Operational improvement" which means improved site management so as to reduce, avoid, or eliminate the generation of hazardous waste.

(C) "Production process change" which means a change in a process, method, or technique which is used to produce a product or a desired result, including the return of materials or their components, for reuse within the existing processes or operations, so as to reduce, avoid, or eliminate the generation of hazardous waste.

(D) "Product reformulation" which means changes in design, composition, or specifications of end products, including product substitution, so as to reduce, avoid, or eliminate the generation of hazardous waste.

(3) "Source reduction" does not include any of the following:

(A) Actions taken after a hazardous waste is generated.

(B) Actions that merely concentrate the constituents of a hazardous waste to reduce its volume or that dilute the hazardous waste to reduce its hazardous characteristics.

(C) Actions that merely shift hazardous wastes from one environmental medium to another environmental medium.

(D) Treatment.

(f) "Source reduction evaluation review and plan" or "review and plan" means a review conducted by the generator of the processes, operations, and procedures in use at a generator's site, according to the format established by the department pursuant to subdivision (a) of Section 25244.16, and which does both of the following:

(1) Determines any alternatives to, or modifications of, the generator's processes, operations, and procedures that may be implemented to reduce the amount of hazardous waste generated.

(2) Includes a plan to document and implement source reduction measures for the hazardous wastes specified in paragraph (1) which are technically feasible and economically practicable for the generator, including a reasonable implementation schedule.

(g) "Source reduction evaluation review and plan summary" or "plan summary" means the summary required by subdivision (c) of Section 25244.19.

(h) "SIC Code" has the same meaning as defined in Section 25501.

(i) "Hazardous waste," "person," "recycle," and "treatment" have the same meaning as defined in Article 2 (commencing with Section 25110).

25244.15. (a) The department shall establish a program for hazardous waste source reduction pursuant to this article.

(b) The department shall coordinate the activities of all state agencies with responsibilities and duties relating to hazardous waste and shall promote coordinated efforts to encourage the reduction of hazardous waste. Coordination between the program and other relevant state agencies and programs shall, to the fullest extent possible, include joint planning processes and joint research and studies.

(c) The department shall adopt regulations to carry out this article.

(d) (1) This article applies only to generators who, by site, routinely generate, through ongoing processes and operations, more than 12,000 kilograms of hazardous waste in a calendar year, or more than 12 kilograms of extremely hazardous waste in a calendar year.

(2) The department shall adopt regulations to establish procedures for exempting generators from the requirements of this article where the department determines that no source reduction opportunities exist for the generator.

25244.16. On or before January 1, 1991, the department shall do both of the following:

(a) Adopt a format to be used by generators for completing the review and plan and plan summary required by Section 25244.19, and the report and the report summary required by Section 25244.20. The format shall include at least all of the factors the generator is required to include in the review and plan, the plan summary, the report, and the report summary. The department may include any other factor determined by the department to be necessary to carry out this article. The adoption of a format pursuant to this subdivision is not subject to Chapter 3.5 (commencing with Section 11340) of Part 1 of Division 3 of Title 2 of the Government Code.

(b) Establish a data and information system to be used by the department for developing the categories of generators specified in Section 25244.18, for processing and evaluating the source reduction and other hazardous waste management information submitted by generators pursuant to Section 25244.18, and for developing the program evaluation required by Section 25244.22. In establishing the data and information system, the department shall do all of the following:

(1) Establish methods and procedures for appropriately processing or managing hazardous waste source reduction and management information.

(2) Use the data management expertise, resources, and forms of already established environmental protection programs, to the extent practicable.

(3) Establish computerized data retrieval and data processing systems, including safeguards to protect trade secrets designated pursuant to Section 25244.23.

(4) Identify additional data and information needs of the program.

25244.17. The department shall establish a technical and research assistance program to assist generators in identifying and applying methods of source reduction and other hazardous waste management approaches. The program shall emphasize assistance to smaller businesses that have inadequate technical and financial resources for obtaining information, assessing source reduction methods, and developing and applying source reduction techniques. The program shall include at least all of the following elements, which shall be carried out by the department:

(a) The department shall encourage programs by private or public consultants, including onsite consultation at sites or locations where hazardous waste is generated, to aid those generators requiring assistance in developing and implementing the review and plan, the plan summary, the report, and the report summary required by this article.

(b) The department shall conduct review and plan assistance programs, seminars, workshops, training programs, and other similar activities to assist generators to evaluate source reduction alternatives and to identify opportunities for source reduction.

(c) The department shall establish a program to assemble, catalogue, and disseminate information about hazardous waste source reduction methods, available consultant services, and regulatory requirements.

(d) The department shall identify the range of generic and specific technical solutions that can be applied by particular types of hazardous waste generators to reduce hazardous waste generation.

25244.18. (a) On or before September 15, 1991, and every two years thereafter, the department shall select at least two categories of generators by SIC Code with potential for source reduction, and, for each category, shall do all of the following:

(1) Request that selected generators in the category provide the department, on a timely basis, with a copy of the generator's completed review and plan, or plan summary, or both, and with a copy of the generator's completed report, or report summary, or both.

(2) Examine the review and plan or plan summary and the report or report summary of selected generators in the category.

(3) Ensure that the selected generators in that category comply with Sections 25244.19 and 25244.20.

(4) Identify successful source reduction and other hazardous waste management approaches employed by generators in the category and disseminate information concerning those approaches to generators within the category.

(b) In carrying out subdivision (a), the department shall not disseminate information determined to be a trade secret pursuant to Section 25244.23.

(c) On and after September 15, 1991, the department may request from any generator, and the generator shall provide within 30 days of the request, a copy of the generator's review and plan, plan summary, report, or report summary. The department may evaluate any of these documents submitted to the department to determine whether it satisfies the requirements of this article.

(d) If the department determines that a generator has not completed the review and plan or plan summary in the manner required by Section 25244.19, or the report or report summary in the manner required by Section 25244.20, the department shall provide the generator with a notice of noncompliance, specifying the deficiencies in the review and plan, plan summary, report, or report summary identified by the department. If the department finds that the review and plan does not comply with Section 25244.19, the department shall consider the review and plan to be incomplete. A generator shall file a revised review and plan, plan summary, report, or report summary correcting the deficiencies identified by the department within 60 days of the receipt of the notice. The department may grant, in response to a written request from the generator, an extension of the 60-day deadline, for cause, except that the department shall not grant this extension for more than an additional 60 days.

If a generator fails to submit a revised review and plan, plan summary, report, or report summary complying with the requirements of this article within the required period, or if the department determines that a generator has failed to implement the measures included in the generator's review and plan or plan summary for reducing the generator's hazardous waste, in accordance with Section 25244.19, except as provided in subdivision (e), the department may impose civil penalties pursuant to Section 25189.3, in an amount not to exceed one thousand dollars ($1,000) for each day the violation of this article continues, notwithstanding Section 25189.2, seek an order directing compliance pursuant to Section 25181, or enter into a consent agreement or a compliance schedule with the generator.

(e) If a generator fails to implement a measure specified in the review and plan, or plan summary, pursuant to paragraph (5) of subdivision (b) of Section 25244.19, the generator shall not be deemed to be in violation of Section 25244.19 for not implementing the selected measure if the generator does both of the following:

(1) The generator finds that, upon further analysis or as a result of unexpected consequences, the selected measure is not technically feasible or economically practicable, or if the selected approach has resulted in any of the following:

(A) An increase in the generation of hazardous waste.

(B) An increase in the release of hazardous chemical contaminants to other media.

(C) Adverse impacts on product quality.

(D) A significant increase in the risk of an adverse impact to human health or the environment.

(2) The generator revises the review and plan and plan summary to comply with the requirements of Section 25244.19.

(f) When taking enforcement action pursuant to this article, the department shall not judge the appropriateness of any decisions or proposed measures contained in a review and plan, plan summary, report, or report summary, but shall only determine whether the review and plan, plan summary, report, or report summary is complete, prepared, and implemented in accordance with this article.

(g) On and after September 15, 1991, an appropriate local agency which has jurisdiction over a generator's site may request from the generator, and the generator shall provide within 30 days, a copy of the generator's current review and plan, plan summary, report, and report summary.

25244.19. (a) On or before September 1, 1991, and every four years thereafter, each generator shall conduct a source reduction evaluation review and plan and a source reduction evaluation review and plan summary pursuant to subdivisions (b) and (c).

(b) Except as provided in subdivision (d), the source reduction evaluation review and plan required by subdivision (a) shall be conducted and completed for each site pursuant to the format adopted pursuant to subdivision (a) of Section 25244.16 and shall include, at a minimum, all of the following:

(1) The name and location of the site.

(2) The SIC Code of the site.

(3) Identification of all routinely generated hazardous waste streams which result from ongoing processes or operations that have a yearly volume exceeding 5 percent of the total yearly volume of hazardous waste generated at the site, or, for extremely hazardous waste, 5 percent of the total yearly volume generated at the site.

(4) For each hazardous waste stream identified in paragraph (3), the review and plan shall include all of the following information:

(A) An estimate of the quantity of hazardous waste generated.

(B) An evaluation of source reduction approaches available to the generator which are potentially viable. The evaluation shall consider at least all of the following source reduction approaches:

(i) Input change.

(ii) Operational improvement.

(iii) Production process change.

(iv) Product reformulation.

(5) A specification of, and a rationale for, the technically feasible and economically practicable source reduction measures which will be taken by the generator with respect to each hazardous waste stream identified in paragraph (3). The review and plan shall fully document any statement explaining the generator's rationale for rejecting any available source reduction approach identified in paragraph (4).

(6) An evaluation, and, to the extent practicable, a quantification, of the effects of the chosen source reduction method on emissions and discharges to air, water, or land.

(7) A timetable for making reasonable and measurable progress

towards implementation of the selected source reduction measures specified in paragraph (5).

(8) Certification pursuant to subdivision (e).

(c) The source reduction evaluation review and plan summary required by subdivision (a) shall be completed in accordance with the format adopted pursuant to subdivision (a) of Section 25244.19 and shall include the information specified in paragraphs (1), (2), (3), and (6) of subdivision (b) and a summary of the information required pursuant to paragraphs (4) and (5) of subdivision (b).

(d) If a generator owns or operates multiple sites with similar processes, operations, and waste streams, the generator may prepare a single multisite review and plan and plan summary addressing all of these sites.

(e) Every review and plan and plan summary conducted pursuant to this section shall be submitted by the generator for review and certification by an engineer who is registered as a professional engineer pursuant to Section 6762 of the Business and Professions Code and who has demonstrated expertise in hazardous waste management, by an individual who is responsible for the processes and operations of the site, or by an environmental assessor who is registered pursuant to Section 25570.3 and who has demonstrated expertise in hazardous waste management. The engineer, individual, or environmental assessor shall certify the review and plan and plan summary only if the review and plan and plan summary meet all of the following requirements:

(1) The review and plan addresses each hazardous waste stream identified pursuant to paragraph (3) of subdivision (b).

(2) The review and plan addresses the source reduction approaches specified in subparagraph (B) of paragraph (4) of subdivision (b).

(3) The review and plan clearly sets forth the measures to be taken with respect to each hazardous waste stream for which source reduction has been found to be technically feasible and economically practicable, with timetables for making reasonable and measurable progress, and properly documents the rationale for rejecting available source reduction measures.

(4) The plan summary meets the requirements of subdivision (c).

(5) The review and plan and plan summary does not merely shift hazardous waste from one environmental medium to another environmental medium by increasing emissions or discharges to air, water, or land.

(f) At the time a review and plan or a plan summary is submitted to the department, the generator shall certify that the generator has implemented, is implementing, or will be implementing, the source reduction measures identified in the review and plan or the plan summary according to the implementation schedule contained in the review and plan or the plan summary. A generator may determine not to implement subdivision (b) only if the generator determines, upon conducting further analysis or due to unexpected circumstances, that the selected measure is not technically feasible or economically practicable, or if attempts to implement that measure reveal that the measure would result in, or has resulted in, any of the following:

(1) An increase in the generation of hazardous waste.

(2) An increase in the release of hazardous chemicals to other environmental media.

(3) Adverse impacts on product quality.

(4) A significant increase in the risk of an adverse impact to human health or the environment.

(g) If the generator elects not to implement the review and plan or plan summary, including, but not limited to, a selected measure pursuant to subdivision (f), the generator shall amend its review and plan and plan summary to reflect this rejection and include in the review and plan and plan summary proper documentation identifying the rationale for this rejection.

25244.20. (a) On or before September 1, 1991, and every four years thereafter, each generator shall prepare a hazardous waste management performance report and a hazardous waste management performance report summary documenting hazardous waste management approaches implemented by the generator.

(b) Except as provided in subdivision (e), the hazardous waste management performance report required by subdivision (a) shall be prepared for each site in accordance with the format adopted pursuant to subdivision (a) of Section 25244.16 and shall include all of the following:

(1) The name and location of the site.

(2) The SIC Code for the site.

(3) All of the following information for each waste stream identified pursuant to paragraph (3) of subdivision (b) of Section 25244.19:

(A) An estimate of the quantity of hazardous waste generated and the quantity of hazardous waste managed, both onsite and offsite, during the current reporting year and the baseline year, as specified in subdivision (d).

(B) An assessment of the effect, during the current year, of each hazardous waste management measure implemented since the baseline year, upon the generation and the onsite and offsite management of hazardous waste. The report shall consider, but shall not be limited to, measures which use all of the following approaches:

(i) Source reduction.

(ii) Recycling.

(iii) Treatment.

(C) A description of factors during the current reporting year that have affected hazardous waste generation and onsite and offsite hazardous waste management since the baseline year, including, but not limited to, any of the following:

(i) Changes in business activity.

(ii) Changes in waste classification.

(iii) Natural phenomena.

(iv) Other factors that have affected either the quantity of hazardous waste generated or onsite and offsite hazardous waste management requirements.

(4) The certification of the report pursuant to subdivision (f).

(c) The hazardous waste management performance report summary required by subdivision (a) shall be completed in accordance with the format adopted pursuant to subdivision (a) of Section 25244.16, shall provide the information specified in paragraphs (1) and (2) of subdivision (b), and a summary of the information required by paragraph (3) of subdivision (b), and shall be certified pursuant to subdivision (f).

(d) For purposes of subdivision (b), the following definitions apply:

(1) The current reporting year is the calendar year immediately preceding the year in which the report is to be prepared.

(2) The baseline year is either of the following, whichever is applicable:

(A) For the initial report, the baseline year is the calendar year selected by the generator for which substantial hazardous waste generation, or onsite or offsite management data is available, prior to 1991, except the generator may select 1990 as the baseline year. If the generator selects 1990 as the baseline year for the initial report, the information required pursuant to paragraph (3) of subdivision (b) for the initial report shall be provided for the 1990 calendar year only.

(B) For all subsequent reports, the baseline year is the current reporting year of the immediately preceding report.

(e) If a generator owns or operates multiple sites with similar processes, operations, and waste streams, the generator may prepare a single multisite report and report summary addressing all of these sites.

(f) Every report and report summary completed pursuant to this section shall be submitted by the generator for review and certification by an engineer who is registered as a professional engineer pursuant to Section 6762 of the Business and Professions Code and who has demonstrated expertise in hazardous waste management, by an individual who is responsible for the processes and operations of the site, or by an environmental assessor who is registered pursuant to Section 25570.3 and who has demonstrated expertise in hazardous waste management. The engineer, individual, or environmental assessor shall certify the report and report summary only if the report and report summary meet all of the following requirements, as applicable:

(1) The report identifies factors that affect the generation and onsite and offsite management of hazardous wastes and summarizes

the effect of those factors on the generation and onsite and offsite management of hazardous wastes.

(2) The report summary complies with the requirements specified in subdivision (e).

25244.21. (a) Every generator shall retain the original of the current review and plan, plan summary, report, and report summary, shall maintain a copy of the current review and plan, plan summary, report, and report summary at each site, or, for a multisite review and plan, plan summary, report, or report summary, at a central location, and upon request, shall make it available to any authorized representative of the department conducting an inspection pursuant to Section 25185. If a generator fails, within five days, to make available to the inspector the review and plan, plan summary, report, or report summary, the department or any authorized representative of the department conducting an inspection pursuant to Section 25185, shall, if appropriate, impose a civil penalty pursuant to Section 25189.3, in an amount not to exceed one thousand dollars ($1,000) for each day the violation of this article continues, notwithstanding Section 25189.2.

(b) If a generator fails to respond to a request for a copy of its review and plan, plan summary, report, or report summary made by the department pursuant to subdivision (c) of Section 25244.18, or by a local agency pursuant to subdivision (g) of Section 25244.18, within 30 days from the date of the request, the department shall, if appropriate, assess a civil penalty pursuant to Section 25189.3, in an amount not to exceed one thousand dollars ($1,000) for each day the violation of this article continues, notwithstanding Section 25189.2.

(c) Any person may request the department to certify that a generator is in compliance with this article by having the department certify that the generator has properly completed the review and plan, plan summary, report and report summary required pursuant to Sections 25244.19 and 25244.20. The department shall respond within 60 days to a request for certification. Upon receiving a request for certification, the department shall request from the generator, which is the subject of the request, a copy of the generator's review and plan, plan summary, report, and report summary, pursuant to subdivision (c) of Section 25244.19, if the department does not have these documents. The department shall forward a copy of the review and plan, plan summary, report, and report summary to the person requesting certification, within 10 days after the department receives the request for certification or receives the review and plan, plan summary, report, and report summary, whichever is later. The department shall protect trade secrets in accordance with Section 25244.23 in a review and plan, plan summary, report, or report summary, requested to be released pursuant to this subdivision.

This subdivision does not prohibit any person from directly requesting from a generator a copy of the review and plan, plan

summary, report, or report summary. Solely for the purposes of responding to a request pursuant to this subdivision, the department shall deem the review and plan, plan summary, report, or report summary to be a public record subject to Section 25152.5, and shall act in compliance with that section.

25244.22. Commencing July 1, 1993, and every other year thereafter, the director shall prepare and submit to the Governor and the Legislature a report of the department's operations and activities in carrying out this article. The director may include this report within the report required under Section 25171. This report shall include, but not be limited to, all of the following information:

(a) An evaluation of the hazardous waste source reduction progress in the state.

(b) Recommendations for legislation.

(c) Identification of any state, federal, or private economic and financial incentives that can best accelerate and maximize the research and development of source reduction and other hazardous waste management technologies and approaches.

(d) The status, funding, and results of all research projects.

25244.23. (a) The department shall adopt regulations to ensure that trade secrets designated by a generator in all or a portion of the review and plan, the plan summary, the report, or the report summary required by this article are utilized by the director, the department, or the local agency only in connection with the responsibilities of the department pursuant to this article, and that those trade secrets are not otherwise disseminated by the director, the department, or any authorized representative of the department, or the local agency, without the consent of the generator. However, any information shall be made available to governmental agencies for use in making studies and for use in judicial review or enforcement proceedings involving the person furnishing the information. As provided by Section 25159.5, the regulations shall conform with the corresponding trade secret regulations adopted by the Environmental Protection Agency pursuant to the Resource Conservation and Recovery Act of 1976, as amended (42 U.S.C. Sec. 6901 et seq.), except that the regulations adopted by the department may be more stringent or more extensive than the federal trade secret regulations. "Trade secrets," as used in this section, may include, but are not limited to, any formula, plan, pattern, process, tool, mechanism, compound, procedure, production data, or compilation of information which is not patented, which is known only to certain individuals within a commercial concern who are using it to fabricate, produce, or compound an article of trade or a service having commerical value, and which gives its user an opportunity to obtain a business advantage over competitors who do not know or use it.

(b) The department and the appropriate local agency shall pursuant to this section. The department shall make available information concerning source reduction approaches that have proved successful, and which do not constitute a trade secret, when carrying out subdivision (c) of Section 25244.17 and to subdivision (a) of Section 25244.18.

(c) This section does not permit a generator to refuse to disclose the information required pursuant to this article to the department or to the appropriate local agency, except an officer or employee of the department, or the appropriate local agency, in connection with the official duties of that officer or employee under this article.

(d) Any officer or employee of the department or the appropriate local agency, or any other person, who, because of his or her employment or official position, has possession of, or has access to, confidential information, and who, knowing that disclosure of the information to the general public is prohibited by this section, knowingly and willfully discloses the information in any manner to any person not entitled to receive it, is guilty of a misdemeanor and, upon conviction thereof, shall be punished by imprisonment in the county jail not exceeding six months, by a fine not exceeding one thousand dollars ($1,000), or by both the fine and imprisonment.

25244.24. On or before December 1, 1993, the Auditor General shall submit a report to the Legislature, assessing the performance of the department in carrying out this article. The report shall include information on all of the following:

(a) The effectiveness of the source reduction evaluation reviews and plans in achieving a net reduction in the generation of hazardous waste.

(b) Data on the frequency of requests for certification pursuant to subdivision (c) of Section 25244.21, and an evaluation of the effectiveness and efficiency of this provision, including the department's implementation, in providing timely information to the public.

(c) Data on regulatory and enforcement activities conducted by the department pursuant to Section 25244.18, and the effectiveness of this section, including the department's implementation, in accomplishing compliance with this article.

(d) Data on the certification process required by Sections 25244.19 and 25244.20, and the effectiveness of this requirement in guaranteeing the integrity of the review and plans, plan summaries, reports, and report summaries.

25244.25. (a) On or before January 1, 1991, the department shall adopt, by regulation, a fair and equitable system for charging and collecting a fee from hazardous waste generators subject to this article. The department shall set the fee in an amount sufficient to produce revenues to efficiently and effectively implement this article, and may set the fees at a level sufficient to repay the Hazardous Waste Control Account for the initial costs of implementing this article.

(b) All fees collected pursuant to this section shall be paid to the department on or before September 1, 1991, and shall be deposited in the Hazardous Waste Control Account in the General Fund, for expenditure by the department, upon appropriation by the Legislature, to carry out this article.

SEC. 2. No reimbursement is required by this act pursuant to Section 6 of Article XIII B of the California Constitution because the only costs which may be incurred by a local agency or school district will be incurred because this act creates a new crime or infraction, changes the definition of a crime or infraction, changes the penalty for a crime or infraction, or eliminates a crime or infraction. Notwithstanding Section 17580 of the Government Code, unless otherwise specified in this act, the provisions of this act shall become operative on the same date that the act takes effect pursuant to the California Constitution.

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Hazardous Waste Minimization

A Strategy for Environmental Improvement

Harry M. Freeman
Waste Minimization Research Program
Hazardous Waste Engineering Research Laboratory
U.S. Environmental Protection Agency
Cincinnati, Ohio

Many public and private organizations in the United States are supporting waste minimization as an approach to reducing waste generation. In this article the author provides an overview of waste minimization, and introduces a new series of articles on waste minimization in various U.S industries to be published in JAPCA this year.

"If I am a large quantity generator, I certify that I have a program in place to reduce the volume and toxicity of waste generated to the degree I have determined to be economically practicable and that I have selected the practicable method of treatment, storage, or disposal currently available to me which minimizes the present and future threat to human health and the environment, or, if I am a small quantity generator, I have made a good faith effort to minimize my waste generation and select the best waste management method that is available to me and that I can afford."

This statement is the Generator's Certification Statement that is included on the Uniform Hazardous Waste Manifest that must be signed by all hazardous waste generators in the United States who ship hazardous waste off site for treatment, storage and disposal. Its inclusion on the manifest was required by the Hazardous and Solid Waste Amendments of 1984 as one of several items related to encouraging waste minimization as a means of reducing environmental problems caused by industrial wastes.

The term "waste minimization" is heard increasingly at meetings and conferences of individuals working in that amorphous field called hazardous waste management. Waste minimization is an umbrella term that includes the first four categories of the EPA's preferred hazardous waste management strategy which is shown below:

1. *Waste Reduction*: Reduce the amount of waste at the source, through changes in industrial processes.
2. *Waste Separation and Concentration*: Isolate wastes from mixtures in which they occur.
3. *Waste Exchange*: Transfer wastes through clearinghouses so that they can be recycled in industrial processes.
4. *Energy/Material Recovery*: Reuse and recycle wastes for the original or some other purpose, such as for materials recovery or energy production.
5. *Incineration/Treatment*: Destroy, detoxify, and neutralize wastes into less harmful substances.
6. *Secure Land Disposal*: Deposit wastes on land using volume reduction, encapsulation, leachate containment, monitoring, and controlled air and surface/subsurface water releases.

In general, the idea underlying the promotion of waste minimization is that it makes far more sense for a generator not to produce waste rather than develop extensive treatment schemes to insure that the waste stream poses no threat to the quality of the environment.

The U.S. Congress specifically stated in the Hazardous and Solid Waste Amendments of 1984 to the Resource Conservation and Recovery Act: "The Congress hereby declares it to be the national policy of the United States that, wherever feasible, the generation of hazardous waste is to be reduced or eliminated as expeditiously as possible. Waste that is nevertheless generated should be treated, stored, or disposed of so as to minimize the present and future threat to human health and the environment."

Other organizations, including the U.S. Congress Office of Technology Assessment, the National Academy of Sciences, the EPA's Science Advisory Board, the Environmental Defense Fund, and the Natural Resources Defense Council have issued strong statements in support of programs to encourage the development and adoption of waste minimization strategies. The EPA's position on the subject was succinctly detailed in its 1986 Report to Congress:

"EPA still has much to learn about waste minimization and recognizes that the cooperation of private and public waste generators will be invaluable as it moves toward the development of sound long term policy. It also believes, however, that the incentives and trends within the hazardous waste management system are unmistakable, and that the program presented here comprises the most positive and constructive steps that can be taken at this time. Aggressive

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action in favor of waste minimization is clearly needed, but a major new regulatory program—at least for the present—does not seem desirable or feasible.

"Incentives for waste minimization are already strong, so EPA must capitalize on them. Most lacking is access by generators to the information that will demonstrate the economic benefits of waste minimization to industry, overcome logistical problems, and help develop creative new approaches. This can be provided by a strong technical assistance and information transfer effort, which can achieve through voluntary means what would be inefficient and possibly counterproductive to attempt through regulation. Unfortunately, non-regulatory programs have often failed at EPA for lack of statutory or regulatory deadlines and institutional advocacy. For such a program to work, it must be given strong organizational support within the Agency. EPA is willing to make this commitment, and seeks support from Congress to ensure its success."

The Agency has recently convened an internal working group to develop implementation plans to convert its recommendations in the report into actual operating programs. There has been a wide consensus of organizations active in encouraging waste minimization programs that a nonregulatory federal program is the most appropriate approach for encouraging waste minimization.

There have been at least six new bills introduced in the U.S. Congress to expand the federal presence in encouraging waste minimization. While the bills differ in particulars, they generally authorize funds for the EPA's waste minimization programs, establish an Office of Waste Reduction within the EPA, and establish clearinghouses for data and technical information. Some of the bills provide for state grants programs. They also support the idea that a non-regulatory program is the best approach.

Several states have initiated and continue to support programs to encourage the adoption of techniques and technologies that result in less waste being generated. The level of assistance, which includes such things as direct technical assistance, information dissemination, research and demonstration grants, and various types of outreach programs, varies. Several states including California, New Jersey, and Michigan have had legislation introduced to expand their state programs to encourage waste minimization.

Interest and support for waste minimizaton has not been confined to the public agencies. Representatives of such large organizations as Dupont, Dow and 3M have on many

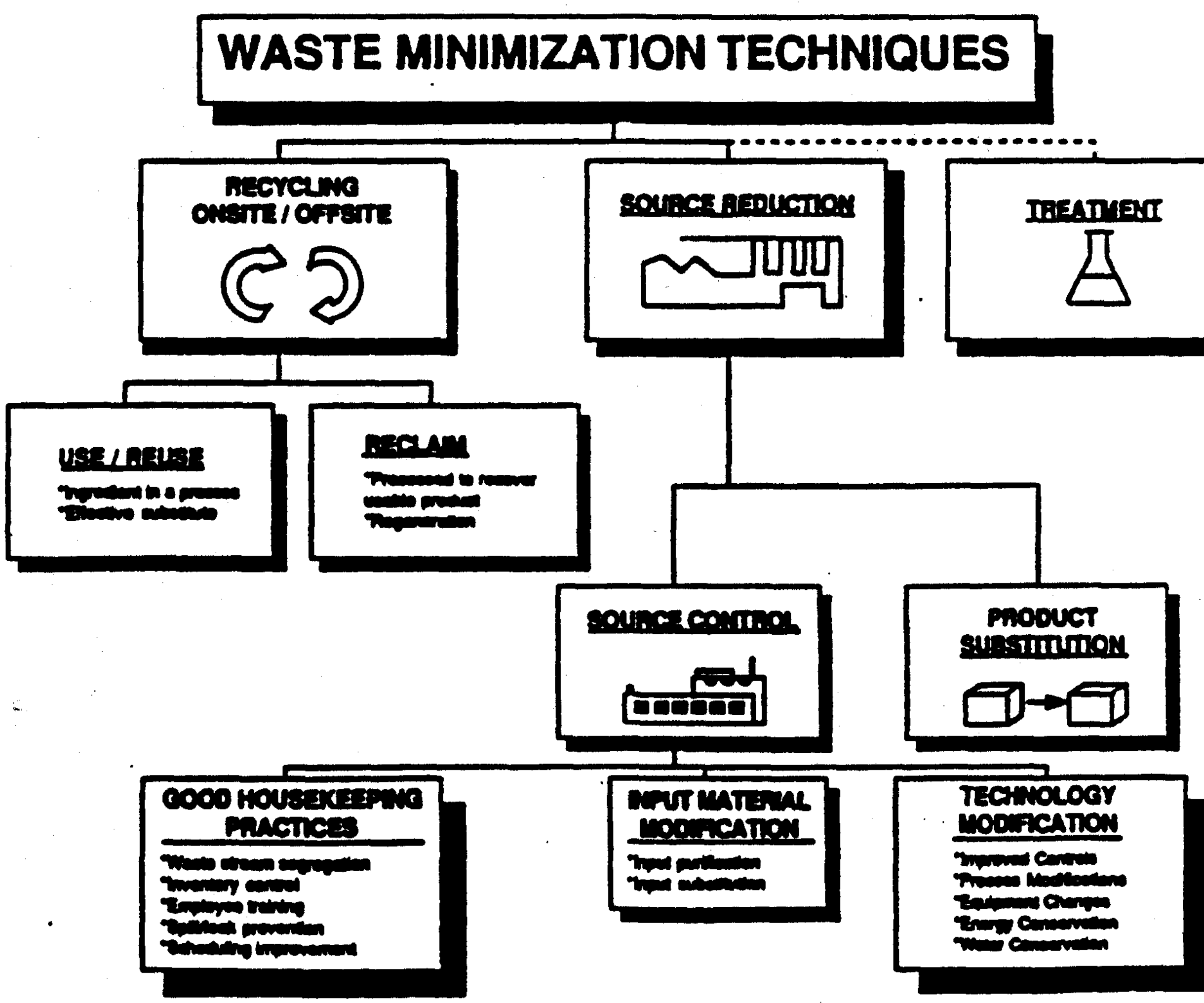

Figure 1. Waste minimization techniques. Source: U.S. EPA Report to Congress on the Minimization of Hazardous Waste, 1986. Treatment is included for reporting purposes only.

occasions told of the successes of their respective waste minimization programs, and endorsed the usefulness of basing environmental improvement programs on waste minimization concepts.* In a June, 1987 meeting sponsored by Tufts University Center for Environmental Management, the U.S. EPA, and the League of Women Voters of Massachusetts, 24 major U.S. corporations reported on their waste minimization activities. All of the companies had active waste minimization programs, and most of the companies reported upgrading their programs during the past 12 months.

Examples of Waste Minimization

Reducing the generation of hazardous wastes can be achieved in many ways. Process chemistry can be changed; potential waste streams can be recycled within a manufacturing process or back into the process; process technology and/or equipment can be modified to produce products more efficiently, resulting in less waste; improved operating procedures can result in producing fewer and smaller waste streams or less waste in general; changes in raw materials (feedstocks) can lead to fewer waste streams or less hazardous waste streams; finally, changes in the end products from manufacturing operations can, in some instances, be made so as to affect the types and quantities of wastes emitted. A listing of the various approaches is shown graphically in Figure 1.

Of course, waste minimization means entirely different things to different industries depending upon the particular waste streams being generated, the physical form in which they are generated, and the amount of the waste being generated. An operator of a steel mill searching for ways to reduce generation rates for spent pickling liquor is faced with an entirely different set of questions from those faced by the operator of a semiconductor manufacturing facility interested in reducing generation rates for solvents. Some examples of real world waste minimization in various industries are shown in Table I. These examples, which were taken from information compiled by the North Carolina Pollution Prevention Pays Program, illustrate the wide range of techniques and technologies considered to be waste minimization.

JAPCA Waste Minimization Series

During the next 10 months in this journal, APCA, in cooperation with the US EPA's Office of Research and Development and the organizations with which the authors are affiliated will be featuring overviews of waste minimization in a variety of large and small industries. We have invited papers from individuals recognized within their respective industries as authorities on the subjects. A listing of the industries to be covered is shown below.

Topic Industries
Chemicals
Electronic Products
Paints and Allied Products
Oil and Solvent Recycling
Pesticide Formulation
Automotive Repair Shops
Electroplating and Metal Finishing
Petroleum
Pharmaceuticals
Department of Defense

* *For an overview of 3M's approach to waste minimization, see "Life Cycle Approach to Effective Waste Minimization,"* J. S. Hunter and D. M. Benforado, in the October 1987 issue of *JAPCA*, page 12[illegible]—*Editor.*

Table I. Examples of waste minimization techniques.

	Industry	Techniques
Inventory management	Textiles	Review all chemical purchases
	Furniture	Purchase only exact amounts of coating required
	Diesel engines	Screen all products purchased
	Organic chemicals	Review new products before production
Material change	Printing	Substitute water-based for solvent based ink
	Office furniture	Use water based paints in place of solvent based paints
	Aerospace	Replace cyanide cadmium plating bath with noncyanide bath
	Ink manufacture	Remove cadmium pigment from products
Production process modifications	Chemical reaction	Optimize reaction variables/reactor design
		Optimize reactant addition method
		Eliminate use of toxic catalysts
	Surface coating	Use airless air-assisted spray guns
		Use electrostatic spray coating system
		Control coating viscosity with heat units
		Use high solids coatings
In-plant recycling	Metal fabricators	Recover synthetic cutting fluids using a centrifuge system.
	Paint fabricating	Use distillation unit to recover cleaning solvents.
	Printed circuit boards	An electrolytic recovering system used to recover copper and tin/lead from process wastewater.
	Power tools	Recover alkaline degreasing baths using ultrafiltration.

Conclusion

Waste minimization is clearly an idea whose time has come in the United States and in other industrialized nations throughout the world. As more and more industries commit to utilizing waste minimization approaches to solving their environmental emission problems, there will certainly come the day when the problems created by hazardous and nonhazardous wastes will cease to be such a significant factor in the world's pollution problems.

Some Further Readings on Waste Minimization

1. *Report to Congress: Minimization of Hazardous Waste*, EPA/530 SW-86-033A Office of Solid Waste, U.S. EPA Washington, DC 20460.
2. *Serious Reduction of Hazardous Waste*, Congress of the United States, Office of Technology Assessment, Washington, DC 20510.
3. *From Pollution to Prevention: A Progress Report on Waste Reduction*, Congress of the United States Office of Technology Assessment, Washington, DC 20510.

4. *Hazardous Waste Minimization Manual for Small Quantity Generators*, Center for Hazardous Materials Research, University of Pittsburgh Applied Research Center, Pittsburgh, PA 15238.
5. *The EPA Manual for Waste Minimization Assessments*, U.S. EPA, Hazardous Waste Engineering Research Laboratory, Cincinnati, OH 45268 (available Spring, 1988).
6. *Pollution Prevention Bibliography*, Pollution Prevention Pays Program, North Carolina Department of Natural Resources and Community Development, Raleigh, NC 27611.
7. *Hazardous Waste Reduction Guidelines for Environmental Health Programs*, May, 1987, prepared by Ventura County Environmental Health for the State of California Department of Health Services, Toxic Substances Control Division, Sacramento, CA 95814.

Mr. Freeman is with the Waste Minimization Research Program, Hazardous Waste Engineering Research Laboratory, U.S. Environmental Protection Agency, Cincinnati, OH 45268. This paper was submitted for peer review September 17, 1987; the revised manuscript was received November 3, 1987.

Underground Storage Tanks

Management's Latest Challenge

A. D. Young, Jr.
Fred C. Hart Associates, Inc.
New York, New York

The advent of stringent regulation of the storage of liquids in underground containers presents a new dimension to an operating practice long taken for granted. Previously, tanks went underground to provide a safe and convenient method for handling liquids. Unfortunately, the environmental impact of leakage from those containers was not anticipated, nor were tank designs properly configured to minimize the threat. As local officials became alert to the potential for damage, public pressure forced tank owners to rethink this casual practice. Manufacturers and suppliers of tanks and associated hardware have moved rapidly to the new state of the art called for to meet the new standards for storage techniques, and to provide effective leak prevention and detection. This paper presents a chronology of the progress made to date in storage equipment and operating practices to provide the environmental protection demanded of underground tank owners and operators. Tank design, secondary containment, monitoring, spill and overfill protection, tank testing methods, and installation and closure procedures—as related to leak prevention—are presented.

Underground Storage Tanks (UST) issues have lately emerged as a most serious management concern for tank owners. Regulations at federal, state or local levels mandating upgrading and remedial action are either in place or under development across the country. Amendments to the Resource Conservation and Recovery Act (RCRA) passed in November 1984 required tanks to be registered by May 8, 1986. On April 17, 1987, EPA published proposed rules for operating tank systems, and after the public comment period and revisions, final rules will be issued early in 1988.

The federal law requires regulations for the storage of petroleum and other regulated substances which must include, among other things:

- Registration and notification
- New tank performance standards
- Leak detection, prevention, and closure
- Corrective action, reporting, and cleanups

Each state, under these RCRA requirements, designated a state agency to collect the registration of all tanks. The states are being encouraged by EPA to take the lead in enforcing RCRA provisions, and many agencies will, no doubt, issue local regulations. These must be no less stringent than federal, and must meet the federal requirements for new tank performance standards, financial responsibility, corrective action, and notification. 34 states either already have regulations in place or are actively drafting their own, while most of the others are waiting to see the final form of the federal rules (Table I). The agencies involved vary from state to state, including fire marshals, environmental, public health, or labor departments.

As an example of state activity, Michigan has had tank regulations in place since July 1983, issued by the State Fire Safety Board and enforced by the State Fire Marshal. These regulations will need to be modified under RCRA since they do not include notification or financial responsibility requirements, and the state may have to update tank performance standards and corrective action stipulations, based on the federal rules soon to be issued.

While no one now has an accurate count of how many tanks are in place (estimates vary from 2,000,000 to 4,000,000), registration should provide a much improved data base. Hopefully, as better information is developed about tank ages and soil conditions, there will also be a better estimate of the potential risk of leakage and environmental hazards from those existing underground tanks not requiring imminent replacement. EPA has been studying this aspect of the problem, and recently released an opinion that 35 percent of tank systems are either leaking or are not liquid-tight.

The new regulations will have a profound effect on the design, manage-

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Chemical Manufacturing Expansion in Developing Countries and Eastern Europe in the 1990s

- 46 new projects planned
- Projected investments total $13 billion
- Annual increase of 9.4 billion pounds in production capacity

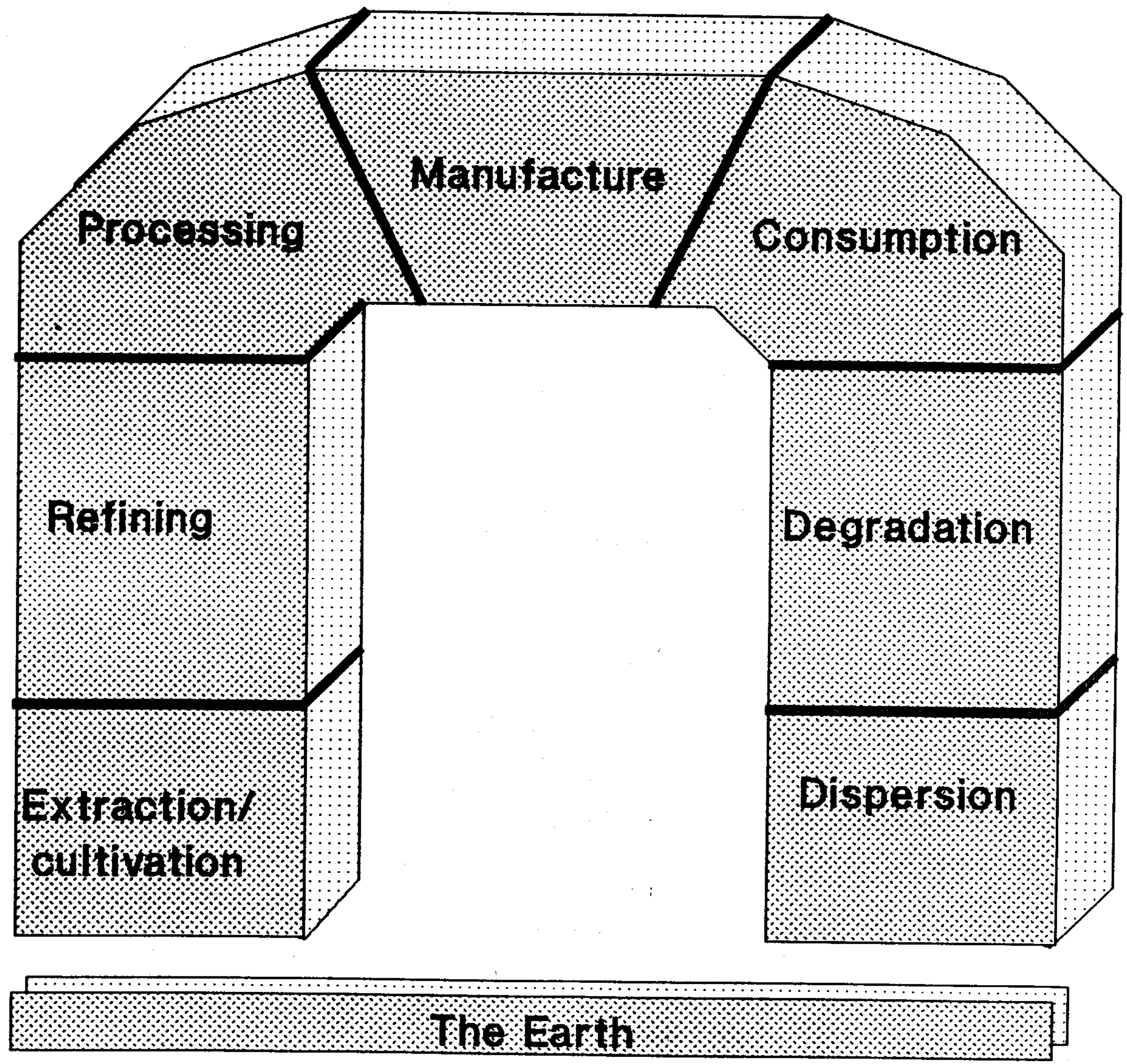
Chemical Production in the Pacific

- Demand growing at an annual rate of 7-10%
- Dupont to spend $2 billion in the 1990s

Of the 46 proposed projects, 80% are targeted for 12 Asian nations.

China	Philippines
Hong Kong	Singapore
India	South Korea
Indonesia	Taiwan
Malaysia	Thailand
Pakistan	Vietnam

Prevention of the generation of waste



Waste, Pollution

Prevention; avoidance; minimization; reduction:

- Waste prevention
- Waste avoidance
- Waste minimization
- Waste reduction
- Pollution prevention
- Pollution reduction
- Recycling

Technology

Technology; technologies:

- New technologies
- Environmental technology
- Prevention aimed environmental technology
- Process integrated environmental technology
- Appropriate technology
- Clean technologies
- Cleaner technologies
- Non-waste technology
- Low- and Non-waste technologies
- Low-waste technology
- Low-polluting technology
- Pollution control technology
- Add-on technologies
- End-of-pipe technologies
- Recycling technologies
- Waste treatment technologies
- Purification treatment
- Cleaning up technology

3,753 a PDF

Waste Minimization

Section 2:

Waste Minimization Techniques and Technologies

- "Waste Reduction Techniques & Technologies" Gary E. Hunt Pollution Prevention Program.

- "Waste Reduction Methods" Waste Reduction Assessment and Technology Transfer Training Manual TVA Waste Technology Program.

- "A Generator's Checklist" Hazardous Waste Reduction Program of Oregon. Oregon Department of Environmental Quality.

- "Approaches to Waste Minimization" from the Hazardous Waste Minimization manual for Small Quantity Generators, Center for Hazardous Materials Research, Pittsburgh, PA.

Chapter

3

Waste Reduction Techniques and Technologies

Gary E. Hunt

Pollution Prevention Program
North Carolina Department of Natural Resources and Community Development
Raleigh, North Carolina

3.1 Introduction to Waste Reduction Techniques

Waste reduction techniques can be applied to any manufacturing process, from something as simple as making a paper clip to something as complex as assembling the space shuttle. Available techniques range from easy operaιιonal changes to state-of-the-art recovery equipment.

This chapter is from the book, Hazardous Waste Minimization , edited by Harry Freeman. McGraw Hill Book Company. New York. 1989

The common factor in these techniques is that they reduce bottom-line operational costs.

Waste reduction is not a new concept—it has been around as long as humans have been producing products. While it has been known over the years by a number of names, it is merely optimization of the production process. For example, a late-eighteenth-century electroplating manual states that "nothing whatever should be allowed to go to waste in well-conducted works."[1] The manual includes many waste reduction methods that are applicable and are discussed in the literature even today. This points up the fact that many waste reduction techniques are relatively "low-tech." In fact, many industries find that simple operational changes, increased training, and improved inventory management can significantly reduce waste generation rates.

Waste reduction techniques can be broken down into four major categories, as shown in Table 3.1. Because the classifications are broad there will be some overlap. In actual application, waste reduction techniques generally are used in combination so as to achieve maximum effect at the lowest cost.

The selection of specific reduction techniques by an individual business must be based on accurate and current information on waste-stream generation and waste management costs. This is accomplished by developing and implementing a waste reduction program as a key part of a comprehensive waste management plan. Components of the reduction program include procedures for collecting information, evaluating options, and identifying cost-effective waste reduction techniques. Once identified, the techniques can be implemented and become an established part of the facilities management and operation. Approaches to developing such a program are discussed in Chap. 4.

TABLE 3.1 Categories of Waste Reduction Techniques

Inventory management
Inventory control
Material control
Production process modification
Operation and maintenance procedures
Material change
Process equipment modification
Volume reduction
Source segregation
Concentration
Recovery
On-site recovery
Off-site recovery

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One point of caution: An evaluation should be made of a reduction technique's impact on all wastestreams, not just the targeted one. This thorough evaluation must be done before the technique is implemented. For example, while changing from a solvent to a water-based cleaner will eliminate the generation of hazardous waste, it may also increase the wastewater's organic load, possibly to such an extent that the facility cannot meet its discharge limits without incurring significantly increased wastewater treatment costs.

3.2 Inventory Management

Proper control over raw materials, intermediate products, final products, and the associated wastestreams is now being recognized by industry as an important waste reduction technique.[2] In many cases waste is just out-of-date, off-specification, contaminated, or unnecessary raw materials, spill residues, or damaged final products. The cost of disposing of these materials not only includes the actual disposal costs but also the cost of the lost raw materials or product. This can represent a very large economic burden on any company. For example, one furniture company had to spend thousands of dollars, at $5/gal, to properly dispose of two-years' worth of unused coating materials. This expense was in addition to the $7/gal the material originally had cost.[3]

There are two basic aspects to inventory management: controlling the types and quantities of materials in the plant inventory; and controlling the handling of raw materials, along with the finished products and wastestreams in the production facility. The former aspect, referred to as *inventory control*, includes techniques to reduce inventory size and hazardous chemical use while increasing inventory turnover. The latter aspect, referred to as *material controls*, includes methods to reduce raw material and finished product loss and damage during handling, production, and storage.

Any effective inventory management program must include process waste. Handling waste as if it were a product will help reduce waste and increase the potential for recovery. Many of the techniques discussed in this section can be applied to waste material as well as to raw materials and finished products.

3.2.1 Inventory control

Methods for controlling inventory range from a simple change in ordering procedures to the implementation of just-in-time (JIT) manufacturing techniques. Most of these techniques are well known in the

3-

business community; however, their use as very effective waste reduction techniques has not been widely recognized. Many companies can help reduce their waste generation by tightening up and expanding current inventory-control programs. This approach will significantly impact the three major sources of waste resulting from improper inventory control: excess, out-of-date, and no-longer-used raw materials. For example, a manufacturer of polyvinyl chloride products reduced the quantity of out-of-date and off-specification raw materials generated by over 50 percent through inventory control. Techniques used included purchase of containerized rather than bulk materials, reduction in purchase quantities, and separation and reuse of excess materials where possible. The program took six months to implement at a negligible cost and saved $50,000 per year in raw material and waste management costs.[4]

Purchasing only the amount of raw materials needed for a production run or a set period of time is one of the keys to proper inventory control. Excess inventory often results from a purchasing department getting a "good deal" on a chemical and buying a tank-car load when only a drum is needed. The excess must be disposed of because it goes out of date before it can be used. Better application of existing inventory management procedures should help to reduce this problem and should be coupled with education programs for purchasing personnel on the problems and costs of disposing of excess materials. Additionally, the set expiration dates on materials should be evaluated, especially for stable compounds, to see if they are too short. A furniture manufacturer reduced excess inventories by having one person assigned to the job of purchasing all solvents and finishes for all divisions. Purchases were based on long-term production schedules, which in turn had been developed to fully utilize finishing materials.[5] Another company, a large paint formulator, reduced the quantity of discontinued finished product by developing a computerized procedure to search inventory at 2 plants and 27 warehouses for available stock before formulating another batch. Transportation costs for moving the finished products are small compared to the high hazardous waste disposal costs.[6]

Another approach to inventory control is to purchase the material in the proper amount and the proper size container. If large quantities of a material are used, then purchasing it in bulk will produce less waste, both in product loss and empty packaging, than if it were purchased in drums or bags. On the other hand, small containers may be better than bulk purchases if the material has a short shelf life or is not used in large amounts. Some companies are purchasing material in returnable, reusable containers, thus eliminating the generation of empty bags or containers. In some cases, raw materials such as pigments and biocides can be packaged in small soluble bags which allow the material and container to be put right into the processed product.[7,8]

If surplus inventories do accumulate, steps should first be taken to use the excess material within the plant or company. If this is not successful, then the supplier should be approached to see if it will take the material back. If the supplier won't, the next step is to identify possible users or markets outside the company. Only if this fails should other management options be examined. The subject of market development is covered more fully in Sec. 3.5.

The ultimate in inventory control procedures is JIT manufacturing, since this system eliminates the existence of any inventory by directly moving raw materials from the receiving dock to the manufacturing area for immediate use. The final product is then shipped out without any intermediate storage. JIT manufacturing is a complex program to implement and cannot be used by all facilities; however, when applicable, it can reduce waste significantly. For example, using JIT techniques, the 3M Company reduced waste generation by 25 to 65 percent in its individual plants.[2]

Developing review procedures for all material purchased is another step in establishing an inventory control program. Standard procedures should require that all materials be approved prior to purchase and checked before acceptance at the facility. In the approval process all production materials should be evaluated to determine if they contain hazardous constituents, and if so, what alternative nonhazardous substitute materials are available (see Sec. 3.3.2). Also, brief evaluation procedures should be established for all incoming raw materials to avoid the acceptance of wrong, off-specification, or defective materials. This will reduce the potential for generation of off-specification products, damaged process equipment, and disposal of unusable raw materials.

Development of review procedures determination can be made either by one person with the necessary chemistry background or a committee made up of people with a variety of backgrounds. Needed information can be obtained from the Material Safety Data Sheets (MSDS) provided by the chemical supplier. If these data sheets do not contain enough information, the supplier should be contacted and asked to provide the necessary information in confidence. If the chemical supplier is unable or unwilling to provide the information, either a new supplier should be found or the materials should be chemically analyzed. Any material which has been approved can be ordered; new material must first go through the approval process. This approach fits very well with health and environmental regulations, which require chemical inventories and collection of MSDSs. Evaluation of this information can lead to fewer chemicals being stored, used, and released, thus reducing regulatory burdens and potential liabilities. Many kinds of companies, hailing from the electronics industry to the textile industry, have established successful material review programs.[9,10,11] Material review procedures should also be applied during new-product development. Before a new product is produced, a thorough evaluation of the materials and processes used to make the product should be made. The use of hazardous materials can then be reduced as much as possible prior to beginning productions.[12,13]

3.2.2 Material control

An important area commonly overlooked or not given proper attention in many manufacturing facilities is material control procedures, which includes storage of raw materials, products, and process waste and the transfer of these items within the process and around the facility. Proper material control procedures will ensure that raw materials will reach the production process without loss through spills, leaks, or contamination. It also will ensure that the material is efficiently handled and used in the production process and does not become waste. Examples of potential sources of material loss are shown

TABLE 3.2 Potential Sources of Process Material Loss

Area	Source
Loading	Leaking fill hose or fill line connections
	Draining of fill lines between filling
	Punctured, leaking, or rusting containers
	Leaking valves, piping, and pumps
Storage	Overfilling of tanks
	Improper or malfunctioning overflow alarms
	Punctured, leaking, or rusted containers
	Leaking transfer pumps, valves, and pipes
	Inadequate diking or open drain valve
	Improper material transfer procedures
	Lack of regular inspection
	Lack of training program
Process	Leaking process tanks
	Improperly operated and maintained process equipment
	Leaking valves, pipes, and pumps
	Overflow of process tanks; improper overflow controls
	Leaks and spills during material transfer
	Inadequate diking
	Open drains
	Equipment and tank cleaning
	Off-specification raw materials
	Off-specification products

in Table 3.2. A resin manufacturer provides an example of how proper raw-material transfer procedures can reduce waste generation. With this manufacturer it was common practice to let the residual material in the hose from the phenol delivery trucks drain into the plant's wastewater collection system after the storage tanks were filled. The unloading procedures were then changed to require the hoses to be flushed with water and the phenol-water mixture be stored in a tank for use in the production process.[14]

Material loss can be greatly reduced through improved process operation, increased maintenance, and additional employee training. Many sources of material loss, such as leaks and spills, can be easily identified and corrected. For example, a dairy plant reduced its product loss by 65 percent through an improved maintenance program.[15] Many of the techniques which can be used to reduce material loss are discussed in Sec. 3.3.1.

Another problem area which is frequently overlooked is waste handling procedures. Waste should be handled and managed like a product. Allowing a recyclable or clean waste material to be contaminated may reduce or eliminate any recovery potential. One way to improve the material control procedures is to have at least one person responsible for handling and tracking waste materials within the plant. This approach can be very cost-effective when the waste material is recoverable or has some market value. This area is discussed further in Sec. 3.5.

3.3 Production Process Modification

Improving the efficiency of a production process can significantly reduce waste generation. Use of this approach can help reduce waste at the source of generation, thus decreasing waste management liability and costs. Some of the most cost-effective reduction techniques are included in this category; many are simple and relatively inexpensive changes to production procedures. Available techniques range from eliminating leaks from process equipment to installing state-of-the-art production equipment. The waste reduction techniques in this category can be divided into improved operation and maintenance, material change, and equipment modifications. Each topic is discussed in more detail in the following sections.

3.3.1 Operational and maintenance procedures

Significant amounts of waste can be reduced through improvements in the way a production process is operated and maintained. This approach is one of the most overlooked of all waste reduction areas because many wasteful operational practices have gone on so long they have become standard operating procedures. Also, in many cases, maintenance is so busy correcting current problems that preventive maintenance is overlooked until it is too late. Improvements in operation and maintenance usually are relatively simple and cost-effective. Most of the techniques are not new or unknown. However, a good deal of information on the source and cause of the waste generation must be known before effective measures can be developed.

A certain dairy processing facility provides a good example of significant waste reduction through improved operation and maintenance procedures. A milk loss prevention program was instituted which included employee training on proper operations, causes of product loss, and impact of waste generation; increased maintenance, including correction of current leaking equipment; better tracking of product losses; and development of improved operational techniques. This program saved the company $288,000 per year and has resulted in a significant reduction in the organic content of the wastewater. All this was obtained without any capital costs.[15,16]

Operational procedures A wide range of methods are available to operate a production process at peak efficiency. These methods are neither new nor unknown and are usually inexpensive to institute, as little or no capital cost is necessary. For example, a manufacturer of plumbing fixtures changed the concentration of chrome in its electroplating baths to the low end of the recommended operating range. By reducing the chrome concentration from 3700 mg/liter to 3350 mg/liter the amount of chrome which had to be treated was reduced by 9 percent without affecting product quality. This not only saved raw material and treatment chemicals, but it also reduced wastewater treatment sludge generation.[17]

Improved operation procedures are quite simply methods which make optimum use of the raw materials used in the production process. Some examples are shown in Table 3.3. Most production processes, no matter how long they have been in operation or how well they are run, can be operated more efficiently. Many sources of waste generation become overlooked because "that is just the way the process works." Additionally, some process steps may in fact be unnecessary, and eliminating them will reduce waste generation. For example, a paint manufacturer found that instead of using a series of coarse to fine filters for grit removal, only the fine filter was necessary. As a result of this change to using only one filter, the generation of spent filter cartridges was reduced by 50 percent.[6] Another company discovered that standard operating procedure was to degrease all parts coming into the facility and then re-oil those that did not require further

TABLE 3:3 Examples of Operational Changes to Reduce Waste Generation

Reduce raw material and product loss due to leaks, spills, drag-out, and off-specification process solution.
Schedule production to reduce equipment cleaning. For example, formulate light to dark paint so the vats do not have to be cleaned out between batches.
Inspect parts before they are processed to reduce number of rejects.
Consolidate types of equipment or chemicals to reduce quantity and variety of waste.
Improve cleaning procedures to reduce generation of dilute mixed waste with methods such as using dry cleanup techniques, using mechanical wall wipers or squeegees, and using "pigs" or compressed gas to clean pipes and increasing drain time.
Segregate wastes to increase recoverability.
Optimize operational parameters (such as temperature, pressure, reaction time, concentration, and chemicals) to reduce by-product or waste generation.
Develop employee training procedures on waste reduction.
Evaluate the need for each operational step and eliminate steps that are unnecessary.
Collect spilled or leaked material for reuse.

SOURCE: From Refs. 4, 6, 7, 19, and 20.

coating and that cleaning only those parts which needed further processing would reduce waste solvent generation.[18] Thus, asking why a process step has to be done will help identify reduction possibilities.

These approaches can be used by all sizes and types of facilities, even by well-designed and well-operated complex operations. For example, an organic chemical company, during a comprehensive process evaluation, found three significant sources of isobutylene emissions to the atmosphere. Laboratory scale tests found that changes in the reaction conditions (temperature, residence time, and concentration) would almost eliminate isobutylene emission while also increasing product generation. For example, for one reaction step emissions were reduced 99 percent, primary product yield was increased from 94.5 to 99.7 percent, and batch cycle time was reduced by half. The total saving from the operational changes at all these reaction steps was $500,000 per year, with a total capital cost of $80,000. Additionally, the need for air pollution control equipment was eliminated.[20]

Once proper operating procedures have been established they must be fully documented and made part of the employee training program. A comprehensive training program is a key element of any effective waste reduction program. For example, a dairy reduced waste by 14 percent and a semiconductor manufacturer reduced waste by 40 percent through use of such training programs.[18,22] For a program to be effective, all levels of personnel should be included, from the line operator to the corporate executive officer. The goal of any program is to make the employee aware of waste generation, its impact on the company and the environment, and ways it can be reduced. Top level managers have to be made aware of the costs, problems, and liabilities of waste management, and the economic benefits of waste reduction. Line managers must understand the effect of their process line on waste generation in order to focus on how waste can be reduced, how to educate and motivate their employees. The majority of the training program should be directed at the line operators. Some possible program elements are shown in Table 3.4. The training program should emphasize management's commitment to waste reduction, the beneficial impact of reduction on job security, and the improvements reduction will make to the local environment. All employees should attend refresher sessions on a regular basis. All new workers should undergo the training, which could be done as part of an established worker right-to-know training program for new employees.

Companies have taken a number of different approaches to waste reduction training. One facility has developed a training video to introduce waste reduction to the line operator with simple written waste reduction procedures for each line operation. Also at this facility, training and written material were developed for line supervisors and all levels of management.[18] A furniture manufacturer took a rather unique approach. Working closely with the line operator, video equipment was used to record the operator's spray technique. The tape was later reviewed by the operator and training personnel to identify problem areas and provide corrective procedures. The operator was videotaped again later so that the operator could see the improvements. The company estimates that coating use and the associated waste gen-

TABLE 3.4 Elements in a Waste Reduction Training Program

1. Explain the need for waste reduction and emphasize benefits to employee and community.
2. Explain the direct effect that an employee can have on improved work and living environment.
3. Express management's commitment to waste reduction.
4. Explain waste management terminology in simple terms.
5. Present general overview of environmental regulations which impact the facility.
6. Examine improved operational practices for reducing waste generation. Illustrate good and poor operating practices utilizing slides or video. Use positive language, e.g., "this is a better way of doing things," instead of "this is what you have to do."
7. Solicit ideas for waste reduction methods and explore possible solutions to identified problems.

SOURCE: From Ref. 23.

eration costs were reduced by about 10 percent. This represented a savings of about $60,000 per year in coating material costs alone. Savings were also realized through reduced waste from spray booth cleanout and reduced air emissions.[3]

Maintenance programs One company stated that one-fourth to one-half of its excess waste load was due to poor maintenance.[24] A strict maintenance program which stresses corrective *and* preventive maintenance can reduce waste generation caused by equipment failure. Such a program can help spot potential sources of release and correct a problem before any material is lost. A good maintenance program is so important because the benefits resulting from the best waste reduction program can be wiped out by just one process leak or equipment malfunction.

A maintenance program can include maintenance cost tracking and preventive maintenance scheduling and monitoring. To be effective, a maintenance program should be developed and followed for each operational step in a production process, with special attention to potential problem points. A strict schedule and accurate records on all maintenance activities should be maintained. The type of information which should be collected and updated regularly in order to establish a preventive maintenance program is listed below:[25]

- A list of all plant equipment and location
- Operating time for each item or area
- Which items are critical to the process(es)
- Problem equipment
- Previous maintenance history
- Vendor maintenance manuals
- A data base of equipment repair histories

Computer-based maintenance scheduling and tracking programs are available from a variety of vendors. A comprehensive program can also include predictive maintenance. This approach provides the means to schedule repairs or replacement of equipment based on actual condition of the machinery. A number of nondestructive testing technologies are available for making the necessary evaluations for this approach.[26]

Maintenance procedures themselves produce waste, such as process materials, rags, scrap parts, oils, and cleanup residue. These wastes, too, can be reduced by using standard waste reduction techniques such as revised operational procedures, equipment modification, source

3-12

segregation, and recovery. For example, before a filter is replaced, all process material should be drained from the housing, either under gravity or pressure, and collected for reuse.[27]

3.3.2 Material change

Hazardous material used in either a product formulation or in a production process may be replaced with a less hazardous or nonhazardous material. Reformulating a product to contain less hazardous material should reduce the amount of hazardous waste generated during both the product's formulation and its end use. Using a less hazardous material in a production process will generally reduce the amount of hazardous waste produced. Some examples of material change to reduce waste generation are given in Table 3.5.

Product reformulation is one of the more difficult waste reduction techniques, yet it can be very effective. As more manufacturers implement inventory management programs, pressure will increase on chemical supply companies to produce products with lower quantities of hazardous materials. Due to the proprietary nature of product formulations, specific examples of product reformulation are scarce. General examples include eliminating pigments containing heavy metals from ink, dyes, and paint formulations; replacing chlorinated solvents

TABLE 3.5 Examples of Waste Reduction Through Material Change

Industry	Technique
Household appliances	Eliminate cleaning step by selecting lubricant compatible with next process step.[28*]
Printing	Substitute water-based ink for solvent-based ink.[29]
Textiles	Reduce phosphorus in wastewater by reducing use of phosphate-containing chemicals.[30] Use ultraviolet instead of biocides in cooling towers.[35]
Air conditioners	Replace solvent-containing adhesives with water-based products.[31]
Electronic components	Replace water-based film-developing system with a dry system.[9]
Aerospace	Replace cyanide cadmium-plating bath with a noncyanide bath.[32]
Ink manufacture	Remove cadmium from product.[33]
Plumbing fixtures	Replace hexavalent chrome-plating bath with a low-concentration trivalent chrome-plating bath.[34]
Pharmaceuticals	Replace solvent-based tablet-coating process with a water-based process.[36]

*Superior numbers refer to sources in Reference list at end of chapter.

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with nonchlorinated solvents or water in cleaning products; replacing phenolic biocides with other less toxic compounds in metalworking fluids; and developing new paint, ink, and adhesive formulations based on water rather than organic solvents. The applicability of this technique will be very product-specific, but with the ever-increasing cost and liability associated with waste management, it is a very important waste reduction and business strategy.

Hazardous chemicals used in the production process can also be replaced with less hazardous or nonhazardous materials. Changes can range from using purer raw materials to replacing solvents with water-based products, which is a very widely used waste reduction technique that is applicable to many industries. Many of these changes involved switching from a solvent to a water-based process solution. For example a diesel engine remanufacturing facility switched from cleaning solvents and oil-based metalworking fluids to water-based products. This change reduced their coolant and cleaning costs by about 40 percent. Additionally, the company was able to eliminate a cleaning step, and machine filters lasted twice as long, thus reducing material and labor costs.[37] A material change may also allow the elimination of a process step. A manufacturer of home appliances used this approach to replace an alkaline degreasing step used in a stamping process. A water-based degreaser had replaced a solvent degreaser using 1,1,1-trichloroethane. However, the alkaline degreaser residue on the parts caused deterioration of the stamping dies. The cleaning step was then eliminated by selecting a new lubricant which was noncorrosive to the stamping dies. Additionally, this lubricant did not have to be removed before the next process step, annealing, because it would be burned off in the annealing ovens.[28]

This last example points out one major source of possible problems with material changes, i.e., an adverse effect on the production process, product quality, or waste generation. This possibility can be overcome by carefully evaluating possible impacts of the proposed change on worker health, product quality, process operation, inventory, production costs, and waste management. Conducting pilot-scale tests, trial runs, and phasing in the change over time will help eliminate some potential problems.

One important area which is sometimes overlooked in making a material change is its impact on the total wastestream. Switching from a solvent-based to a water-based product can increase wastewater volumes and concentrations, which could adversely affect the current wastewater treatment system, cause effluent limits to be exceeded, and possibly increase wastewater treatment sludge production. Thus, before any change is made, its impact on all emissions must be evaluated. For example, a small metal fabricator switching from a solvent-based to a water-based product can significantly increase the organic and oil concentration in the wastewater. This increase may require the plant to install new or additional wastewater treatment capacity and/or pay significantly increased sewer use fees.

Reducing or eliminating hazardous materials from the production process can decrease not only hazardous waste generation, but also the quantity of hazardous materials in air emissions and wastewater effluents. This can, if properly evaluated, reduce the capital investment in treatment systems needed to meet pollution discharge limits. For example, a producer of gift-wrapping paper switched from solvent-based to water-based inks. This change saved the company $35,000 per year on hazardous waste management costs. Furthermore, it saved the company from having to install an air pollution control system, to control volatile organic carbon emissions, which would have cost several million dollars.[31]

3.3.3 Process equipment modification

Waste generation may be reduced by installing more efficient process equipment or modifying existing equipment to take advantage of better production techniques. New or updated equipment can use process materials more efficiently, producing less waste. Additionally, higher-efficiency systems may reduce the number of rejected or off-specification products, thereby reducing the amount of material which has to be reworked or disposed of. The use of more efficient equipment or processes can pay for itself through higher productivity, reduced raw material costs, and reduced waste management costs. The necessary capital investment can usually be justified by the increased production rates, and reduced waste management costs provide an added bonus.[33,9] Some examples of process modifications are given in Table 3.6.

Modifying existing process equipment can be a very cost-effective method for reducing waste generation. In many cases the modifications can just be relatively simple and inexpensive changes in the way the materials are handled within the process to ensure that they are not wasted or lost. This can be as easy as redesigning parts racks to reduce drag-out in electroplating operations, installing better seals on process equipment to eliminate leakage, or installing drip pans under equipment to collect leaking process material for reuse.[38,18] In many cases, process modifications and improved operational procedures are used together to reduce waste. One chemical company reduced the waste from a sump in a production area from 31,750 kg/year to 1360 kg/year by installing a sight glass, using better pump scales, and purchasing a broom.[39] Modifying equipment to improve operational effi-

TABLE 3.6 Examples of Production Process Modifications for Waste Reduction

Process step	Technique
Chemical reaction	Optimize reaction variables and improve process controls. Optimize reactant-addition method. Eliminate use of toxic catalysts. Improve reactor design.
Filtration and washing	Eliminate or reduce use of filter aids and disposable filters. Drain filter before opening. Use countercurrent washing. Recycle spent washwater. Maximize sludge dewatering.
Parts cleaning	Enclose all solvent cleaning units. Use refrigerated freeboard on vapor degreaser units. Improve parts draining before and after cleaning. Use mechanical cleaning devices. Use plastic-bead blasting.
Surface finishing	Prolong process bath life by removing contaminants. Redesign part racks to reduce drag-out. Reuse rinse water. Install spray or fog nozzle rinse systems. Properly design and operate all rinse tanks. Install drag-out recovery tanks. Install rinse water flow control valves. Install drip racks and drainboards.
Surface coating	Use airless air-assisted spray guns. Use electrostatic spray-coating system. Control coating viscosity with heat units. Use high-solids coatings. Use powder coating systems.
Equipment cleaning	Use high-pressure rinse system. Use mechanical wipers. Use countercurrent rinse sequence. Reuse spent rinse water. Use "pigs" to clean lines. Use compressed gas to blow out lines.
Spills and leaks	Use bellow-sealed valves. Install spill basins or dikes. Use sealless pumps. Maximize use of welded pipe joints. Install splash guards and drip boards. Install overflow control devices.

SOURCE: From Refs. 18, 21, and 40–44.

ciency requires a thorough understanding of both the production process and wastestream generation. In many cases it is best to phase in the required process modifications over a period of time to reduce any potential effects on the whole production process and to evaluate its impact on the wastestream. As discussed before, the impact on all wastestreams must be evaluated.

Installing new, more efficient equipment and, in some cases, modifying current equipment will require capital investment in equipment, facility modifications, and employee training. The extent of the investment will vary over a large range depending on the type of equipment used. Replacing a solvent vapor degreaser with a household dishwasher to clean circuit boards may cost only several hundred dollars, while replacing a spray coating operation with a powder coating system may cost hundreds of thousands of dollars and require new facilities and extensive employee training. What they have in common is that they both will pay back the investment costs.[18]

Examples of new, more efficient process equipment are numerous in the literature, but little is usually said about reduced waste generation and management costs. The following example shows wwat one company saved when new process equipment was installed. When an automated metal electroplating system was installed to replace the manual operation, annual productivity increased and system downtime decreased from 8 percent to 4 percent. Chemical consumption decreased 25 percent, resulting in an annual reduction of $8000 per year in raw material costs. Water costs were reduced by $1100 per year, and plating wastes, including acids, caustic, and oils, decreased from 204 kg/day to 163 kg/day. Treatment costs for the process water used in the plating operation were reduced by 25 percent. Annual personnel and maintenance cost savings attributable to the new system are $35,000 per year. The automated system has also eliminated worker exposure to acids and caustics, which had been required with the previous manual operation.[17]

As discussed earlier in this section, the use of more efficient process equipment can also mean changing to less hazardous process materials. For example, one furniture company switched from a manual staining operation using solvent-based materials to an automatic staining system using water-based stains. The new process reduced the time required to stain a pallet of parts by 95 percent and reduced raw material usage by 20 percent. The savings in labor alone paid for the new staining system in just three months.[3]

One important factor which is sometimes overlooked in evaluating the cost-effectiveness of equipment modifications is the cost associated with reworking or disposing of off-specification products. This can be very expensive, not only in terms of labor and materials, but also in waste management costs. In many manufacturing operations which involve coating a product, such as electroplating or painting, chemicals are used to strip off the coating from rejected products so that they can be recoated. These chemicals, which can include acids, caustics, cyanides, and chlorinated solvents, often are hazardous wastes which must be properly managed. By reducing the quantity of parts which must be reworked, the quantity of waste can be reduced.

3.4 Volume Reduction

Volume reduction includes techniques to separate hazardous wastes and recoverable wastes from the total wastestream. These techniques are usually used to increase recoverability, reduce the volume and thus the disposal costs, or increase management options. The available techniques used range from simple segregation of wastes at the source to complex concentration technology, as shown in Table 3.7. They are applicable to all types of wastestreams. These techniques can be divided into two general areas: source segregation and waste concentration. Only those methods which are actual waste reduction techniques will be discussed in this section.

3.4.1 Source segregation

Segregation of wastes is in many cases a simple and economical technique for waste reduction. For example, by segregating wastes at the

TABLE 3.7 Examples of Waste Reduction Through Volume Reduction

Industry	Technique
X-ray film	Segregate polyester film scrap from other production waste and recycle.[2*]
Resins	Collect waste resin and reuse in next batch.[42]
Printed circuit boards	Use filter press to dewater sludge to 60% solids and sell sludge for metal recovery.[17]
Pesticide formulation	Use separate bag houses at each process line and recycle collected dust into product.[45]
Research laboratory	Segregate chlorinated and nonchlorinated solvents to allow off-site recovery.[17]
Aircraft components	Use ultrafiltration to remove recoverable oil from spent coolants.[13]
Paint formulation	Segregate and reuse tank-cleaning solvents in paint formulations.[23]
Furniture	Segregate and reuse solvents used to flush spray-coating lines and pumps as coating thinner.[23]

*Superior numbers refer to sources in Reference list at end of chapter.

source of generation and handling the hazardous and nonhazardous wastes separately, waste volume and thus management costs can be reduced. Additionally, the uncontaminated or undiluted wastes may be reusable in the production process or may be sent off site for recovery.

The segregation technique is applicable to a wide variety of wastestreams and industries and usually involves simple changes in operational procedures. For example, in metal-finishing facilities, wastes containing different types of metals can be treated separately so that the metal values in the sludge can be recovered. Keeping spent solvents or waste oils segregated from other solid or liquid waste may allow them to be recycled. Wastewater containing toxic material should be kept separate from uncontaminated process water to reduce the overall volume of water which must be treated.

A commonly used waste segregation technique is to collect and store washwater or solvents used to clean process equipment (such as tanks, pipes, pumps, or printing presses) for reuse in the production process. This technique is used by paint, ink, and chemical formulators, as well as by printers and metal fabricators. For example, a printing firm segregates and collects toluene used for press and roller cleanup operations. By segregating the used toluene by color and type of ink contaminant, it can be reused later for thinning the same type and color of ink. The firm now recovers 100 percent of the waste toluene, totally eliminating a hazardous wastestream.[17]

Another way to apply the segregation technique is to collect and reuse back in the product dust and excess materials generated during the manufacturing process. This technique is used by one pesticide formulator to reduce the volume of hazardous waste it generates. The firm collects the dust generated during the formulation process in a separate bag house for each process line. The collected dust is then reused in the product as an inert filler. This has eliminated the generation of 20,412 kg/year of waste, saving the company $9000 in disposal costs and $2000 in raw material costs. These savings paid for the necessary equipment in less than a year.[17]

3.4.2 Concentration

Various techniques are available to reduce the volume of a waste through physical treatment. Such techniques usually remove a portion of a waste, such as water. For example, concentration techniques are commonly used to dewater wastewater treatment sludges and reduce the volume by as much as 90 percent. Available concentration methods include gravity and vacuum filtration, evaporation, ultrafiltration, reverse osmosis, freeze vaporization, filter press, heat drying, and compaction. Many of these actually are recovery techniques and will be discussed further in the next section. Concentration techniques are available for all types of wastestreams and are used by a wide range of industries.

Unless a material can be recycled, just concentrating a waste so more waste can fit into a drum is not waste reduction. In some cases concentration of a wastestream may also increase the likelihood that the material can be reused or recycled. For example, filter presses or sludge driers can increase the concentration of metals in electroplating wastewater treatment sludge to such a level that they become valuable raw material for metal smelters. A printed circuit board manufacturer dewaters its sludge using a filter press to 60 percent solids. The company receives $7200 per year through the sale of the dewatered sludge for copper reclamation.[17]

3.5 Recovery

Recovering wastes can provide a very cost-effective waste management alternative. This technique can help eliminate waste disposal costs, reduce raw material costs, and possibly provide income from a salable waste. Recovery of wastes is a widely used practice in many manufacturing processes and can be done on site or at an off-site facility. It has been used for centuries to increase productivity and profitability. In fact, the organic chemical industry in the mid-1800s produced aniline dyes which were made from coal gasification plant waste.[46] Current production facilities have the potential to increase greatly the recycling of waste materials based on present regulatory impacts, increased waste management costs, and new waste recovery technologies and approaches.

Waste recovery should only be considered after all other waste reduction options have been instituted. Actually reducing the amount of waste generated at the source will usually be more cost-effective than recycling. In many cases this is because a waste is lost raw material or product which requires time and money to manage and recover. Also, simply generating and handling a waste produces a range of regulatory, health, and environmental liabilities.

All of the previously discussed waste reduction techniques can be used in conjunction with recovery to produce a cost-effective waste management program. One company, a producer of breaded foods, used a variety of waste reduction techniques to significantly reduce waste generation. A management and employee training program on waste reduction techniques and their impact on company profits was instituted. Improved operation and maintenance procedures were instituted, including using dry clean::: for spills and equipment, installing or modifying drip trays under process equipment to better collect lost process material, and developing better systems for collecting and handling waste materials so they could be sold to a recovery firm. These, plus a number of reduction techniques, decreased water usage by about 30 percent, eliminated the landfilling of waste solids, reduced the organic load of the wastewater by almost 80 percent, and allowed the company to sell 2,359,000 kg/year of solids to recovery firms.[47]

The effective use of recovery will depend on the segregation of the recoverable waste from other process wastes or extraneous material. This segregation ensures that the waste is uncontaminated and the concentration of recoverable material is maximized. The waste, then, must be handled like a product. Many of the inventory control techniques discussed in Sec. 3.1 can be applied to waste materials. Some companies have assigned responsibility for the handling, collection, and scheduling of recovery of waste material to one individual.[13,47,48] This helps ensure that the maximum value of the waste can be recovered.

3.5.1 On-site recovery

In most cases the best place to recover process wastes is within the production facility. Wastes which are simply contaminated versions of the process raw materials are good candidates for in-plant recycling. Such recovery can significantly reduce raw material purchases and waste disposal costs. Waste can be most efficiently recovered at the point of generation, because the possibility of contamination with other waste materials is reduced, as is the risk involved with handling and transporting waste materials. See Sec. 3.4 for information on segregation techniques. Some examples of on-site waste recovery are shown in Table 3.8.

Some wastestreams can be reused directly in the original production process as raw material. This easy reuse is usually accomplished when the waste material is lightly contaminated or is excess raw material. Examples include the cleaning waste from printers, coaters, and chemical or product formulators; electroplating drag-out solutions; process solutions from filter changes; and dust collector residue from pesticide formulators.[21,27,38,45,90] Lightly contaminated waste can sometimes be reused in operations not requiring high-purity materials. For example, spent high-purity solvents generated during the production of microelectronics can be reused in less critical metal-degreasing operations, or a caustic waste material can be reused to treat an acid wastestream.

Some waste may have to undergo some type of purification before it

TABLE 3.8 Examples of Waste Reduction Through Recovery and Reuse

Industry	Technique
Printing	Use a vapor-recovery system to recover solvents.[17]*
Photographic processing	Recover silver, fixer, and bleach solutions.[17]
Metal fabrication	Recover synthetic cutting fluid using a centrifuge system.[33]
Mirror manufacturing	Recover spent xylene using a batch-distillation system.[33]
Printed circuit boards	Use electrolytic recovery system to recover copper and tin/lead from process wastewater.[49]
Tape measures	Recover nickel-plating solution using an ion-exchange unit.[40]
Medical instruments	Use reverse-osmosis system to recover nickel-plating solution.[40]
Power tools	Recover alkaline degreasing baths using an ultrafiltration system.[17]
Textiles	Use ultrafiltration system to recover dye stuffs from wastewater.[50]
Hosiery	Reconstitute and reuse spent dye baths.[50]
Food processing	Send all solids off site for by-product recovery.[47]
Wastewater treatment	Reuse waste caustic solids to treat acid wastestream.[51]
Pickles	Transfer waste brine pickle solution to a textile plant as a replacement for virgin acetic acid.[52]
Chemicals	Use spent electrolyte from one division as raw material in another.[53] Purify hydrochloric in wastestream and sell as a product.[54]
Industrial and consumer products	Segregate and sell office paper, corrugated cardboard, paper trimming, and rejected paper products.[2]
Aluminum die-caster	Sell waste fumed amorphous silica for use in concrete.[55]

*Superior numbers refer to sources in Reference list at end of chapter.

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can be reused. A number of physical and chemical techniques available on the market can be used to reclaim a waste material, as shown in Table 3.8. These techniques range from simple filtration to state-of-the-art techniques such as freeze crystallization.[56,57] The method of choice will depend on the physical and chemical characteristics of the wastestream recovery economics, as well as on operational requirements. For a number of wastestreams there are economical small modular recovery units available. Some of the materials commonly recycled by these modular units are spent solvents, electroplating process waste, and spent metalworking fluids.

A certain manufacturer of shopping carts provides a good example of on-site recovery methods and cost savings. The company installed three atmospheric evaporators on the nickel- and chrome-plating lines. These units evaporate water from the plating bath, allowing all rinse water to be returned and thus recovering all dragged-out nickel and chrome plating solutions. With the start-up of the evaporators, raw chemical use declined dramatically: purchases of 1800 kg of nickel sulfate per month have declined to zero; chromic acid purchases have declined by 75 percent, from 900 kg/month to 200 kg/month; and sodium bisulfite used in the waste treatment process for chromic acid has declined from 1800 kg/month to 200 kg/month. Annual savings are projected to be $112,500. The cost of the three atmospheric evaporators was $60,500, with a payback period of only seven months and an annual savings of $145,000.[9]

Most on-site recovery systems will generate some type of residue (i.e., contaminants removed from the recovered material). This residue can either be processed for further recovery or properly disposed of. For example, a solvent distillation system will usually recover only 90 percent of the input spent solvent for reuse. The residues or distillation bottoms are a hazardous waste and as such must be managed in an approved manner. The economic evaluations of any recovery technique must include the management of these residues.

3.5.2 Off-site recovery

Wastes may be recovered at an off-site facility when (1) the equipment is not available to recover on site, (2) not enough waste is generated to make an in-plant system cost-effective, or (3) the recovered material cannot be reused in the production process. Off-site recovery usually entails recovering a valuable portion of the waste through chemical or physical processes or directly using the waste as a substitute for virgin material. Some materials which are commonly reprocessed off site are oils, solvents, electroplating sludges and process baths, lead-acid batteries, scrap metal, food-processing waste, plastic scrap, and cardboard. Wastes directly used are usually chemically or physically specific for a select purpose (i.e., have the same physical or chemical properties as the raw materials they replace) and can range from concentrated acids to chemical by-product streams. This alternative is described further in Sec. 3.2.1. Some examples of materials which have been recovered off site are shown on Table 3.8.

For wastes regulated under the Resource Conservation and Recovery Act (RCRA) there are regulatory barriers to some forms of off-site recovery. Additionally, for hazardous waste the generator is liable for the waste material handled at a recovery facility and for any residue produced. This responsibility may pose possible long-term liability problems. Check with state and federal regulatory agencies for the impact of the regulation on any off-site recovery activity.

The cost of off-site recycling will depend on the purity of the waste and the market for the waste or recovered material. Some materials may be salable, while others may require a fee to be paid for disposal. The markets for some wastes, such as scrap metals and waste oils, are very volatile, and a waste material which has a value one day may have none the next.

For some process materials, such as solvents, the supplier may provide services to pick up the material, recover it, and return it for reuse. Known as *tolling*, this vendor service provides a good way to reduce disposal and raw material costs because the reclaimed material is usually cheaper than virgin material. This arrangement is widely used for metal-cleaning operations, such as machine shops or automotive repair stations, that use cold cleaners. In these operations, a solvent cleaner is provided for use in a leased parts-washing sink. On a regular schedule the supplier brings in fresh solvent and removes the spent solvent for recovery. This procedure is much cheaper for a small company than if it were to dispose of the solvent itself; however, the generator is still liable for proper recovery of the solvent and management of the distillation residues.

In some situations a waste may be transferred to another company for use as a raw material in the other company's manufacturing process. This exchange can be economically advantageous to both firms as it will reduce the waste disposal costs of the generator and reduce the raw material costs of the user. This upgrade of a waste into a product requires a strong commitment from the generator to find markets for the waste material. In some cases the production process or the waste may have to undergo some modification in order to make a more salable product.

A product-development approach can be used to identify and develop markets for a waste material. An example of the ordered steps in such an approach follows:[53,58]

- Determine waste composition and generation rate.
- Evaluate on-site and in-company uses.
- Evaluate off-site uses and locate potential customers and markets.
- Identify any processing required to meet product specifications.
- Evaluate potential customers.

- Negotiate recycle agreement.

The marketing effort is usually undertaken by individuals in a company's sales or purchasing department, with support from engineering and technical staff. Some larger companies have dedicated groups for just marketing waste materials and surplus materials. Markets for the waste can be identified through advertising, contacts with trade associations, waste exchanges, industrial contacts, brokers, and a number of literature sources.[58,59]

Regional waste exchanges have been set up by a number of states to act as information clearinghouses of wastes that are available and wastes that are sought. A waste exchange can help identify possible markets for a material. The service usually offered is a listing in a catalog or computer data base form of wastes available from generators and sought by users. This information is distributed throughout a specific geographic area. A company interested in a waste contacts the waste exchange, which forwards the inquiry to the listing company. Usually, actual negotiations and material transfers are handled directly by the companies. A current listing of waste exchanges is given in Table 3.9.

Before a company looks outside itself for markets, internal uses should be evaluated. Probably some of the most cost-effective recycling efforts are made within a company because the waste replaces material that otherwise would have to be purchased or produced. It may be possible to use the material directly, or the material may have to undergo some further processing, as discussed below. One chemical manufacturer had the distillation bottoms from a production process refined at an outside custom processor for use as raw material at another facility, saving the company over $1 million per year in raw material and disposal costs.[53] One approach for excess off-specification material is to set up a corporate waste exchange using a newsletter or even a computer data base system to help identify users for waste material. This approach has been taken by a number of companies.[12,27,59] For example, one large corporation purchasing department lists surplus materials at all plant locations in a computer data system. Before any materials are purchased for a given plant, the purchasing department checks to determine if they are available at another location.[27]

Some wastes may have to be upgraded before a market can be found for them. This upgrading can be in the form of purification, concentration, particle sizing, or other processes. The material itself can undergo processing, or else the production process can be modified to produce a higher-quality wastestream. For example, a circuit board manufacturer found that in order to market its copper-containing wastewater treatment sludge, the sludge must have a low iron concen-

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TABLE 3.9 North American Waste Exchanges

Alberta Waste Materials Exchange 4th Floor Terrace Plaza 4445 Calgary Trail South Edmonton, Alberta Canada T6H 5R7	Industrial Waste Information Exchange New Jersey Chamber of Commerce 5 Commerce Street Newark, NJ 07102
California Waste Exchange Department of Health Services Toxic Substances Control Division 714 P Street Sacramento, CA 95814	Manitoba Waste Exchange c/o Biomass Energy Institute 1329 Niakwa Road Winnipeg, Manitoba Canada R2J 3T4
Canadian Waste Materials Exchange Ontario Research Foundation Sheridan Park Research Community Mississauga, Ontario Canada L5K 1B3	Montana Industrial Waste Exchange Montana Chamber of Commerce P.O. Box 1730 Helena, MT 59624
Great Lakes Regional Waste Exchange 470 Market St., S.W., Suite 100A Grand Rapids, MI 49503	Northeast Industrial Waste Exchange 90 Presidential Plaza, Suite 122 Syracuse, NY 13202
Indiana Waste Exchange Environmental Quality Control 1220 Waterway Boulevard P.O. Box 1220 Indianapolis, IN 46206	Southeast Waste Exchange Urban Institute UNCC Station Charlotte, NC 28223
Industrial Material Exchange Service P.O. Box 19276 Springfield, IL 62794-9276	Southern Waste Information Exchange Institute of Science and Public Affairs Florida State University P.O. Box 6487 Tallahassee, FL 32313

SOURCE: From Ref. 60.

tration and be high in solids and copper concentration. An effort was undertaken to modify the wastewater treatment process so that iron-containing treatment chemicals were not used. Additionally, the sludge was dewatered using a filter press to 50 percent solids. This dewatering increased the copper concentration to 25 to 35 percent by weight, and a market for the material with a copper smelter was found. This effort, along with finding uses for several other wastestreams, now allows the company to market over 90 percent of the hazardous waste it generates.[61]

3.6 Summary

As has been shown, a wide range of waste reduction techniques currently exist and are available for most manufacturing steps. However, technology alone will not reduce waste generation. Only a comprehensive waste reduction program will be successful. Such a program should include management commitment, data collection, cost-effective technology selection and implementation, employee training and involvement, and program monitoring. The foundation of any successful program is the evaluation of what wastes are generated and why they are produced. Based on this information, a range of reduction techniques can then be identified and evaluated, and the cost-effective ones implemented. A more detailed discussion of how to develop a waste reduction program is covered in Chap. 4.

Sources of specific information on waste reduction techniques are available from a number of places. The best source, however, is discussion with the process operators, who in most cases can identify operations and equipment problems which generate waste. Additional information may be obtained from trade associations and trade journals, as well as government research reports, regulatory agencies, and technical assistance groups.

Industrial trade associations can provide the most detailed and current technical information. Many associations have staff experts with extensive knowledge and experience in waste management. A list of trade associations can be found in Ref. 63. Trade publications are another very good source of information. Many journals contain articles on case studies, current research, vendor information, and suggestions from industrial experts.

Other sources of technical information are federal and state regulatory agencies and technical assistance programs. The U.S. Environmental Protection Agency (U.S. EPA) has established an Office of Pollution Prevention to help promote waste reduction efforts by the regulated community. These efforts include research, education, and technical information. A number of states have established waste reduction technical assistance programs. The level of assistance offered by these programs varies, and the programs may include on-site technical assistance, access to information data base and documents, workshops, referral services, research, and matching grant programs. Current programs are discussed in Chap. 12. Check with your respective state environmental agencies to find out if such a program is available in your locality.

In the final analysis, waste reduction depends on looking at waste in a different way, not as something that inevitably must be treated and disposed of, but for what it really is—a loss of valuable process materials, the reduction of which can have significant economic benefits. One corporate executive summarized it all when he stated that waste is a specialty product for which a market has not yet been found.[64]

3.7 REFERENCES

1. William Wahl, *A Practical Guide for the Gold and Silver Electroplater and the Galvanoplastic Operator*, Henry Carey Baird & Co., Philadelphia, 1883.
2. John Hunter III, "Minimizing Waste by Source Segregation and Inventory Control," *Technical Strategies for Hazardous Waste Prevention and Control Seminar*, Government Institutes, Inc., Washington, D.C., 1987.
3. Jerome Kohl et al. *Managing and Recycling Solvents in the Furniture Industry*, North Carolina Board of Science and Technology, Raleigh, N.C., 1986.
4. Susan Boyle and Raghu Raghawan, "Hazardous Waste Source Reduction Case Studies," *Proceedings of the CMA Waste Minimization Workshop*, vol. 1, Chemical Manufacturing Association, Washington, D.C., 1987.
5. Jerome Kohl, *Hazardous Waste Minimization: The New RCRA Initiative*, Industrial Extension Service, North Carolina State University, Raleigh, 1988.
6. R. A. Mead, "Waste Reduction at a Paint Plant—An OE Approach," *Proceedings of the Hazardous Waste Reduction Audit Workshop*, New Jersey Department of Environmental Protection, Trenton, N.J., 1987, pp. 156–163.
7. Gregory Lorton, "Waste Minimization in the Paint and Allied Products Industry," *J. Air Pollution Control Association*, 38:4, 1988.
8. Ryan Delcambre, "Waste Reduction: Program Practice and Product at Dow Chemical," *Waste Minimization and Recycling Report*, 1(1):7, 1986.
9. *Governor's Award for Excellence in Waste Management—1987*, Governor's Waste Management Board, Raleigh, N.C., 1988.
10. Paul Dadak, "Waste Minimization: The Hewlett Packard Experience," *Waste Minimization Manual*, Government Institutes, Inc., Washington, D.C., 1987.
11. Stephen Mims, "Glycol II—Absorber Water Upgrade Project," *Proceedings of the CMA Waste Minimization Workshop, vol. 1*, Chemical Manufacturers Association, Washington, D.C., 1987.
12. Steven Rice, "Waste Reduction in the R & D Industry," *Proceedings of the Hazardous Waste Reduction Audit Workshop*, New Jersey Department of Environmental Protection, Trenton, N.J., 1987, pp. 181–190.
13. *Governor's Award for Excellence in Waste Management—1986*, Governor's Waste Management Board, Raleigh, N.C., 1987.
14. David J. Sarokin et al., *Cutting Chemical Wastes: What 29 Organic Chemical Plants Are Doing to Reduce Hazardous Wastes*, Inform, Inc., New York, 1985.
15. Rupert Bullard, John Rushing, and Roy Carawan, "A Dairy Processor Does It," *Proceedings of the Conference Waste Reduction Pollution Prevention: Progress and Prospects within North Carolina*, Pollution Prevention Program, North Carolina Department of Natural Resources and Community Development, Raleigh, N.C., 1988, pp. 29. 1–29.6.
16. David Adkins, Gary Hunt, and Roger Schecter, *Pollution Prevention Challenge Grants: Project Summaries*, Pollution Prevention Program, North Carolina Department of Natural Resources and Community Development, Raleigh, N.C., 1988.
17. Donald Huisingh, *Profits of Pollution Prevention: A Compendium of North Carolina Case Studies*, North Carolina Board of Science and Technology, Raleigh, N.C., 1985.
18. Case Study Files from the Pollution Prevention Program, Division of Environmental Management, North Carolina Department of Natural Resources and Community Development, Raleigh, N.C.
19. Herbert Skovronek, "Paint Application: Waste Management," *Proceedings of the Hazardous Waste Reduction Audit Workshop*, New Jersey Department of Environmental Protection, Trenton, N.J., 1987, pp. 164–172.
20. Charles Parmele, Robert Fox, and Richard Standifer, "Waste Minimization Through Effective Chemical Engineering," *Proceedings of the Conference on Performance and Costs of Alternatives to Land Disposal of Hazardous Waste*, Air Pollution Control Association, Pittsburgh, Pa., 1986, pp. 115–123.
21. Carl Fromm and Sunivas Budarajer, "Reducing Equipment Cleaning Wastes," *Chemical Engineering*, 95(10):117, 1988.
22. Thomas K[illegible]nowski and Mary Ann Keon, *Waste Generation and Disposition Practices and Currently Applied Waste Minimization Techniques within the Semiconduc-*

au: query, rep 65

au: query, rep 66

tor Industry, State of California Department of Health Services, Sacramento, Ca., 1987.

23. Roy Carawan, James Chambers, and Robert Zall, *Management Control of Water Use and Wastes in Food Processing*, AM-18L, Agricultural Extension Service, North Carolina State University, Raleigh, N.C., 1979.
24. Robert Shober, "Water Conservation and Waste Load Reduction in Food Processing Facilities," *1988 Food Processing Waste Conference Proceedings*, Georgia Tech Research Institute, Georgia Institute of Technology, Atlanta, Ga., 1988.
25. U.S. Environmental Protection Agency, *Waste Minimization Issues & Options: Vol. II*, EPA/530-SW-86-042, Office of Solid Waste and Emergency Response, Washington, D.C., 1986.
26. R. Keith Mobley, "Turning Maintenance Dollars into Bottom-Line Profits," *CPI Equipment Reporter*, May/June 1988, p. 21.
27. John Hunter III, "Life Cycle Approach to Effective Waste Minimization," paper presented at *Conference on Engineering to Minimize the Generation of Hazardous Waste*, Engineering Foundation, Hinniker, N.H., 1987.
28. Bill Pitchford, "Process Modification: One Alternative to Chlorinated Solvents," *Focus Waste Minimization*, North Carolina Department of Human Resources, Issue IV, 1987, pp. 5–6.
29. George Makrauer, "Water-Based Inks in Flexographic Printing—High Slip Polyethylene Film," *Proceedings of the Conference Waste Reduction—Pollution Prevention: Progress and Prospects within North Carolina*, Pollution Prevention Program, North Carolina Department of Natural Resources and Community Development, Raleigh, N.C., 1988.
30. Gary Hunt and Roger Schecter, *Accomplishments of North Carolina Industries: Case Summaries*, Pollution Prevention Program, North Carolina Department of Natural Resources and Community Development, Raleigh, N.C., 1987.
31. *Governor's Conference on Pollution Prevention Pays Proceedings*, Governor's Safe Growth Team, Nashville, 1986.
32. T. E. Higgins, *Industrial Processes to Reduce Generation of Hazardous Waste at DOD Facilities, Phase I Report Evaluation of 40 Case Studies*, Department of Defense Environmental Leadership Project Office, Washington, D.C., and U.S. Army Corps of Engineers, Huntsville, Ala., 1985.
33. Jerome Kohl, Phillip Moses, and Brooke Triplett, *Managing and Recycling Solvents: North Carolina Practices, Facilities, and Regulations*, North Carolina Board of Science and Technology, Raleigh, N.C., 1984.
34. Jerome Kohl, Jeremy Pearson, and Brooke Triplett, "Reducing Hazardous Waste Generation with Examples from the Electroplating Industry," *Waste Management Advisory Note*, vol. 22, Solid and Hazardous Waste Management Branch, North Carolina Department of Human Resources, Raleigh, N.C., 1986.
35. J. Edward Smith, *Evaluation of a Teflon-Based Ultraviolet Light System on the Disinfection of Water in a Textile Air Washer*, Pollution Prevention Program, North Carolina Department of Natural Resources and Community Development, Raleigh, N.C., 1987.
36. 3M Company, "Riker Innovation Meets Air Regulation," *Ideas: A Compendium of 3P Success Stories*, 3M Company, Saint Paul, Minn.
37. Alice Johnson, "Experiences in Getting Rid of Solvent-Based Degreasing in a Diesel Engine Remanufacturing Plant," *Proceedings of the Conference Waste Reduction—Pollution Prevention: Progress and Prospects within North Carolina*, Pollution Prevention Program, North Carolina Department of Natural Resources and Community Development, Raleigh, N.C., 1988, pp. 15.1–15.5.
38. Gary Hunt, "Waste Reduction in the Metal Finishing Industry," *J. Air Pollution Control Association*, 38(5):672, 1988.
39. W. Beck, "Waste Minimization—A Plant Approach to Getting Started," *CMA Waste Minimization Workshop Proceedings*, vol. I, Chemical Manufacturers Association, Washington, D.C., 1987.
40. Jerome Kohl and Brooke Triplett, *Managing and Minimizing Hazardous Waste*

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Metal Sludges: North Carolina Case Studies, Services and Regulations, Governor's Waste Management Board and the Hazardous Waste Management Branch, North Carolina Department of Human Resources, Raleigh, N.C., 1984.

41. Monica E. Campbell and William M. Glenn, *Profit from Pollution Prevention, A Guide to Industrial Waste Reduction and Recycling*, Pollution Probe Foundation, Toronto, 1982.
42. Versar, Inc., and Jacobs Engineering Group, *Waste Minimization Issues and Options*, vol. III, EPA 530-SW-86-043, Office of Solid Waste, U.S. Environmental Protection Agency, Washington, D.C., 1986.
43. Carl H. Fromm and Michael S. Callahan, "Waste Reduction Audit Procedure—A Methodology for Identification, Assessment, and Screening of Waste Minimization Options," in *Proceedings of the National Conference on Hazardous Wastes and Hazardous Materials*, Hazardous Materials Control Research Institute, Silver Springs, Md., 1986.
44. *U.S. EPA Summary Report—Control and Treatment Technology for the Metal Finishing Industry—In-Plant Changes*, EPA-625/8-82-008, U.S. Environmental Protection Agency, Cincinnati, 1982.
45. Davis Lewis, "Waste Minimization in the Pesticide Formulation Industry," *J. Air Pollution Control Association*, 38(10):1293, 1988.
46. James Burke, *Connections*, Little, Brown & Co., Boston, 1978.
47. James Waynick, Roy Carawan, and Fred Tarver, "A Breaded Foods Processor Does It Too!" *Proceedings of the Conference Waste Reduction—Pollution Prevention: Progress and Prospects within North Carolina*, Pollution Prevention Program, North Carolina Department of Natural Resources and Community Development, Raleigh, N.C., 1988, pp. 30.1–30.9.
48. Jerome Kohl and John Currier, *Managing Waste Oils*, Industrial Extension Service, North Carolina State University, Raleigh, N.C., 1987.
49. Thomas J. Nunno and Mark Arienti, "Waste Minimization Case Studies for Solvents and Metals Waste Streams," presented at the *Hazardous Waste Disposal Conference*, U.S. Environmental Protection Agency, Cincinnati, 1986.
50. Resource Integration Systems, Inc., J. L. Richards & Associates Limited, Ontario Research Foundation, and The Proctor and Redfern Group, *Technical Manual: Waste Abatement, Reuse, Recycle, and Reduction Opportunities in Industry*, Environment Canada, Toronto.
51. Catherine Patriquen, "Beneficial Use of Wastes within Specialty Chemicals Manufacturing," *Proceedings of the CMA Waste Minimization Workshop*, vol. II, Chemical Manufacturers Association, Washington, D.C., 1987.
52. Brent Smith, *Identification and Reduction of Pollution Sources in Textile Wet Processing*, Pollution Prevention Program, North Carolina Department of Natural Resources and Community Development, Raleigh, N.C., 1986.
53. James Nesmith III, "Marketing Industrial Waste: A Generator's Perspective," *Proceedings of the Fourth National Conference on Waste Exchange*, Southeast Waste Exchange, Charlotte, N.C., 1987.
54. Edward Shields, "Transforming Wastes into Products," *Proceedings of the Source Reduction of Hazardous Waste Seminar*, New Jersey Department of Environmental Protection, Trenton, N.J., 1985.
55. Travis A. Turberville, "Market Development for Fumed Amorphous Silica and Ladle Rakeout," *Proceedings of the Conference Pollution Prevention Pays: Waste Reduction in Alabama*, University of Alabama Center for Urban Affairs, Birmingham, 1985.
56. Kenneth E. Noll et al., *Recovery, Recycle and Reuse of Industrial Waste*, Lewis Publishers, Chelsea, Mich., 1985.
57. Harry Freeman (ed.), *Standard Handbook of Hazardous Waste Treatment and Disposal*, McGraw-Hill Book Co., New York, 1988.
58. Richard Dowing, "Marketing Waste Byproducts as Reusable Feedstocks (Part 1)," *Waste Minimization and Recycling Report*, Issue 22, 1988, pp. 7–9.
59. David Jacobs, "Brokering of Industrial By-Products," *Proceedings of the Fourth Na-*

au: query rep 78

3-30

tional Conference on Waste Exchange, Southeast Waste Exchange, Charlotte, N.C., 1987.

60. Bill Stough, "Waste Exchanges: Catalysts for Innovation in Waste Minimization," *J. Air Pollution Control Association*, 38(6):744, 1988.
61. Terry Schurter, "Waste Marketing: A Case Study from the Electroplating Industry," *Proceedings of the Conference Waste Reduction—Pollution Prevention: Progress and Prospects within North Carolina*, Pollution Prevention Program, North Carolina Department of Natural Resources and Community Development, Raleigh, N.C., 1988, pp. 33.1–33.3.
62. Energy Pathways, *Catalogue of Successful Hazardous Waste Reduction/Recycling Projects*, Waste Management Division, Environment Canada, Toronto, 1987.
63. *National Trade and Professional Association of the U.S.—1986*, Columbia Books, Washington, D.C., 1986.
64. *Solvent Waste Reduction Alternatives Seminar*, U.S. Environmental Protection Agency, Chicago, 1988.

WASTE REDUCTION METHODS

The waste reduction assessment is a systematic and periodic survey of a business's operations designed to identify areas of potential waste reduction. The first step in reducing or eliminating the amount of waste generated is to identify all waste "streams" (types of waste), and determine which processes create these wastes. The assessment process will be discussed in detail in Chapter 7. When the waste streams have been identified, they can be evaluate how each stream might be reduced or eliminated by making one or more of the followings changes.

Improved Operational Procedures and Housekeeping

Improved housekeeping and good operating practices are the simplest waste reduction practices. Improved housekeeping relies on using good common sense and is often the most effective first step toward waste reduction. Sloppy housekeeping can result in more waste being generated than is necessary. To reduce excess waste production:

- Buy only the amount of raw material needed. Buying in quantity may initially save money but often leaves a company with excess material which may exceed shelf life, requiring expensive disposal;

- Use raw materials sparingly so that excess waste is not generated;

- Use raw materials in correct proportions so that excess waste is not generated by making defective products or formulations;

- Make sure equipment (e.g. parts cleaning tanks and painting equipment) is working properly. Be sure to check for faulty valves or pipes to make certain that the product is not being lost from the system or unintentionally contaminated; and

- Ensure that all products and waste is inventoried, clearly labeled and properly stored. Inadequate labeling may make it hard to identify wastes later, and necessitate expensive testing prior to disposal. Improper storage can result in accidental contamination of a nonhazardous waste, which must then be disposed of through more expensive hazardous waste methods.

Material handling and inventory practices include ways to reduce loss of input materials due to mishandling, expired shelf life of time-sensitive materials, and proper storage conditions. Loss prevention reduces wastes by avoiding leaks from equipment and spills. For example:

- A large consumer product company in California adopted a corporate policy to reduce the generation of hazardous waste. In order to implement the policy, the company mobilized quality circles made up of employees representing areas within the plant that generated hazardous wastes. The Company experienced a 75% reduction in the amount of wastes generated by instituting proper maintenance procedures suggested by the quality circle teams. Since the team's members were also line supervisors and operators, they made sure the procedures were followed.

Waste Segregation

Many wastes are actually mixtures of hazardous and nonhazardous waste. Much of their content may even be water. By segregating key toxic constituents, isolating liquid fractions, or keeping hazardous streams from nonhazardous waste, businesses can sometimes save substantial amounts of money on disposal or find new opportunities for recycling and reuse. In many cases, segregation of wastes allows for certain wastes to be recycled or reused. For example:

- A paper manufacturer produced waste oil contaminated with solvents, water and other materials. This had resulted in disposal of what would have been a recyclable waste. The manufacturer now keeps the waste oil containers closed and locked, requiring the supervisor to personally dispose of the wastes to ensure proper segregation.

- A large machine shop had been disposing of 4,000 gallons of cutting oil contaminated with trichlorethane. The company was given information on the recycling of these wastes and instituted segregation procedures to eliminate cross contamination.

Labels

By properly labeling its chemical substances and wastes, a business can reduce the waste and risk associated with mistaken usage or disposal of the wrong substance. This type of operational procedure is a key element of a waste reduction program's good housekeeping practices. All hazardous substances used in the workplace should be properly labeled to comply with the Worker Right-to-Know law. In addition, all wastes, once segregated, should be labeled as well. This procedure helps to ensure the safe handling of the waste and proper storage of incompatible wastes. Once segregated, the business can assess the potential for recycling, reuse, or even resale of the waste.

Product and Material Substitution

Product Substitution entails substituting nonhazardous products for hazardous materials the business currently uses. This practice can eliminate some hazardous waste streams. (For example, solvent-based, metal-containing paints have been replaced by non-metallic, water-based paints for many applications). As the demand for nonhazardous raw materials and products increases and a market develops, more nonhazardous product alternatives will become available. For example:

- In a painting business, water-based coatings are finding increasing applications where solvent-based paints were used before. These products do not contain toxic or flammable solvents that make solvent-based paints hazardous when they are disposed. Also, cleaning the applicators with solvent is not necessary. The use of water-based paints instead of solvent-based paints also greatly reduces volatile organic compound (VOC) emissions to the atmosphere.

Upon completion of a waste assessment, a business may identify specific input materials that are producing the hazardous wastes. If this is the case, it may be possible to find a substitute material which is less hazardous. Although material substitution is only applicable in certain situations, it can prove to be an efficient part of a hazardous waste reduction program. For example:

- An electronic manufacturing facility of a large diversified corporation originally cleaned printed circuit boards with solvents. The company found that by switching from a solvent-based cleaning system to an aqueous-based system that the same operating conditions and workloads could be maintained. The aqueous-based system was found to clean six times more effectively. Results: lower product reject rate and elimination of a hazardous waste.

Technology Changes

Technology changes are oriented toward process and equipment modifications to reduce waste, primarily in a production setting. These can range from minor changes that can be implemented in a matter of days at low cost, to the replacement of processes involving large capital costs. A product can sometimes be manufactured by two or more distinct processes, and one process may produce less hazardous waste than the other.

Technological changes include the following:

- Changes in the production process;
- Equipment, layout, or piping changes;
- Use of automation;
- Changes in process operating conditions;
- Waste concentration or volume reduction; and
- Energy conservation.

Process Modifications

Old or inefficient production processes can be sources of hazardous waste. By changing to a newer, more efficient process, a business can decrease the amount of hazardous waste it generates. In addition, many businesses can experience improved production capacity and product quality, and realize savings in expenditures for utilities and raw materials. Remember, process changes often entail subsequent equipment changes. For example:

- A manufacturer of fabricated metal products cleaned nickel and titanium wire in an alkaline chemical bath prior to using the wire in their product. In 1986, the company began to experiment with a mechanical abrasive system. The wire was passed through the system which uses silk and carbide pads and pressure to brighten the metal. The system worked, but required passing the wire through the unit twice for complete cleaning. In 1987, the company bought a second abrasive unit and installed it in series with the first unit. This allowed the complete elimination of the chemical cleaning bath. Waste reduction was therefore 100%.

- In 1985, an electroplating business was using an acid solution to remove titanium oxide from the metal, resulting in the production of 15 tons per year of acid solution containing metals. In 1986, the business installed a mechanical scraping process for the removal of oxides from the metal. This resulted in the complete elimination of the acid cleaning process, reducing acid waste production to zero.

Equipment, Layout, or Piping Changes

Replacing existing machines with more efficient equipment for the same operation can significantly reduce waste generation. Equipment changes accomplish waste reduction by reducing or eliminating equipment-related inefficiency. Equipment changes can be made to enhance recovery or recycling options for a business. An equipment modification leaves the production process intact and unchanged, because it modifies only the equipment used in the process. For example:

- In the coating industry, the replacement of conventional air-atomized spray paint equipment (transfer efficiency 30-60%) with more efficient electrostatic equipment (65-80% efficient) or powder coating equipment (90-99% efficient) results in a substantial reduction of waste; and

- An aircraft and truck aluminum parts manufacturer uses a forging process which dulls the aluminum. Acid and alkaline cleaning and etching processes are required to check aerospace parts and "shine" the truck hubs. The aqueous solution with metals was routinely disposed of at a Class I landfill at a cost of $10,000 per month. The aqueous solution with metals can be treated using a typical neutralization - precipitation - filter press wastewater treatment unit. The company is now planning to install an on-site treatment system for this waste stream. In 1986, the manufacturer installed an ultrafiltration unit for its cutting oils and now has it recycled by a commercial oil recycler, thereby eliminating land disposal costs.

Use of Automation

Process automation involves the use of automatic devices to assist or replace human employees. Automation can include the monitoring and subsequent adjusting of process parameters by computer, or mechanical handling of hazardous substances. Waste reduction is accomplished by minimizing the probability of employee error (which can lead to spills or off-spec products) and by increasing product yields through the optimum use of raw materials. It can also reduce the liability of exposing workers to hazardous materials.

Changes in Process Operating Conditions

Often the generation of hazardous waste may not be the fault of the equipment. Instead, the fault may lie in the way the equipment is set to operate. Many pieces of equipment have optimum settings at which they operate most efficiently. By determining the optimum settings for certain parameters (such as optimum flow rates, residence times, temperatures, and pressures), less waste is generated as a byproduct. These are often the most easy and inexpensive of equipment changes to make for waste reduction. For example:

- An electronics manufacturing firm using 1,1,1-trichlor cleaning baths found that they could reduce the content of the bath by one third, thus eliminating losses by evaporation and savings in raw materials cost.

- A plumbing products manufacturer uses electroplating and cleaning processes that produce hazardous waste. The company discovered it could use their chrome and copper electroplating bath system at lower cyanide levels thus saving raw materials and producing less hazardous waste sludge.

Waste Concentration or Volume Reduction

Some hazardous wastes contain such large volumes of water that transportation, treatment, and disposal becomes overly expensive or impractical. Although not as significant as other approaches, water conservation can have an effect on reducing hazardous waste generation. For example:

- Commercially available equipment such as sludge dryers or filter presses remove the water content of a pretreatment sludge, thus reducing the weight and volume of the hazardous waste requiring disposal.

- By reducing the amount of water used for washing certain organic chemical products, companies can lower the amount of wastewater which must be pretreated before disposal.

Hazardous Waste Reduction Program of Oregon

A Generator's Checklist

Use this checklist to guide your company's waste reduction efforts. it should help you come up with several good reduction options for each of your operations.
Company name:

Today's date:

1. Your management stratey

have you considered:
- developing a hazardous waste reduction plan for your facility?
- training employees to be aware of hazardous waste reduction opportunities?
- accounting for hazardous waste treatment and disposal expenses as a direct cost of producing a product?

2. Water use/reuse

have you considered:
- flow control valves?
- identifying water Inflow and outflow from each unit process?
- evaluating reuse of clean or contaminated water?
- using timers or foot pedals to control water usage?
- using conductivity cells in plating rinse systems?
- reactive rinsing?

3. Material handling

have you considered:
- segregating raw and waste material containers?
- segrating different waste materials in separate containers?
- purchasing materials in bulk or larger containers?
- controlling Inventory to reduce waste?
- labeling all containers property?
- labeling process tanks?

4. Solvent cleaners

have you considered:
- avoiding cross-contamination of solvent?
- avoiding water contamination of solvent?
- removing sludge continuously?
- utilizing tank cover or air knife to reduce surface evaporation?
- monitoring solvent composition?
- consolidating cold cleaning operations? recycling spent solvent?
- using plastic media basting for paint stripplng Instead of solvent stripping?
- using non-chlorinated solvents instead of chlorlinated solvents?
- installing a vapor recovery system to capture vaporized solvents?
- installing on-site distillation units?
- evaluating work removal rate?

5. Alkaline/acid cleaners

have you considered:
- removing sludge more frequently?
- avoiding cross-contamination of solvent?
- reusing cleaners by filtering and rejuvenating?
- removing dropped pieces frequently?

6. Plating/etching/metal finishing

have you considered:
- using low temperature baths to reduce surface evaporation?
- prolonging plating solution bath life through filtration, reducing dragout, avoiding contamination, etc.?
- using lower concentration plating bath?
- redesigning part racks to reduce dragout prior to rinsing, possibly with air blow-off?
- using trivalent Cr Instead of hexavalent Cr?
- using non-cyanide plating solutions such as chloride or sulfate solutions?
- using In-line recovery techniques? regenerating spent bath solutions?
- segregating all waste streams?
- maintaining parts like racks, barrels, and tanks, for cleanliness?
- using spray or fog nozzle rinses to reduce dragout?
- using wetting agents to reduce surface tension, thus minimizing dragout?
- reusing rinse water?
- recovering chrome and nickel plating solutions by an evaporation unit?

7. Rinse water have you considered:

have you considered:

- using multiple rinse tanks?
- using countercurrent rinsing?
- installing drainboards and drip tanks?
- installing racks above plating tanks to reduce dragout?
- using fog nozzles and spray units?
- agitating rinse bath (air or solution agitation)?
- recycling and reusing spent rinse water through such metal recovery techniques as ion exchange, reverse osmosis, and electrochemical recovery?
- segregating all waste streams?
- using an evaporator for material recovery from rinse tanks and reuse in plating bath?

8. Paint application

have you considered:

- using equipment with high transfer efficiency such as electrostatic applicators?
- using high-solids coatings such as powder coatings?
- segregating all waste streams?
- using cheesecloth over filters to reduce spent filter generation?
- recycling overspray from, for instance, powder coatings?
- evaluating the use of different types of paint arrestors such as water wash and filters?
- arranging for formal training for spray operators?
- optimlzing spray conditions in terms of speed, distance, angle, pressure, etc.?
- using booth coatings for easy booth cleaning? inspecting all parts, such as racks, for cleanliness? using gun washer equipment for equipment cleanout?
- reducing the use of solvent-based and metals-based paints, where possible; and utilizing water-based coatings?
- using a charged screen with electrostatic system to reduce edge buildup and to capture and reuse overspray paint?

9. Leaks and spills

have you considered:

- using seal-less pumps?
- installing spill basins on dikes?
- installing splasn guards and drip boards?
- installing overflow control devices?
- maximizing use of welded pipe joints?

10. Sludge dewatering

have you considered:
- using mechanical dewatering devices such as filter presses, centrifuges, vacuum filters, or compression filters?
- keeping different metals sludges segregated?
- using filter bags?
- using sludge dryers?

11. Parts washing

have you considered:
- covering all solvent cleaning units?
- using refrigerated freeboard on vapor degreaser units?
- improving parts draining before and after washing?

12. Printing

have you considered:
- segregating and reusing waste wash solvents In Ink formulation?
- using a vapor recovery system to recover solvents?
- using a distillation unit to recover waste alcohol solutions for reuse?
- recovering silver from fixer and developer solutions?

13. Oil/water separation

have you considered:
- using a centrifuge system to recover cutting fluids?
- chemical treatment?
- filtration?
- coolant regeneration?

After you complete this checklist, you 'll want to consider developing a strategy for implementing options you did not check into your plants maintenance or capital improvement procedures. For more information on hazardous waste reduction options, contact the Oregon Department of Environmental Quality (DEQ), 811 SW 6th., Portland, Oregon 97204; or call (503) 229-5913.

5.0 APPROACHES TO WASTE MINIMIZATION

Up to this point, you have been introduced to the importance of waste minimization to the small quantity generator, the advantages of waste minimization, and how complying with various environmental regulatory requirements can be an important first step in minimizing your hazardous waste.

For the next four chapters, you will be shown the actual approaches and techniques of waste minimization, illustrated in a format easily used in the workplace.

5.1 Introduction

Approaches to waste minimization are primarily low-cost, low-risk alternatives to hazardous waste disposal. Most of the approaches do not require a great deal of sophisticated technology and can be relatively inexpensive. In short, waste minimization approaches are:

- technically feasible,
- economically viable, and
- ecologically beneficial.

In general, any waste minimization program should include or consider:

- management initiatives,
- waste audits,
- improved housekeeping,
- materials substitution,
- redesigning equipment,
- recycling and reuse, and
- waste exchange.

The following sections will introduce you to these various approaches to waste minimization. By becoming familiar with these general approaches, you will be better prepared to understand the next three chapters, which describe how to actually implement a waste minimization program.

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5.2 Developing Management Initiatives

The commitment to waste minimization must come from the top—the management of a business or organization. Management initiatives are vital to the success of any waste minimization efforts, and like the waste audit, should be considered as a preliminary step in your waste minimization program.

5.2.1 Overview

Two management actions are crucial to a successful waste minimization program:

- **Communication:** Management must make all employees aware of the waste minimization effort.
- **Incentives:** Just as incentives are used to boost employee productivity, management should provide incentives for the development of useful waste minimization ideas.

Although a waste minimization commitment should begin with management, the employees are often able to suggest improvements in the day-to-day operations of the business. To utilize this important resource, many businesses give their employees incentives such as:

- recognition awards for outstanding waste minimization projects, as well as for resource and energy conservation projects; and
- financial awards for innovative approaches to waste minimization.

These incentives can take any form suitable to the company and the employees. Indeed, the incentives offered by a company with approximately 200 employees may differ greatly from a company with 5 employees. Regardless of the form of the incentives, employees should realize part of the benefits of their waste minimization ideas.

The new management initiatives should foster the following elements of waste minimization success:

- increased awareness and attention to hazardous chemicals,
- motivation to change old work patterns,
- knowledge of options for change,
- willingness to innovate and change,
- willingness to provide resources to implement changes, and
- willingness to learn from changes.

Another important management tool in the waste minimization process is employee training. Although training can be presented in many ways, training programs should include:

- occupational and plant safety;
- company regulatory compliance requirements;
- a statement of the company's waste minimization plan (including incentives for waste minimization ideas and an introduction to why waste minimization is important); and
- Material Safety Data Sheets (MSDSs) and other information that comply with the requirements of worker and community right-to-know laws.

5.2.2 Problem-Solving Through Employee Participation

This section outlines a problem-solving process that can be used to gain employee commitment to and active responsibility for the goals of your company. It is a method that can be directly applied to developing a hazardous waste minimization program.

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This method:

- applies some of the most effective approaches in business and industry,
- has been used extensively world wide,
- has been shown to increase productivity as well as decrease operational costs,
- utilizes employee participation realizing that their involvement will directly affect the ultimate operation of your company, and
- can be used as an innovative training technique which gains and holds your employees' attention.

This process is known as Problem Solving Through Employee Participation and consists of five steps. They are:

- state purpose or goal,
- identify problems in the work area,
- list ways to solve the problems identified,
- develop an action plan, and
- follow up.

The key to the success of this problem-solving method is the willingness of management to allow employee participation in the process. This is normally done through group meetings. In order to properly prepare for this, a manager or trainer must:

- state the purpose for conducting the meeting,
- clarify in advance what problems must be solved (waste audit information can be used when applying this method to waste minimization),
- plan the meeting so that time is well used and employee time away from work stations is minimized, and

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- organize employees into groups of no more than 2 to 15 individuals.

Following is an outline showing the key ingredients for conducting an employee problem-solving meeting.

A. State the purpose of the meeting.

1. Example—"To minimize waste generated in the work area."

B. Briefly outline what will happen in the meeting.

1. Review the order of the meeting.
2. Participant roles.

    a. Leader (generally manager, supervisor, or trainer):

    - conducts meeting,
    - encourages participation,
    - allows individual choice,
    - gives equal opportunity, and
    - sets example, listens.

    b. Scribe/Reporter:

    - notes statements as spoken, and
    - does not editorialize until team critiques list.

    c. Members in attendance take responsibility to participate and to encourage others.

3. Use audio/visual aids if possible.

C. Method

1. Brainstorming (give each group member an opportunity to contribute to solving the problem).

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   a. Proceed around the group until each member is satisfied that the list includes all of their concerns/ideas.

   b. If a group member has no concerns or ideas, they indicate this by saying "pass."

2. Critique/review your list (combine items on list, clarify, gain consensus).

   a. Incorporate statements that are much the same.

   b. Get agreement on wording.

3. Develop an action plan.

   a. State a goal (this could be the same as one stated at the beginning of the meeting).

   b. Define action to be taken (example: provide individual containers for different waste types).

   c. Determine a time frame for action to be taken.

   d. Assign responsibilities (who, what to do, when, where, how often).

   e. Write down action plan and post or distribute to employees (this can be done by the leader after the meeting).

4. Close meeting.

   a. Recognize member contributions.

   b. Reinforce the purpose of the meeting (e.g., remind employees to be conscientious about minimizing waste in their work areas).

   c. Review action plan and follow-up procedures.

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D. Conduct follow-up to the meeting.

1. This can be done in the work area or in another meeting.
2. Review goals with people responsible for carrying out assignments.
3. Have responsible people give a progress report on their assignments.
   a. Determine progress made toward achieving goals.
   b. Define any problems encountered by employees in pursuing goals.
4. Reinforce the positive aspects of performance toward achieving goals.
5. Make any changes or adjustments necessary to further pursue goals.
6. Determine what additional training or instruction is needed to achieve goals.
7. Record additional assignments and changes that have been made to the action plan, and post or distribute to employees.

5.3 Performing a Waste Audit

The waste audit is the most basic of all of the approaches to waste minimization. However, it is important to keep in mind that the waste audit is a preliminary step—it is an essential precursor to the other waste minimization approaches. A waste audit alone will not minimize your waste, but it will get you started.

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The waste audit tracks your hazardous waste by monitoring all of the waste which is produced at your place of business to learn where it was generated. You can determine where hazardous materials are used and where raw materials are being wasted. As a result, you may discover that you are purchasing much more of a raw material than your business can use in a given time, or you may discover areas of waste production that you did not recognize before the audit.

The waste audit can be divided into six steps:

1. Identify hazardous substances in waste or emissions.
2. Identify the sources of these substances.
3. Set priorities for various waste reduction actions to be taken.
4. Analyze some technically and economically feasible approaches to waste minimization.
5. Make an economic comparison of waste minimization and waste management options.
6. Evaluate the results.

The waste reduction audit is a systematic and periodic survey of a company's operations and is designed to identify areas of potential waste reduction. More detailed guidance on conducting a waste audit is provided in Chapter 6.

5.4 Improving Housekeeping

Improved housekeeping, or "good operating practice," is the simplest waste minimization practice. Improved housekeeping relies on using common sense and is often the most effective first step toward waste reduction.

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Good housekeeping practices involve the procedural or organizational aspects of a manufacturing process and include elements such as:

- inventory control,
- waste stream segregation,
- material handling improvements,
- scheduling improvements,
- spill and leak prevention, and
- preventive maintenance.

Good housekeeping is good operating practice which can be applied industry-wide. A detailed discussion of good operating practices is provided in Section 7.1.

5.4.1 Waste Segregation

One relatively simple housekeeping method is waste segregation. In many cases, segregation of wastes allows for certain wastes to be recycled or reused, as illustrated in the following examples.

- In a business using both chlorinated and non-chlorinated solvents, these waste types should be kept separate. This enables you to identify precisely which wastes can be recycled.

- In a business which plates metal parts and generates plating wastes, such as cyanide and heavy metals, the parts can be pre-screened for defects. In this way, the company plates only those parts fit for sale, uses less plating solution, and generates less waste.

- At a printing company, waste toluene from printing press cleanup can be eliminated by segregating this solvent according to the color and type of ink cleaned from the press. Each segregated batch of toluene can be reused for thinning the same color ink.

5.4.2 Improved Labeling

Improved labeling allows employees to know precisely what a container or pipeline holds, and guards against accidental spills and unnecessary usage—both a waste of materials. All substances used in the workplace should be properly labeled. In addition, all wastes, once segregated, should be labeled as well. This procedure helps to ensure safe handling of wastes, and can point out containers of waste which have the potential for recycle, reuse, or even resale.

5.5 Substituting Materials

Upon completion of a waste audit, you may identify specific materials within your business which are producing hazardous waste. If this is the case, it may be possible to find a substitute material which is less hazardous. Although material substitution is only applicable in certain situations, it can prove to be an efficient hazardous waste minimization approach.

- A painting business uses a hydrocarbon solvent (toluene) for daily cleanup of hydrocarbon-based paint. By switching to water-based paint, water can be substituted for toluene for cleanup.

- Water-soluble cleaning agents can often replace organic solvents or degreasers. One company did this and successfully reduced its 1,1,1-trichloroethane use by 30 percent, resulting in a $12,000 annual savings.

5.6 Technology Modifications

In many instances, technological modifications or material substitutions are also very effective in minimizing wastes. Some products can be manufactured by two or more distinct processes, and one process may produce less hazardous waste than the other. Modifying equipment within a given process is another way to reduce waste generation.

Technological modifications can be generally categorized as:

- process modifications,
- equipment modifications,
- process automation,
- changes in operation settings,
- water conservation, or
- energy conservation.

5.6.1 Process Modifications

Production processes may be responsible for the production of hazardous waste. Old or inefficient processes could be sources of hazardous waste. By changing to a newer, more efficient process, a company could decrease the amount of waste it generates. In addition, many companies can experience improved production capacity and product quality and realize savings in expenditures for utilities and raw materials.

- In printed circuit board manufacturing, the use of screen printing for image transfer instead of photolithography eliminates the use of developers.

- By replacing a solvent-based painting system with a water-based electrostatic immersion painting system, the Emerson Electric Company has reduced waste solvent and paint solids generation by over 95 percent.

Process modifications often entail subsequent equipment modifications.

5.6.2 Equipment Modifications

Equipment modifications accomplish waste reduction by reducing or eliminating equipment-related inefficiency. An equipment modification leaves the production process intact and unchanged, because it modifies only the equipment which comprises the process.

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- A simple dragout recovery system was installed by the Stanadyne Company on a nickel plating machine. Less than $1,000 was invested for a dragout recovery tank, which saved the firm $4,200 worth of nickel per year and reduced nickel sludge generation by 9,500 pounds per year.

5.6.3 Process Automation

Process automation involves the use of automatic devices to assist or replace employees. Automation can include monitoring and subsequently adjusting process parameters by computer or mechanically handling hazardous substances. Waste minimization is accomplished by reducing the probability of employee error (which can lead to spills or off-spec products) and by increasing product yields through the optimum use of raw materials.

5.6.4 Changes in Operation Settings

Often the generation of hazardous waste may not be the fault of the equipment. Instead, the fault may lie in the way the equipment is set to operate. These are often the most easy and inexpensive equipment changes.

- Many spraying processes operating at decreased pressures have less overspray and subsequently less waste.

- In formulating their cyanide copper plating baths, the Stanadyne Company determined that lower chemical concentrations can be used. By running the potassium cyanide concentration at 2.5 ounces per gallon, instead of 3.5 ounces, the cyanide dragout concentration was reduced by 28 percent—without any adverse effect on plating quality.

Most equipment has optimum settings at which it operates most efficiently. By determining the optimum settings for certain parameters (such as optimum temperature and pressure), less waste is generated as a by-product.

5.6.5 Water Conservation

Although not as significant as other approaches, water conservation can have an effect on minimizing hazardous waste generation.

- By reducing the amount of water used for washing some organic chemical products, companies can lower the amount of waste water which must be pretreated before disposal.

5.6.6 Energy Conservation

Energy conservation minimizes the waste associated with the treatment of raw water, cooling water blowdown, and boiler blowdown. In addition, lower energy usage means a reduction in the generation of ash and other wastes associated with combustion. Energy conservation can be accomplished through a series of heat exchangers within the production process.

5.7 Recycling and Reuse

Recycling and reuse of hazardous wastes can be a very economical undertaking. Many companies have discovered that the cost of installing on-site recycling equipment can be quickly recovered and future profits gained by savings in waste management and raw material costs.

- A pesticide manufacturer generated pesticide dust from two major production systems. The firm replaced the single baghouse with two separate vacuum-air-baghouse systems specific to the two production lines for $9,600. The collected material was recycled to the process where it was generated. The firm has eliminated over $9,000 in annual disposal costs, and estimates that the recovered material is worth more than $2,000 per year.

- The Rexham Corporation facility in Greensboro, North Carolina installed a distillation unit to reclaim n-propyl alcohol from their waste solvent for a total installed cost of $16,000. The distillation unit recovers 85 percent of the solvent

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in the waste stream, resulting in a savings of $15,000 per year in virgin solvent costs—and in a $22,800 savings in hazardous waste disposal costs.

In addition, there are many off-site recyclers who will take a company's waste, recycle it, and sell the refined product back to the company at a price significantly less than the cost of virgin material. Additionally, that company will not have to incur waste disposal costs.

- The Hamilton Beach Division of Scovill, Inc. operation requires 1,1,1-trichloroethane solvent to degrease metal stampings. Ashland Chemical Company was contracted to recycle the waste by distilling 1,1,1-trichloroethane. Substituting the recycled solvent for the virgin product has reduced Hamilton Beach's overall raw material costs by $5,320 per year. Scovill also eliminated all of their previous waste disposal costs, estimated to be about $3,000 per year.

The array of reuse options is too extensive for detailed discussion here. Numerous recovery technologies are presented in Chapters 7, 8, and 9.

5.8 Participating in Waste Exchanges

Waste exchanges are networks of businesses which attempt to find markets for the wastes they generate. Remember that hazardous waste to one business can be a valuable resource to another. The exchange attempts to match the waste from one business with the raw material requirements of another business. Small businesses can also find excellent recycling opportunities through such organizations. Often a "buyer" company is able to purchase, recycle, and subsequently reuse another's waste. In this way, the buyer is able to save on raw material costs, and the hazardous waste generator is able to market a new product as opposed to disposing a hazardous by-product.

For more information on waste exchanges, see Section 11.5.

Waste Minimization

Section 3:

Conducting Waste Minimization Assessments

- Title Pages form Selected Waste Minimization Assessment Manuals.
- Project Summary - The EPA Manual for Waste Minimization Opportunity Assessments; EPA/600/52-025: August, 1988.
- "Succeeding at Waste Minimization"; From et al. "Chemical Engineering, September 14, 1987.
- Lecture overheads.

The Small Business Guide to Hazardous Materials Management

Jacqueline Maher
Patricia Rafferty
Orville Burch

GREAT LAKES RURAL NETWORK
Administering Agency WSCS Community Action Commission Inc

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Industrial Waste Audit and Reduction Manual

A practical guide to conducting an in-plant survey for waste reduction

OWMC
Ontario Waste Management Corporation

Published by the Ontario Waste Management Corporation (OWMC) with the assistance of CANVIRO Consultants. OWMC is a provincial Crown agency created by an act of the Ontario legislature in 1981 to establish a provincial system for treating and disposing of liquid industrial and hazardous wastes. OWMC also helps industry with waste reduction, reuse, recycling, recovery and exchange.

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WASTE MINIMIZATION
RESOURCE MANUAL

Prepared by:

Chemical Manufacturers Association

2501 M Street N.W.

Washington, DC 20037

(202) 887-1100

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This manual is intended to be an information document that generally outlines the broad elements of the legal, regulatory, and technical framework of a waste minimization program. It is not within the scope of this manual to analyze specific legal, policy, or technical issues that may arise in establishing such a program. Rather, it is the purpose of the guide to identify significant issues that may be faced in this area. Each company should consult with EPA or its own legal counsel as to compliance issues. CMA does not make any warranty or representation, either express or implied, with respect to the accuracy, completeness, or utility of the information contained in this manual; nor does CMA assume any liability of any kind whatsoever resulting from the use of or reliance upon any information, procedure, conclusion, or opinion contained in this manual.

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Hazardous Waste Engineering
Research Laboratory
Cincinnati, OH 45268

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EPA

Project Summary

The EPA Manual for Waste Minimization Opportunity Assessments

Gregory A. Lorton, Carl H. Fromm, and Harry Freeman

Waste minimization (WM) is fast gaining recognition as a means of contending with the nation's hazardous waste problem and other forms of environmental pollution. Opportunities exist for waste minimization throughout industry and government. The waste minimization assessment procedure described in the full report offers a means of determining a facility's waste situation and identifying and evaluating potential viable options for reducing waste. (In addition to its availability through the National Technical Information Service, this report is being issued as a technology transfer manual, EPA-625/7-88/003.)

This Project Summary was developed by EPA's Hazardous Waste Engineering Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

What is Waste Minimization?

Waste minimization is comprised of source reduction and recycling. Source reduction is defined as any activity that reduces or eliminates the generation of waste at the source, usually within a process. Recycling is defined as the recovery and/or reuse of what would otherwise be a waste material. Figure 1 illustrates the various categories of waste minimization techniques.

The emphasis in this paper is on "hazardous waste." However, all waste streams must be considered when conducting an assessment. This includes air emissions, wastewater, and non-hazardous solid waste. The transfer of pollutants from one medium to another is not waste minimization.

Incentives

There are a variety of incentives for minimizing wastes. These include the following:

- Attractive economics (including reducing waste treatment and disposal costs, and savings in raw material costs)
- Increasing regulations (including landfill disposal regulations, reporting requirements, and permitting requirements for waste treatment)
- Reduced liability (including liability for environmental problems and workplace safety)
- Improved public image and environmental concern

The economic performance of WM projects has been enhanced in recent years by the dramatically increasing costs of waste disposal. Environmental regulations, especially RCRA (Resource Conservation and Recovery Act), have had a major effect on treatment and disposal costs.

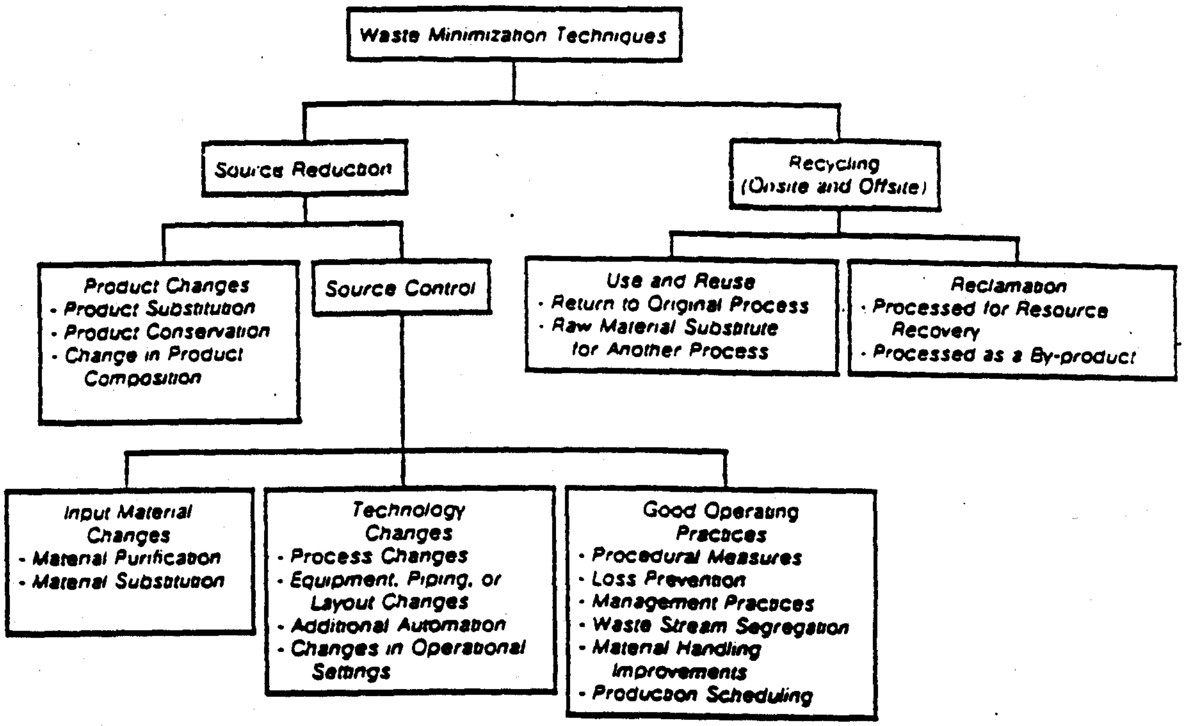

Figure 1. Waste Minimization Techniques

aste Minimization ...ssment Procedure

The waste minimization assessment procedure presented here is a systematic framework that can be used by a facility's own employees to identify WM opportunities. As a structured program, it provides intermediate milestones and a step-by-step procedure to (1) understand the facility's wastes and processes, (2) identify options for reducing waste, and (3) determine which of the options are technically and economically feasible to justify implementation. On the other hand, the procedure should be modified to meet the specific needs of the individual company. As such, this manual should be viewed as a source of ideas and concepts, rather than a rigorous prescription of how to do assessments.

Figure 2 illustrates the WM assessment procedure. The WM assessment procedure is one part of a larger waste minimization program, which is required of hazardous waste generators. Careful planning and organization precedes the assessment itself. The assessment procedure can be split into two major phases:

- Assessment phase (collect information, and identify and screen potential WM options)
- Feasibility analysis step (technical and economic evaluation of the options)

Implementation of the recommended options follows the assessment. The WM program should be viewed as a continuing program, rather than a one-time effort.

Planning and Organization

Careful planning and organization is necessary to bring about a successful WM program. To start the program and maintain momentum and control, it is necessary to obtain management commitment. The program should set general goals by which to measure its effectiveness. Selecting a good program staff is critical to the ultimate success of the program. Since the program is a project organization within the company, a task force provides an effective way of carrying out the program.

Assessment Phase

The assessment serves to identify the best options for minimizing waste through a thorough understanding of the waste-generating processes, waste streams, and operating procedures. Therefore, the assessment task force's first major tasks are to collect information about the facility's waste streams, processes, and operations.

Collecting and Compiling Facility Information

Information about the facility's waste streams can come from a variety of sources, such as hazardous waste manifests, biennial reports, environmental audits, emission inventories, waste assays, and permits. Mass balances should be developed for each of the important waste-generating operations to identify sources and gain a better understanding of the wastes' origins.

Collecting waste stream data and constructing mass balances will create a basis by which the assessment task can track the flow and characteristics of the waste streams over time. This will be useful in identifying trends in waste generation and will also be critical in the task of measuring the performance of implemented WM options later. The result of the activity is a catalog of waste

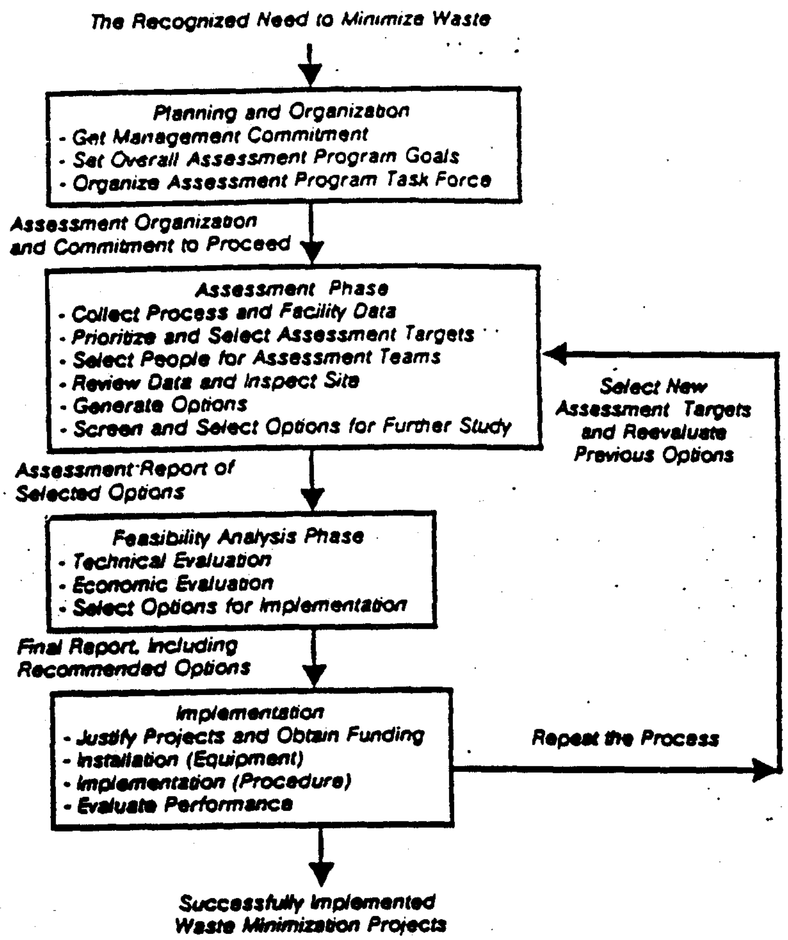

Figure 2. The Waste Minimization Assessment Procedure

streams that provides a description of each waste, including quantities, frequency of discharge, composition, cost of management, and other important information.

In addition to data about waste streams, other information is needed to fully understand the facility's operations. This includes the following items.

- Process, equipment, and facility design information
- Environmental reports, assays, manifests, documents, and permits
- Raw material production information
- Operating cost information
- Policy and organizational information

Prioritizing and Selecting Waste Streams to Assess

Ideally, assessments should be conducted on all of the waste-generating operations in a plant. However, in larger plants this often is not practical, considering the limited resources (money, time, and expertise) available. In this case, the assessment program task force should prioritize the streams. Important criteria to consider in prioritizing waste streams and/or facility areas to assess include the following:

- Compliance with current and future environmental regulations
- Disposal cost and/or quantity of the waste
- Hazardous nature of the waste, and other safety considerations
- Potential for (and ease of) minimization
- Potential for removing production or waste treatment bottlenecks
- Available budget and expertise for the waste minimization assessment program

A practical consideration in selecting waste streams for the first assessment is to find those that can be reduced with a good likelihood of success. A successfully implemented WM project will ensure the acceptance of further waste minimization efforts within the organization.

Select Assessment Team Members

The assessment team must include people who are familiar with the area of the facility to be assessed. Including first line operators and production supervisors is recommended. These people may or may not already be on the assessment program task force. (In a large facility, the task force should have a broad understanding of the facility's operations, while the assessment team should have a specific understanding of the areas to be assessed.) It may be advisable to include people from other parts of the facility that regularly interact with the areas to be assessed.

Site Inspection

Although collecting and reviewing data is important in the assessment, the assessment team must be familiar with the actual operation at the site. To do this requires that the assessment team visit the site during the various stages or cycles of an operation. If all of the assessment team members work at the facility (or are located relatively close by) it is easy for the team members to visit the site. However, if one or more members are from outside of the facility, it is recommended that a formal site inspection be carried out.

The formal inspection serves to resolve all questions raised during the review and to complement that information already obtained and reviewed earlier. The inspection also confirms whether or not the facility actually operates in the way it was originally intended to. This inspection concentrates on understanding how the wastes are generated.

The assessment team should "walk the line" from the beginning of the process to the point where products and wastes leave the facility. Since waste can be generated in receiving and storage areas as well as the production areas, all areas within the site should be visited. The following guidelines will help in organizing an effective site inspection:

- Prepare an agenda in advance.
- Schedule the inspection to coincide with the particular operation of interest.
- Monitor operations at different times during the shift.
- Interview operators, foremen, and supervisors. Assess the operating personnel's awareness of the waste generation aspects of the operation.
- Observe the housekeeping aspects of the operation. Assess the overall cleanliness of the site.
- Review the organizational structure and level of coordination of waste-related activities between the assessed facility area and other related areas.
- Assess the administrative controls.

Generating WM Options

Following the collection of data during the assessment preparation step and the site inspection, the members of the assessment team will have begun to identify possible ways of reducing waste in the assessed area. The generation of options is both a creative and analytical process. While the individual assessment team members may be able to suggest many potential WM options on their own, the process can be enhanced by using some of the common group decision techniques, such as brainstorming. These techniques allow the team to identify options that the individual members might not have come up with on their own.

Identifying potential options requires the expertise of the assessment team members. Much of this knowledge comes from their education and on-the-job experience. Other sources of background information on potential options include the following:

- Trade associations
- Published literature
- Environmental conferences and exhibits
- Equipment vendors
- Plant personnel (especially the operators)
- Federal, state, and local government environmental agencies
- Consultants and/or employees from other facilities

Screening and Selecting the Most Promising Options for More Detailed Evaluation

A successful assessment will result in many WM options being proposed. At this point it is necessary to identify those options which offer a real potential to minimize waste and reduce costs. The screening procedure serves to eliminate those suggested options that are perceived as marginal, impractical, or inferior, without the detailed and more costly feasibility study. The procedures for screening these options can range from an informal decision made by the assessment program manager or a vote of the assessment team, to a weighted sum method that combines relative weights of such factors as operating cost reduction, capital cost requirement, reduction in waste hazard etc.

Some options (such as procedural changes) may involve no capital costs and can be implemented quickly. The screening procedure should account for the ease of implementation for an option. If such an option is clearly desirable and indicates a potential cost savings, it should be considered for further study or outright implementation.

In screening the options, the assessment team determines what the important criteria are in terms of the WM assessment program goals and constraints, and the overall corporate goals and constraints. Examples of criteria that can be used include the following:

- Does the necessary technology exist to develop the option?
- How much will the option reduce waste quantity, hazard, and treatment/disposal costs?
- How much will the option reduce safety hazards?
- How much will the option reduce the use of input materials?
- What will the impact be on liability and insurance costs?
- How much does it cost? Is it cost effective?
- Can the option be implemented within a reasonable amount of time?
- Does the option have a good "track record"? If not, is there evidence that the option can work in this case?
- What other benefits will occur?

Feasibility Analysis Phase

The WM options that are successfully screened in the assessment step then undergo a more detailed feasibility analysis. The feasibility analysis is not unlike that carried out for any new project within most organizations. However, there are some important characteristics to consider when evaluating waste minimization projects that are not necessarily considered with other types of projects.

Technical Evaluation

The purpose of the technical evaluation is to be sure that the option will really work as intended, and whether it can be implemented with specific facility constraints and product requirements. Typical criteria for the technical evaluation include the following:

- Will the option work in this application?
- How has it worked in similar applications?

- Is space available? Are utilities available? Or must new utility systems be installed?
- Is the new equipment or procedure compatible with the facility's operating procedures, work flow, and production rates?
- How long will production be stopped in order to install the system?
- Will product quality be maintained or improved?
- Is special expertise required to operate or maintain the new system? Does the vendor provide acceptable service?
- Does the system or procedure create or remove safety hazards?
- Does the system or procedure create other environmental problems?

All affected groups in the facility should contribute to and review the results of the technical evaluation. Prior consultation and review with the affected groups is needed to ensure the viability and acceptance of the option. If the option calls for a change in production methods, the effects on the quality of the final product must be determined. If the project appears infeasible or impractical after the technical evaluation, it is dropped.

Economic Evaluation

The economic evaluation is carried out using the standard measures of profitability, such as payback period or discounted cash flow techniques (internal rate of return and net present value). Each company uses its own economic evaluation procedures and criteria for selecting projects for implementation. In performing the economic evaluation, various costs and savings must be considered. As in any project, the cost elements can be broken down into capital costs and operating costs.

Capital costs for WM projects are similar to most other projects. These costs include not only the fixed capital costs for designing, purchasing, and installing equipment, but also costs for working capital, permitting, training, start-up, and financing charges. As mentioned earlier, it is important to realize that some WM options, such as procedural or materials changes, will not have any capital costs. Also, many source reduction options have the advantage of not requiring environmental permitting in order to be implemented.

WM projects need to show a savings in operating costs to be economically effective. Operating costs and savings typically associated with WM projects include the following:

- Reduced waste treatment, disposal, and reporting costs
- Raw material cost savings
- Insurance and liability savings
- Increased costs (or savings) associated with product quality
- Decreased (or increased) utilities, operating and maintenance costs, and overhead costs
- Increased (or decreased) revenues from changes in production marketable by-products.

Once the capital and operating cost savings have been determined, the project's profitability can be determined using the profitability measures. These methods are discussed in virtually all financial management, cost accounting, and engineering economics textbooks. Those options that require no capital costs should be implemented as soon as savings in operating costs can be shown.

An important consideration of WM projects is their potential to reduce the risk of environmental and safety liabilities for a company. Although these risks can be identified, it is difficult to predict if and when liability problems will occur and the financial impact. It is important that the managers within the company who decide to fund the company's projects be aware of the significance of these risks and factor the risk reduction benefits of waste minimization into these projects. Also, while the profitability of a WM assessment program is important in deciding whether to implement a project, compliance with environmental regulations may be more important, since violation may ultimately result in shutting down the facility, and possible criminal penalties for the company's responsible people.

Final Report

The product of a WM assessment is a report that presents the results of the assessment and technical and economic feasibility analyses. It also contains recommendations to implement the feasible options. A good final report can be an important tool for getting an attractive project implemented. The report should include not only how much the project will cost and its expected performance, but also how it will be done. Important topics to discuss include the following:

- whether the technology or procedure is established, with a mention of successful applications.
- the required resources (money, expertise, and manpower) available in-house, and those resources that must be brought in from outside.
- the estimated construction period and production downtime.
- the means by which performance can be evaluated after the project has been implemented.
- the reductions in environmental and safety liability.

Before the report is finalized, be sure to review the results with the affected groups. It is important to solicit the support of the affected groups. By having people from these groups assist in preparing and reviewing the report the chances are increased that the attractive projects are successfully implemented.

Implementation

The implementation of the WM project is not unlike any other project that involves new equipment or procedures. It may be necessary to overcome inertia or resistance to change within the organization. The commitment of management to waste minimization is important at this time.

Once the project has been implemented and operating, it is important to evaluate its performance. Is it performing as expected? If not, should it be abandoned, or is its use still beneficial? What other potential options have been identified through the operation of this option?

Ongoing Program

The WM program should be viewed as a continuing one. As WM options are implemented, the task force should continue to look for new opportunities, assess other waste streams, and consider attractive options that were not pursued earlier. The ultimate goal is to reduce wastes to the maximum extent practical.

Conclusion

The waste minimization assessment offers opportunities to reduce operating costs, reduce potential liability, and improve the environment, while improving regulatory compliance. The WM assessment procedure results in a careful review of a plant's operations toward reducing wastes. The WM program task force should strive to build a waste minimization philosophy within the company. In doing so, the entire company can help to minimize waste.

Gregory A. Lorton (presently with WESTEC Services, Inc., San Diego, CA) and Carl H. Fromm are with Jacobs Engineering Group, Pasadena, CA 91101 and Harry Freeman (also the EPA Project Officer) is with the Hazardous Waste Engineering Research Laboratory, Cincinnati, OH 45268.

The complete report, entitled "The EPA Manual for Waste Minimization Opportunity Assessments," (Order No. PB 88-213 004/AS; Cost: $19.95, subject to change) will be available only from:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650

The EPA Project Officer can be contacted at:

Hazardous Waste Engineering Research Laboratory
U.S. Environmental Protection Agency
Cincinnati, OH 45268

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SUCCEEDING AT WASTE MINIMIZATION

A step-by-step auditing procedure produces a comprehensive list of waste-reduction possibilities. And, its ranking system provides guidance for selecting the optimum option.

Carl H. Fromm and Michael S. Callahan, Jacobs Engineering Group
Harry M. Freeman, U. S. Environmental Protection Agency
Marvin Drabkin, Versar, Inc.

Waste disposal is getting increasingly difficult and costly. For instance, landfilling, traditionally the favored disposal option for a majority of hazardous wastes, is now subject to stiff controls in the U. S.: Landfill regulations mandate groundwater monitoring, leachate collection-and-treatment systems, and double liners. Over the last three years, the cost of land disposal has increased by a factor to two to six, depending upon the type of waste and its location. And the threat of future legal liabilities has further blunted the appeal of that option.

Alternative disposal techniques, such as incineration, pose their own sets of difficulties and escalating costs.

Facing this disposal dilemma, many plants are now looking at ways to minimize the amount of wastes leaving their sites. There are other incentives, too, for reducing waste generation:

- It is a desirable environmental goal.
- It can reduce a firm's potential liability for problems associated with offsite waste-handling and disposal.
- Generators must certify that waste has been minimized to the maximum extent deemed economically feasible (Item No. 16 on the Uniform Hazardous Waste Manifest); Also, there is a biennial reporting requirement.
- There is a prospect of stronger waste-minimization directives when the U. S. Environmental Protection Agency in 1990 reevaluates industry's efforts.

There are three basic techniques for waste minimization: source reduction, recycling, and waste treatment. Invariably, reducing or avoiding waste generation is the most-desirable goal, and should be explored first. Then comes recycling, followed by treatment. Table I details elements of these approaches.

Identifying all waste-minimization possibilities, and then selecting the best ones, can pose a real challenge. An auditing procedure, as we will spell out, can markedly help to uncover the most-workable options. Unlike an environmental audit, a waste-reduction one focuses on "how to" issues, rather than regulatory compliance and "are we supposed to" concerns.

Using such auditing, a waste-minimization program involves six stages, as detailed in Table II.

Taking care of essential preliminaries

Initiation of a successful waste-minimization program demands top-management commitment, allocation of adequate financial and technical resources, an appropriate organization, and good definition of goals and planning.

From the onset, it is important to realize that the program may have to overcome such barriers as: a lack of awareness of the benefits of waste minimization; limitations of technical staff; concern over tampering with an adequately running process; and organizational inertia and politics. Thus, constructive approaches may have to be used to cope with these factors.

The auditing procedure can be carried out by an internal taskforce with

Table I — Waste-minimization approaches should be explored in order of their environmental desirability: first, source reduction; then, recycling; and, last, waste treatment

SOURCE REDUCTION

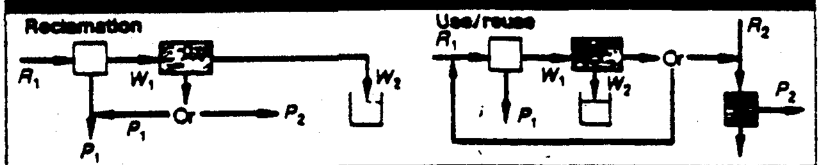
Product alteration

- ☐ Product substitution
- ☐ Product conservation
- ☐ Alteration of product composition

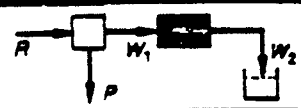
Source control

Input-material alteration	Technology alteration	Procedural or institutional changes
☐ Material purification	☐ Process changes	☐ Procedural measures
☐ Material substitution	☐ Equipment, piping or layout changes	☐ Loss prevention
	☐ Additional automation	☐ Personnel practices
	☐ Changes in operational settings	☐ Wastestream segregation
	☐ Energy conservation	☐ Material-handling improvements
	☐ Water conservation	

RECYCLING



TREATMENT



Legend

= Process

= Waste-treatment unit (end of pipe)

= Waste to disposal

Notes

P = Product

R = Raw material

W = Waste 1 = Primary, 2 = Secondary

$W_2 < W_1$ for both volume and/or toxicity

Table II — A successful waste-minimization program generally should include six separate stages

Step	Elements
1. Initiation	Secure commitment and authority Define goals Establish organization
2. Pre-audit	Prepare "needs" list and inspection agenda Hold pre-audit meeting and inspection Compile data and select target wastestreams
3. Audit	Inspect plant Generate a comprehensive list of waste-minimization options Evaluate options (separately by audit team and plant personnel) Select options for further analysis
4. Post-audit	Conduct technical and economic feasibility studies
5. Recommendation	Suggest preferred options
6. Implementation	Design, procure and construct Start up Monitor performance

or without an outside consultant. The leader should have solid technical credentials as well as proven problem-solving abilities. The team should include at least one "outsider," e.g., a person from another plant or production unit; that person will help spot and avoid inbred plant biases.

The audit team must be given enough authority so that it can gain access both to all required technical documentation (process flow diagrams, piping and instrumentation diagrams, inventory and operations logs, etc.) and to technical personnel at the plant.

Now, the team can start the pre-audit stage. Review of pertinent documentation and references should result in a well-defined list of information needs, or a plant-inspection agenda designed to fill in the gaps.

A site visit, including a guided tour of the facility, then should provide first-hand information about the plant, particularly with an eye to filling information needs and gaps in essential data.

At this time, the views of plant operating personnel on the focus and function of the audit should be sought. Indeed, the visit should establish a good working relationship with the site personnel. The initial point of contact (for example, the plant manager, or environmental coordinator) should be enlisted to champion the program.

Information on all waste streams leaving the plant should be compiled. Reviews of waste manifests, process flow diagrams, piping and instrumentation diagrams, and heat-and-material balances are particularly useful. Each diagram should be analyzed for all points where waste generation could occur.

Equipment-cleaning wastes must also be considered. Indeed, in batch processes, large quantities of wastes may be associated with operations such as cleaning a reactor or mixing vessel. Yet these incidental wastes rarely appear on process flow diagrams or are quantified in process descriptions; so, discussions with key operations personnel are essential to define such wastes.

Waste streams should be quantified on a uniform basis. If a stream is intermittent, it should be represented as a pseudo-continuous one. Once all waste streams are quantified, each should be expressed as as percentage of the total quantity of waste leaving the plant.

Armed with this information, the team can select the waste stream to be targeted for immediate attention. Since this establishes a focus of the entire audit activity, a great deal of thought must be given to this targeting. Usual criteria include:

- Method and cost of disposal.
- Composition of the waste.

4-9

Table III — Use this checklist as a starting point in considering alternatives, and add existing waste-reduction efforts

Process element	Options to investigate	Process element	Options to investigate
Materials	☐ Buy higher-purity raw materials ☐ Switch to less-toxic raw materials ☐ Use noncorrosive raw materials	Filtration and washing	☐ Employ efficient washing and rinsing methods ☐ Eliminate the use of filter aids ☐ Adopt countercurrent washing ☐ Recycle spent washwater
Operating practices	☐ Tighten equipment inspection and maintenance ☐ Improve operator training ☐ Provide closer supervision of personnel ☐ Practice better housekeeping ☐ Employ better process-monitoring systems ☐ Improve quality control	Leaks and spills	☐ Employ bellows-sealed valves ☐ Specify pumps with double mechanical seals, or canned (sealless) ones ☐ Maximize use of welded, instead of flanged, pipe joints ☐ Curtail water use for spill cleanup
Materials handling	☐ Segregate containers by prior contents ☐ Use washable/recyclable drums ☐ Buy materials in bulk or larger containers ☐ Purchase materials in preweighed packages ☐ Employ pipelines for intermediate transfer	Equipment-cleaning	☐ Use corrosion-resistant materials ☐ Convert from batch to continuous processing ☐ Alter production schedule to minimize the number of cleanings ☐ Increase equipment-drainage time ☐ Agitate storage tanks ☐ Use mechanical wipers on mix tanks ☐ Clean mix tanks immediately after use ☐ Install a high-pressure spray-wash system ☐ Adopt a countercurrent rinse sequence ☐ Re-examine the need for chemical cleaning ☐ Use in-process cleaning devices ☐ Recycle spent rinsewater ☐ Blanket with nitrogen to reduce oxidation
Reaction/ processing	☐ Optimize the reactor design and reaction conditions ☐ Optimize the reactant-addition method ☐ Eliminate the use of toxic catalysts		

- Quantity (present and future).
- Degree of hazard (toxicity, flammability, etc.).
- Potential for minimization.
- Compliance status (current and future).

Once this analysis is finished, the results should be summarized in a written report, which should contain the following: the facility location and size; a description of the process or operations of concern, with diagrams necessary to detail pertinent aspects of waste generation; details about the waste streams — including generation rates, compositions, disposal and raw-material costs — focusing on sources and current methods of management; the rationale for selection of that waste stream.

Conducting the audit

With the aim of the audit now focused, the team should carefully conduct an inspection to develop an understanding of how the targeted waste is generated. This inspection should also provide any additional information needed to decide about minimization options.

The following suggestions may prove helpful:

1. Have an agenda ready.
2. Plan to observe the operation at different times during a shift. Sometimes, monitoring of all shifts is essential — especially when waste generation is highly dependent on human involvement (as is typical of many discrete manual operations, such as painting or parts cleaning).
3. Obtain permission to directly interview the operators and supervisors. Listen attentively, and do not hesitate to interview more than one person on the subject. Assess their awareness of the waste-generation aspects of the operation.
4. Get approval to photograph the facility. Photographs are particularly valuable in the absence of layout drawings, and can capture many useful details that will help in the later phases of the audit.
5. Observe the housekeeping. Check for signs of leaks and spills. Visit the maintenance department and inquire about its problems in maintaining equipment leakfree.
6. Assess the organizational structure and the level of coordination of environmental activities between various departments.

In addition, it may prove beneficial during the preparation and conduct of the audit inspection to mentally "walk the line" from the suspected source of waste generation to the point of exit.

Now, the team should be in a position to generate a comprehensive set of waste-minimization options. A brainstorming session involving the entire audit team is one way to do this, or each member can develop lists on an independent basis.

In exploring options, let us reemphasize that source reduction should be considered before recycling or treatment.

It is important to create as comprehensive a list of options as possible. The checklist appearing in Table III may be helpful in thinking about alternatives. The waste-minimization measures currently in place are also worth listing, since they may lead to additional approaches. At this point, do not worry too much about the viability of the suggestions. A written rationale, backed by literature references or recorded discussions with equipment- or material suppliers or consultants, should suffice.

Once a thorough list has been developed, the team's attention can turn to assessing the various options. Alternatives that do not merit further attention can be weeded out, and the remaining choices ranked in the order of desirability.

Ranking can be performed by taking each option in turn and looking at how it stacks up on key criteria such as:

- Effectiveness for reducing waste.
- Technical risk.
- Extent of current use in the facility.
- Industrial precedent.
- Capital and operating costs incurred.
- Effect on the quality of product.
- Impact on plant operations.
- Required time for implementation.
- Other aspects important in the particular situation.

Assign a numerical value (say, from 1 to 10, with 10 being best) for the weight of each of these criteria. Then, rate each option with respect to each criterion on the same scale, and add the products of the weights and ratings.

Such evaluations should be conducted independently by the audit team, and facility personnel. This provides a useful framework for identifying, and resolving, differences of opinion. The ratings should be compared and discussed at a joint meeting, so as to evolve mutually acceptable ratings — with the audit team leader in firm control of discussions.

(It is important how some options are introduced — the audit team should be particularly sensitive to the way in which the housekeeping measures are presented. For example, a recommendation to keep covers on degreasers may seem trivial and even a little insulting. The operating staff may be tempted to respond: "Don't you think we know that already." However, if, in this case, a rough estimate of avoided solvent-replacement cost is given, the suggestion will likely be better understood and not dismissed as trivial.)

This reconciliation session should lead to a list of waste-minimization options with revised ratings.

Selection of options for feasibility analysis should be based on the revised weighted-sum values. The number of alternatives considered further depends on the time, budget and other resources available for such study.

Deciding upon the best option

Those waste-minimization approaches selected should be explored during the post-audit stage in enough detail to derive study-grade estimates of capital and operating costs. Capital and operating costs should then be subjected to standard profitability analysis, which must take into consideration avoided costs for disposal and materials [4].

Technical feasibility should also be assessed — based on industrial precedent or additional benchscale or trial-production-run testing. Close attention should be paid to effects on product quality, especially in cases of material substitution.

Such an approach leads to a rational basis for selection. The findings of the analysis should then be summarized in a final report. This should give clear recommendations as to a course of action. It also should document the basis and methodology used to derive the expected results.

This completes the audit portion of a waste-minimization project. If management decides to go ahead with the project, the implementation stage then proceeds along a well-established route of preliminary design, final design, procurement, construction and startup. Alternatively, this phase may be preceded by additional research and development.

However, many waste-minimization options uncovered during the audit can be put into practice immediately, as they do not cost money. These options usually fall into the areas of good operating practices or housekeeping — for instance, better operator training or waste segregation.

Some final thoughts

How does one measure the success of a waste-minimization program? The relative waste-generation rate, which is based on pounds of waste constituents of concern per unit production, appears suitable. Alternatively, one can use the ratio of input-materials mass to unit production.

Although this systematic approach should prove useful in identifying and evaluating waste-minimization options and in conducting effective audits, its success requires cooperation between the audit team and plant operating personnel, as well as a good understanding of the process and its underlying principles — and creativity and hard work.

Mark D. Rosenzweig, Editor

References

1. Josephson, J., Hazardous Waste Landfills, *Envir. Sci. and Tech.*, Vol. 15, Mar. 1981, pp. 250–253.
2. Fox, R. D., Pollution Control at the Source, *Chem. Eng.*, Vol. 80, No. 18, Aug. 6, 1973, pp. 72–82.
3. Briner, R. P., Making Pollution Prevention Pay, *EPA Jour.*, Dec. 1984, pp. 28–29.
4. Fromm, C. H., and Butler, D., Practical Guidelines for Estimating Profitability of Waste Minimization Measures, presented at 4th Hazmat Conference, Atlantic City, N.J., June 3, 1986.

The authors

Carl H. Fromm is a project manager for the Hazardous and Toxic Materials Div. of the Jacobs Engineering Group, Inc., 251 South Lake Avenue, Pasadena, CA 91101-3063; telephone: (213) 681-3781. He leads a taskforce on waste reduction, which is currently developing standardized waste-minimization-auditing guidelines under the auspices of the U. S. E.P.A. He holds a B. S. in chemical engineering from Wayne State University, and is a registered chemical engineer in California. He is a member of AIChE, Sigma Xi and the American Assn. for the Advancement of Science.

Michael S. Callahan is a chemical engineer in the Hazardous and Toxic Materials Div. of the Jacobs Engineering Group in Pasadena. He joined the company in 1980 after having received a bachelor's degree in chemical engineering from the University of California at Los Angeles. A registered engineer in California, he is a member of AIChE and the Institute of Electrical and Electronic Engineers.

Harry M. Freeman is research program project manager at the U. S. Environmental Protection Agency's Hazardous Waste Engineering Research Laboratory, 26 W. Saint Clair St., Cincinnati, OH 45268; telephone: (513) 569-7418. He is responsible for managing waste-minimization research projects. Previously, he worked on EPA's research programs on solid wastes and incineration. He has a bachelor's degree in industrial engineering from the University of Mississippi, and an M.B.A. from Loyola University (New Orleans). He is a Diplomate in the American Academy of Environmental Engineers, and is a member of AIChE.

Marvin Drabkin is a senior staff chemical engineer at Versar, Inc., 6621 Electronics Dr., Springfield, VA 22151; telephone: (703) 750-3000. He has had eleven years of experience in pollution-control-technology evaluation. Besides Versar, he has worked for U. S. Synthetic Fuels Corp., and Mitre Corp. He has a B. S. from City College of New York, an M. S. from University of Wisconsin and a Ph. D. from University of Pittsburgh, all in chemical engineering.

Waste Minimization

Section 4:

Measuring Waste Minimization

- Lecture Overheads.

MEASURING PROGRESS IN WASTE REDUCTION

John L. Warren
Program Director, Hazardous Waste

Rachel D. Baker
Economist

Center for Economics Research
Research Triangle Institute
Research Triangle Park, NC , USA 27709
PHONE#: (919) 541-7308 FAX #: (919) 541-5945

Waste Minimization Training Course
November 9 - 10, 1990
1990 Pacific Basin Conference on Hazardous Waste
East - West Center, Honolulu, Hawaii

1. Introduction
   1.1 Why measure progress?
      1.1.1 Meet regulatory requirements
      1.1.2 Provide feedback
      1.1.3 Determine the effectiveness of corporate policies
      1.1.4 Learn which technologies work and which don't
      1.1.5 Pinpoint problems
      1.1.6 Document results
      1.1.7 Demonstrate to government that voluntary efforts are successful
   1.2 Overview of rest of presentation

2. What is progress?
   2.1 Introduction - how you define define progress determines what data you keep track of and measure
   2.2 Different definitions of progress
      Net reduction in costs
      Reduced toxic chemical inputs
      Reduced waste generation
      Reduced toxic chemical release generation
      Reduced waste release
      Reduced chemical release
   2.3 With each of the above definitions of progress, do you consider any reduction progress?
      - Only reductions due to waste reduction activities are indicative of successful waste reduction programs and effective waste reduction activities -- in other words, provide the information needed to make the assessments that were the reasons we wanted to measure progress in the first place.
   2.3 Different levels of detail for defining progress
      for a project
      for a process
      for a product
      for a chemical release
      for a waste stream
      for a plant
      for the whole firm
      for a region or country

3. Possible Measures of Waste Reduction Progress
   3.1 Introduction - depends on how you defined progress and on firm's organizational structure, types of production processes and waste generating activities
   3.2 Descriptive measures
      3.2.1 Was a waste reduction program established for the facility/waste/process/project?
      3.2.2 Was a waste reduction activity implemented for the facility/waste/process/project?
      3.2.3 Was a successful waste reduction activity implemented for the facility/waste/process/project? ("Success" could be assessed by any of the methods described below.)
   3.3 Measures of actual quantity change
      3.3.1 In general, $Q_t - Q_{t-1}$ = actual quantity change, where Q = quantity of waste or chemical (see below)

t = time period for which progress is being measured
actual quantity changes < 0 indicate waste reduction, and the larger the actual quantity change the more waste reduction progress occurred. Can be calculated at any level of detail.

3.3.2 actual change in the quantity of toxic inputs (throughput)
3.3.3 actual change in the quantity of toxic chemical releases generated
3.3.4 actual change in the quantity of toxic chemicals released
3.3.5 actual change in the quantity of waste generated
3.3.6 actual change in the quantity of waste released

3.4 Measures that adjust for changes in production (Adjusted Quantity Change)

3.4.1 Two methods:

3.4.1.1 $Q_t/A_t - Q_{t-1}/A_{t-1}$

3.4.1.2 $Q_{t-1} \times (A_t/A_{t-1}) = Q_{t-1}^*$, or the quantity that would have been generated in time t-1 if the production level had been the same as in time t.

$Q_{t-1}^* - Q_t$ = adjusted quantity change, where >0 indicates waste reduction progress.

where Q = quantity of waste or chemical (see below)
A = level of activity (see below)
t = time period for which progress is being measured

The assumption is that waste generation changes in proportion to production changes unless waste reduction is implemented. Here the level of detail is critical because the definition of the level of activity depends on this. In general, *If waste generation is associated with a production activity,* the greater the level of detail, the greater the correlation between waste generation and activity.

3.4.2 Measures of the quantity of waste
- toxic inputs (throughput)
- toxic chemical releases generated
- toxic chemicals released
- waste generated
- waste released

3.4.3 Measures of level of activity
- toxic inputs (throughput)
- toxic chemicals incorporated into the product
- number of products produced (mass, volume, surface area)
- sales dollars
- value added
- dollars budgeted
- number of employees (total, direct labor hours,etc.)
- hours operational

3.5 . Measures of cost savings

3.5.1 Net Present Value of waste reduction project
3.5.2 Return on Investment of waste reduction project
3.5.3 question: what interest rate do you use?
the lower the interest rate, the more projects will be considered "profitable"
one option is to use a lower interest for evaluating waste reduction projects than other projects to provide an incentive for managers to implement waste reduction. Lower interest rates can be used to acknowledge that there are additional benefits of waste reduction

(such as improved public image, reductions in liability, reductions in worker exposure) that are difficult to explicitly include in profitability calculations

4. Advantages/Disadvantages

4.1 Generic problems
- delayed effects of waste reduction (for net present value measures this isn't a problem)
- product design and process development (can use engineering estimates, if available)
- changes in level of hazard (or toxicity)

4.2 Descriptive measures

4.2.1 advantages
- uses less resources
- requires less detailed data
- greater accuracy
- avoids many of the data problems described below

4.2.2 disadvantages
- provides less information
- can't evaluate the degree of progress achieved

4.3 Measures of changes in quantity released (versus generated)

4.3.1 advantages
- data often currently monitored and available

4.3.2 disadvantages
- changes in treatment and disposal affect quantity

4.4 Measures of changes in waste generated (versus chemical)

4.4.1 advantages
- data useful for waste management decision making
- combination of chemicals within a waste stream is often relevant
- often metered - more accurate

4.4.2 disadvantages
- difficult to assess changes in toxicity or effect of input substitution
- (although can also collect concentration data)

4.5 Measures of changes in chemical generated (versus waste)

4.5.1 advantages
- can evaluate changes in toxicity or input substitution

4.5.2 disadvantages
- don't know concentration
- don't know the constituents with which it is released

4.6 Measures that do not control for production changes

4.6.1 advantages
- ease of calculating
- ease of data collection
- avoid definitional problems discussed below

4.6.2 disadvantages
- doesn't distinguish between changes due to waste reduction and changes due to other factors
- do you consider it progress if waste generation falls, regardless of the cause?

4.7 Measures that do control for production changes

4.7.1 advantages

- removes the effects of one factor that affects waste generation and chemical usage

4.7.2 disadvantages
- difficult and expensive to determine
- How do you define "product"
  - change in product or product mix - sometimes constantly new products
  - what if the discontinuation of the product line <u>is</u> the waste reduction activity? quantity = 0, but denominator also = 0
  - multi-process, interrelated production lines
- how do you measure the level of waste generating activity?
- wastes not related to production
  - lab, clean up, cooling water, inventory, etc.
- factors affecting wastes other than production
  - raw material quality, operating conditions, worker productivity, weather conditions, one-time events (e.g., fire)

4.8 Process-level measurement

4.8.1 advantages
- for production-related wastes, waste generation is correlated to the level of waste generating activity only, which may not be the same as the plant production level
- forces managers to take a look at their production processes and how they generate waste

4.8.2 disadvantages
- very resource intensive
- how do you define process?
  - multi-process, interrelated production lines
  - non-production related wastes - what's the process?

4.9 Project-level measurement

4.9.1 Advantages
- alternative for non-production related wastes or wastes from multi-product, multi-process production lines for which measures that adjust for changes in production are not appropriate
- focuses on changes due to a waste reduction progress -- eliminates problem of changes due to other factors

4.9.2 Disadvantages
- often based on design or engineering estimates rather than observed changes
- more appropriate for changes in materials or equipment than behavioral changes such as better housekeeping or operating practices.

5. Examples of Problems and Discussion of Potential Solutions

5.1 problem: wastes not related to production
solution: don't index these wastes to a production processes. Look at actual quantity change

5.2 problem: multi-product production line where product mix changes constantly and waste generation varies based on the product mix
solution: calculate waste reduction achieved per project implemented (problem with this approach is may depend on design specifications rather than empirical results - may not achieve all the

waste reduction expected due to, e.g., improper operating procedures. Also, techniques such as improved employee training don't lend themselves to this technique.)

5.3 problem: waste generation varies due to factors other than production or waste reduction
solution: project specific measurement, or gather data on those "other factors", if not quantitative at least qualitative so that you know what is affecting your waste generation (and subsequent handling, treatment, disposal, and liability costs!)

5.4 problem: waste generated from several production and non-production processes, all with varying levels of production activity
solution: meter wastes at their source. Need this information anyway to conduct a thorough waste audit

5.5 problem: changes in measurement/metering technique
solution: estimate a conversion factor that will allow you to compare waste generation in both years

6. Conclusion

6.1 There is no single, feasible measure that can accurately measure waste reduction for all situations

6.2 Measures chosen should be tailored to reflect your firms' production and waste reduction activities, with the goal of providing as much information as feasible given resource and technical constraints.

6.3 we recommend a multi-indicator approach combining several descriptive as well as quantitative measures of progress with additional data that allows the firm to determine which measures are most applicable for each situation. Flexibility in defining a measure and evaluating progress will allow measures to be tailored to accurately reflect each unique situation. While this approach will not allow you to say definitely that, for example, a process had a 17.8% waste reduction, it will allow a more back-of-the-envelope determination of whether or not progress has been made and the degree of progress achieved in more general terms.

6.4 Typically, you'll measure change in quantity, either actual or adjusted for changes in production. Keep in mind that these are just proxies -- ways of estimating what we really want -- change in waste generation (or chemical waste generation or toxic use) due to waste reduction activities

7. Sources of information

7.1 Introduction

7.2 Chemical Manufacturers Association (CMA) Waste Minimization Resource Manual

7.3 EPA Waste Minimization Opportunity Assessment Manual. EPA/625/7-88/003. Hazardous Waste Engineering Research Laboratory, Cincinnati, Ohio.

7.4 USEPA's Pollution Prevention Information Clearinghouse

7.5 UNEP's Network to Promote Low- and Non-Waste Technologies

Slide 1

Why measure progress?

- meet regulatory requirements
- provide feedback
- pinpoint problems
- document results

RTI

Slide 2

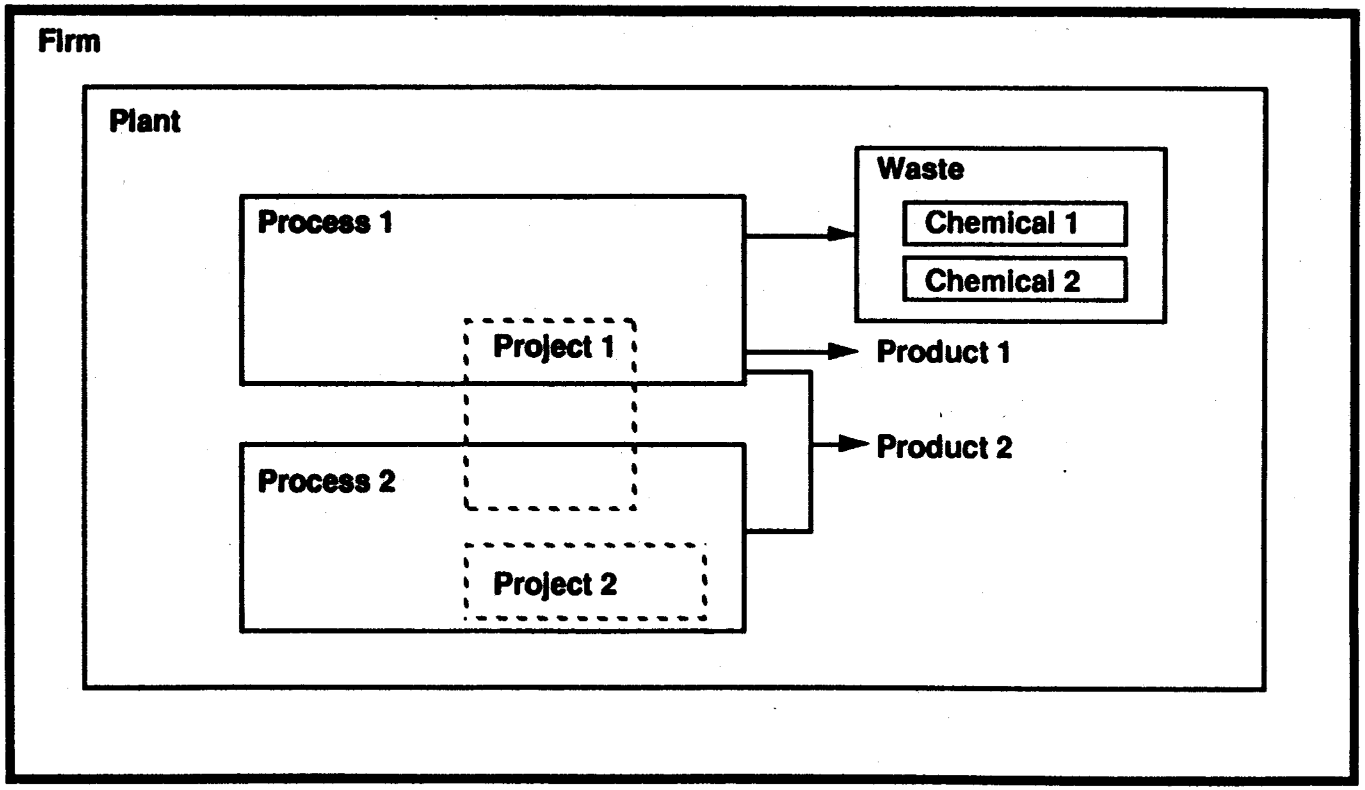
What is progress?

- implementing a project
- cost savings
- reduction in toxic chemical inputs
- reduction in waste generation
- reduction in generation of toxic chemical releases
- reduction in release of waste
- reduction in release of toxic chemicals

RTI

Slide 3

What level of detail?



RTI

Slide 4

Descriptive measures

- waste reduction program established
- waste reduction project implemented
- waste reduction activity successful

RTI

Slide 5

Actual quantity change = $Q_t - Q_{t-1}$

- toxic inputs
- chemical release prior to treatment or recycling
- chemical release
- waste generated prior to treatment or recycling
- waste released

RTI

Slide 6

Adjusted quantity change =

$$(1)\ Q_t/A_t - Q_{t-1}/A_{t-1}$$

$$(2)\ Q_{t-1} \times (A_t/A_{t-1}) - Q_t$$

Quantity

- toxic inputs (throughput)
- toxic chemical releases generated
- toxic chemicals released
- waste generated
- waste released

Activity Level

- toxic chemical inputs
- toxic chemicals in the product
- amount of products produced
- sales dollars / value added
- dollars budgeted
- number of employees
- hours operational

RTI

Slide 7

Cost Savings

- Net Present Value
- Return on Investment

RTI

Slide 8

Net Present Value

Advantages

- gives "credit" for future affects of waste reduction

Disadvantages

- difficult to estimate potential savings (e.g., liability)
- estimated, not observed

RTI

Slide 9

Descriptive measures

Advantages

- easy & inexpensive

Disadvantages

- can't evaluate project's effectiveness

RTI

Slide 10

Changes in quantity released

Advantages

- data may be currently available

Disadvantages

- change in treatment or disposal affects measure

RTI

Slide 11

Waste-specific measures

Advantages

- often metered, more accurate
- data useful for waste management decision making

Disadvantages

- difficult to assess change in toxicity

RTI

Slide 12

Chemical-specific measures

Advantages

- easier & less expensive

Disadvantages

- often estimated & inaccurate

RTI

Slide 13

Measures that don't control for production change

Advantages

- easier & less expensive

Disadvantages

- don't distinguish between changes due to waste reduction & changes due to other factors

RTI

Slide 14

Measures that do control for production change

Advantages

- removes the affect of one factor affecting waste generation

Disadvantages

- not relevant for all wastes
- changes in product or product mix
- multi-process, interrelated production lines
- other factors affect waste reduction

RTI

Slide 15

Process-level measures

Advantages

- focuses attention on production processes
- change in process production generally more correlated with waste generation

Disadvantages

- expensive
- how do you define process

RTI

Slide 16

Project-level measures

Advantages

- useful for wastes for which defining production levels is not feasible
- changes due to waste reduction only—not other factors

Disadvantages

- often estimated
- only appropriate for changes in materials or equipment

RTI

Slide 17

Waste generation not related to production

Example: scrubber water from an incinerator that operates constantly

	1988	1989	Percentage Change
Waste generated (tons)	150,000	150,000	0
Production (units)	9,000	12,000	+33
Waste/product	16.67	12.5	-25

RTI

Slide 18

Waste generation and production not linearly related

Example: acid used to rinse steel pipes (minimum amount required)

	1988	1989	Percentage Change
Waste generated (tons)	95,000	75,000	-21
Production (units)	10,000	6,500	-35
Waste/product	9.5	11.5	+21

RTI

Slide 19

Measurement change

Example: wastewater effluent was estimated, now rerouted and metered

	1988	1989	Percentage Change
Waste generated (tons)	430,000	570,000	+32.5
Production (units)	15,000	13,500	-10
Waste/product	28.67	42.2	+47

RTI

Slide 20

Other Factors Affecting Waste Generation

Example: stormwater runoff contaminated with oil from roads

	1988	1989	Percentage Change
Waste generated (tons)	58,000	30,000	-48
Production (units)	7,000	7,500	+7
Waste/product	8.3	4.0	-52

RTI

Slide 21

Multi-Product Production Process (Part I)

Product	1988 Waste Generated	1988 Units of Product	1988 Waste/ Product	1989 Waste Generated	1989 Units of Product	1989 Waste/ Product
A	15	35	.43	30	70	.43
B	10	50	.20	5	25	.20
C	5	15	.33	10	30	.33
Total	30	100	.30	45	125	.36

RTI

Slide 22

Multi-Product Production Process (Part II—with waste minimization)

Product	1988 Waste Generated	1988 Units of Product	1988 Waste/ Product	1989 Waste Generated	1989 Units of Product	1989 Waste/ Product
A	35	15	.43	22.5	70	.33*
B	50	10	.20	5	25	.20
C	15	5	.33	10	30	.32
Total	30	100	.30	37.5	125	.30

RTI

Slide 23

Measurement Problems and Possible Solutions

Problem	Solution
• wastes not related to production	• don't index the waste to production levels; use actual quantity change
• multi-product production line	• use waste reduction per project measures
• other factors affect waste generation or chemical use	• use waste reduction per project measures; • gather data on the other factors that affect waste generation
• waste stream generated from several production processes	• meter wastes at their source
• change in measurement/metering	• estimate conversion factor to allow comparison between years

RTI

Slide 24

Recommendations

- multi-indicator approach
- tailor measure to facility or process
- provide flexibility

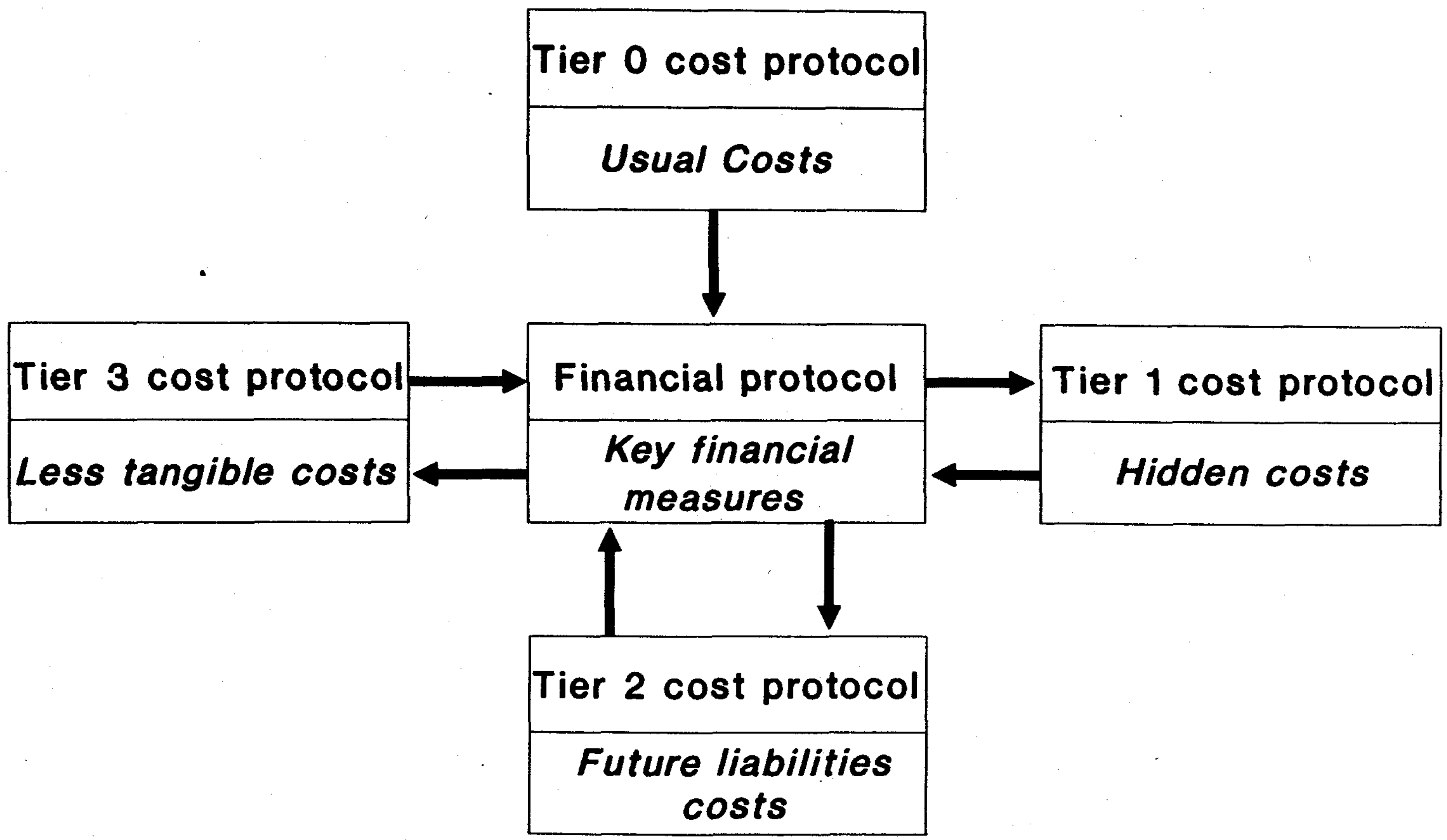
RTI

Waste Minimization

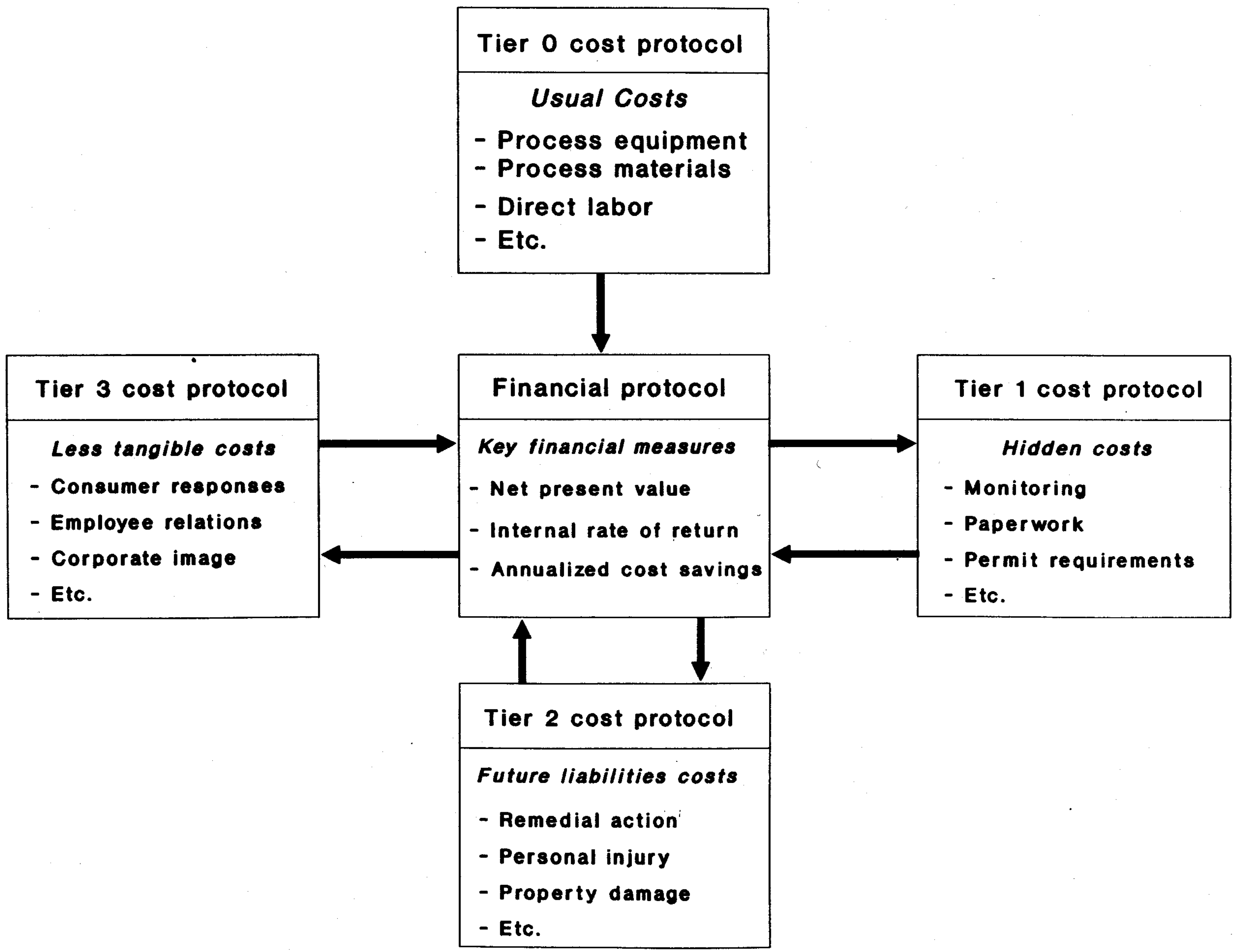
Section 5:

Economics of Waste Minimization

- Lecture Overheads.



Tier 0 cost protocol
Usual Costs
Tier 3 cost protocol
Less tangible costs
Financial protocol
Key financial measures
Tier 1 cost protocol
Hidden costs
Tier 2 cost protocol
Future liabilities costs


Tier 0 cost protocol
Usual Costs
- Process equipment
- Process materials
- Direct labor
- Etc.
Tier 3 cost protocol
Less tangible costs
- Consumer responses
- Employee relations
- Corporate image
- Etc.
Financial protocol
Key financial measures
- Net present value
- Internal rate of return
- Annualized cost savings
Tier 1 cost protocol
Hidden costs
- Monitoring
- Paperwork
- Permit requirements
- Etc.
Tier 2 cost protocol
Future liabilities costs
- Remedial action
- Personal injury
- Property damage
- Etc.

Financial protocol

Key financial measures

- Net present value
- Internal rate of return
- Annualized cost savings

Tier 0 cost protocol

Usual Costs

- Process equipment
- Process materials
- Direct labor
- Etc.

Tier 1 cost protocol

Hidden costs

- Monitoring
- Paperwork
- Permit requirements
- Etc.

Tier 2 cost protocol

- *Future liabilities costs*

  - Remedial action
  - Personal injury
  - Property damage
  - Etc.

Tier 3 cost protocol

Less tangible costs

- Consumer responses
- Employee relations
- Corporate image
- Etc.

<u>WASTE MINIMIZATION</u>

SECTION 6:

CLASSROOM EXERCISES

- The Amazing ~~Blitz for~~ Waste Minimization Exercise.
- ABE's Electric Company.
- ACE Manufacturing.

Problem #1

ABE's Electric Company

Abe's Electric Company produces ceramic filaments by mixing two powders into a slurry which is then placed in molds. . A part of the process involves wet mixing of the two powders using a vibaratory grinder. Powder A Consists of inert ceramic material and Powder B contains lead oxide, a required ingrediant for ceramic fusion. The two powders are delivered in 50 lb. sacks to the weighing station. Six pounds of A and three pounds of B are weighed and manualy transferred to a wet grind process to adequately mix the powders. The slurry is then transferred to shallow trays which are placed manually into a drying oven. The ceramic "cake"which has been oven dried is then manually put into a dry grinding mixer to delump the compund for the calcination process. The ceramic powder goes dry into this process.

Abe is facing a number of problems including:

1) OSHA has issued a citation to the company for violating TTLV for lead. (worker expo sure)

2) EPA's land disposal restrictions will prevent Abe from disposing of the hazardous waste sludge.

Chemical substitution is not a viable Waste Minimization option, so Abe has hired you to modify the process in which the filament mixture is formulated in order to address the described problems.

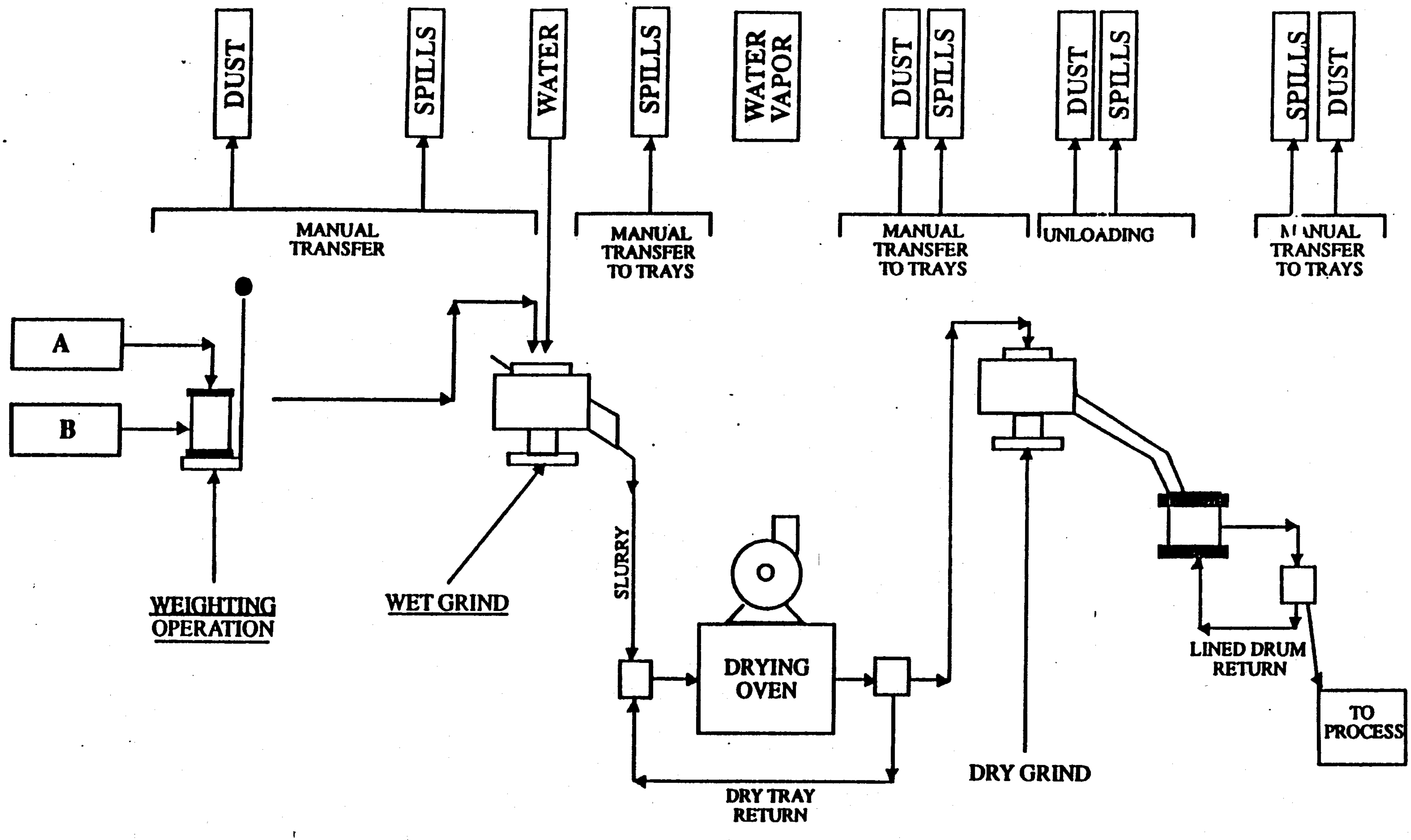
Problem

* Emission of Powders into workplace
* Powders settle on floor
* Area is washed down daily
* Waste goes to settling pit and hazardous sludge is disposed of offsite

Objective

* Reduce hazardous sludge
* Reduce worker exposure to lead dust

SEE ATTACHED PROCESS FLOW DIAGRAM



CASE EXAMPLE: WASTE MINIMIZATION

PROBLEM 3

An accountant for Ace Manufacturing, an employer of 2,000 people, reported that the company spent $250,000 for off-site treatment and disposal of hazardous wastes last year. Based on the manifest information, the only source of available information on wastes, the company and its eight divisions generated the following waste streams:

50 tons acidic waste
10 tons paint waste
5 tons used oil
10 tons various solvents; MEK,TCE, Naptha, Perc.
1 ton adhesives
15 tons contaminated soil
30 tons clarifier sludge

The General Manager, alarmed by the 200% increase in disposal costs assigns you to develop a waste minimization program. You have no budget to do this but can devote all of your time to the project.

1. Outline what steps you would take to begin to develop a waste minimization program.

2. How would you prioritize wastes for reduction?

3. What resources would you use?

Problem 1

Colorama Paint Factory

You are a production superintendent in a large paint formulating plant. A customer has ordered 5000 gallons of red paint and 2000 gallons of green paint. Three tank sizes are available for final mixing: 5000 gallons, 2000 gallons and 1000 gallons. All tanks are clean and ready to use. At the end of the production campaign, all tanks must be cleaned for the next order.

1. Which tank utilization strategy would result in

(a) least number of production batches
(b) least amount of cleaning waste generated*

2. List considerations other than waste minimization that enter into strategy development.

**Hint:* Assume that the amount of cleaning waste is proportional to the tank internal surface area wetted by the paint at the time when the tank is ready for cleaning. These areas are as follows:

350 ft^2 for the 5000 gallon tank
190 ft^2 for the 2000 gallon tank
120 ft^2 for the 1000 gallon tank

Problem 2

Mechanical Specialties Inc.

Mechanical Specialties Inc. produce mechanical components for use in the automotive industry. Steel parts are manufactured by a milling process which uses conventional oil-water emulsion coolant. Grease is then applied to the parts to protect them against oxidation during prolonged storage outdoors.

Prior to assembly, the steel parts are cleaned in cold naptha solvent to remove the protective grease. After cleaning in solvent, the parts are alkaline cleaned and painted. The wastes associated with this process include air emissions and grease-rich solvent which is periodically removed and sent off site for recycling. Recovered solvent is returned to the facility.

You have been hired to provide the facility with viable waste minimization options for their degreasing operation.

Hint:
Make a list of operating sequences, or flow diagram, to assist you in determining wastestreams, sources, and potential areas for waste minimization options.

COURSE EVALUATION FORM

Date:________________________
Location:______________________
Section:_______________________

Please help evaluate this workshop in order to improve its content.

1. Were the contents of this workshop beneficial to you?

2. Describe how this course did or did not meet your needs and expectations.

3. Please evaluate the quality of the teaching, listing briefly both strengths and weaknesses:

Strengths:

Weaknesses:

4. How could this workshop be improved to meet your needs better?

5. Would you like to see more workshops of this type made available to you?

6. COMMENTS:

WASTE MINIMIZATION

SECTION 7:

ESTABLISHING A WASTE MINIMIZATION PROGRAM AT YOUR FACILITY

- "Draft Guidance to Hazardous Waste Generators on the Elements of a Waste Minimization Program"; USEPA, June 12, 1989.

- Establishing a Waste Minimization Program at your Facility; Harry Freeman and M.A. Curran; USEPA, Paper presented at the Conference, Waste Minimization in the Tri-state area, August 1989.

- Waste Reduction in the Chemical Industry: DuPont's Approach G.J. Hollod and R.F. McCartney; Article in APCA Journal, February 1989.

- "Waste Reduction Case Histories: What's Worked, What Hasn't and Why." Daniel Krayhill, et al. Hazardous Waste Research and Information Center.

- People Management: The forgotten Element in Waste Reduction
Gary E. Hunt. North Carolina Pollution Prevention Program

ENVIRONMENTAL PROTECTION AGENCY

[OSWER-FR-3421-1]

Draft Guidance to Hazardous Waste Generators on the Elements of a Waste Minimization Program

AGENCY: Environmental Protection Agency (EPA).

ACTION: Draft guidance and request for comment.

SUMMARY: Comments are being solicited on the following document, entitled *Draft Guidance to Hazardous Waste Generators on the Elements of a Waste Minimization Program.* This guidance was developed to assist hazardous waste generators in complying with the certification requirements of sections 3002(b) and 3005(h) of the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act (RCRA) and the Hazardous and Solid Waste Amendments of 1984 (HSWA), which became effective on September 1, 1985.

An effective waste minimization program as viewed by the Agency should have the following basic elements: (1) Top Management Support; (2) Characterization of Waste Generation; (3) Periodic Waste Minimization Assessments; (4) A Cost Allocation System; (5) Encouragement of Technology Transfer, and (6) Program Evaluation. While these elements provide guidance to generators on how a minimization program for hazardous waste may be structured, the Agency believes that they are equally valid for the design of a multi-media source reduction and recycling program. This guidance is consistent with EPA's belief that facilities should have broad pollution prevention programs with the goal of preventing or reducing wastes, substances, discharges and/or emissions to all environmental media—air, land, surface water and ground water.

Related Action: EPA published in the Federal Register, on January 26, 1989 (54 FR 3845), a proposed policy statement on source reduction and recycling. This policy commits the Agency to a preventive strategy to reduce or eliminate the generation of environmentally-harmful pollutants which may be released to the air, land, surface water or ground water. It further proposes to incorporate this preventive strategy into EPA's overall mission to protect human health and the environment by making source reduction a priority for every aspect of Agency decision-making and planning, with environmentally-sound recycling as a second priority over treatment and disposal. Today's draft guidance is an example of the application of this policy in the RCRA program for hazardous waste.

DATES: EPA urges interested parties to comment on this draft notice in writing. The deadline for submitting written comments is September 11, 1989.

ADDRESSES: All comments must be submitted (original and two copies) to: EPA RCRA Docket (room SE-201) (mail code OS-305), 401 "M" Street, SW., Washington, DC 20460. Place the docket number, # F-88-WMPP-FFFFF, on your comments.

FOR FURTHER INFORMATION, CONTACT: James Lounsbury, Office of Solid Waste, (202) 382-4807, or the RCRA Hotline (800-424-9346).

Draft Guidance to Hazardous Waste Generators on the Elements of a Waste Minimization Program

I. Purpose

The purpose of today's notice is to provide non-binding guidance to generators of regulated hazardous wastes on what constitutes a "program in place" to comply with the certification requirements of sections 3002(b) and 3005(h) of the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act (RCRA) and the Hazardous and Solid Waste Amendments of 1984 (HSWA). Such certifications require generators to implement programs to reduce the volume and toxicity of hazardous wastes generated to the extent economically practicable. This guidance is intended to fulfill a commitment made by EPA in its 1986 report to Congress entitled, *Minimization of Hazardous Waste.*[1]

II. Background

With the passage of HSWA, Congress established a national policy declaring the importance of reducing or eliminating the generation of hazardous waste. Specifically, section 1003(b) states:

> The Congress hereby declares it to be a national policy of the United States that, wherever feasible, the generation of hazardous waste is to be reduced or eliminated as expeditiously as possible. Waste that is nevertheless generated should be treated, stored, or disposed of so as to minimize present and future threat to human health and the environment.

In this declaration, Congress established a clear priority for reducing or eliminating the generation of hazardous wastes (a concept referred to as waste minimization) over managing wastes that were "nevertheless" generated.

EPA believes that hazardous waste minimization means the reduction, to the extent feasible, of hazardous waste that is generated prior to treatment, storage or disposal of the waste. It is defined as any source reduction or recycling activity that results in either: (1) Reduction of total volume of hazardous waste; (2) reduction of toxicity of hazardous waste; or (3) both, as long as that reduction is consistent with the general goal of minimizing present and future threats to human health and the environment.[2]

Waste minimization can result in significant benefits for industry. EPA believes an effective waste minimization program will contribute to:

(1) Minimizing quantities of regulated hazardous waste generated, thereby reducing waste management and compliance costs;

(2) Improving product yields;

(3) Reducing or eliminating inventories and releases of "hazardous chemicals" reportable under Title III of the Superfund Amendments and Reauthorization Act; and/or

(4) Lowering Superfund, corrective action and toxic tort liabilities.

Besides establishing the national policy, Congress also enacted several provisions in HSWA for implementing hazardous waste minimization. These included a generator certification on hazardous waste manifests and permits for treatment, storage, or disposal of hazardous waste. RCRA 3002(b). These certifications (effective September 1, 1985) require generators certify two conditions: That (1) the generator of the hazardous waste has a program in place to reduce the volume or quanity and toxicity of such waste to the degree determined by the generator to be economically practicable; and (2) the proposed method of treatment, storage or disposal is that practicable method currently available to the generator which minimizes the present and future

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[1] 51 FR 44683 (12/11/86), Notice of Availability of the report to Congress.

[2] Hazardous waste minimization involves volume or toxicity reduction through either a source reduction or recycling technique and results in the reduction of risks to human health and the environment. The transfer of hazardous constituents from one environmental medium to another does not constitute waste minimization. Neither would concentration conducted solely for reducing volume unless, for example, concentration of the waste allowed for recovery of useful constituents prior to treatment and disposal. Likewise, dilution as a means of toxicity reduction would not be considered waste minimization, unless later recycling steps were involved.

threat to human health and the environment.

In addition, Congress also added a new provision in 1984 that requires hazardous waste generators to identify in their biennial reports to EPA (or the State): (1) The efforts undertaken during the year to reduce the volume and toxicity of waste generated; and (2) the changes in volume and toxicity actually achieved in comparison with previous years, to the extent such information is available prior to 1984 (RCRA 3002 (a)(6)).

Today's notice provides non-binding guidance to hazardous waste generators in response to the certification requirements in HSWA. Specifically, it addresses the first of the certification conditions that states that, "the generator of the hazardous waste has a program in place to reduce the volume or quantity and toxicity of such waste to the degree determined to be economically practicable."

EPA is not, however, providing guidance on the determination of the phrase "economically practicable". As Congress indicated in its accompanying report to HSWA [3] the term "economically practicable" is to be defined and determined by the generator and is not subject to subsequent re-evaluation by EPA. The generator of the hazardous waste, for purposes of this certification, has the flexibility to determine what is economically practicable for the generator's circumstances. Whether this determination is made for all of its operations or on a site-specific basis is for the generator to decide.

EPA has received numerous inquiries on what constitutes a waste minimization program. In today's notice EPA is providing draft guidance to hazardous waste generators on what the Agency believes are the basic elements of a waste minimization program.

EPA believes that today's guidance may provide direction to large quantity and small quantity generators in fulfilling their manifest certification requirement. Small quantity generators, while not subject to the same "program in place" certification requirement as large quantity generators, have to certify that they have "made a good faith effort to minimize" their waste generation.

Th- elements discussed here reflect the results of agency analyses conducted over the last several years and extensive interaction with private and public sector waste minimization program managers. EPA believes that an effective waste minimization program should include each of the general elements discussed below, although EPA realizes that some of these elements may be implemented in different ways depending on the preferences of individual firms.

A. *Top Management Support.* Top management should ensure that waste minimization is a company-wide effort. There are many ways to accomplish this goal. Some of the methods described below may be suitable for some firms and not others. However, some combination of these techniques should be used by every firm to demonstrate top management support.

—Make waste minimization a company policy. Put this policy in writing and distribute it to all departments. Make it each person's responsibility to identify opportunities for minimizing waste. Reinforce the policy in day-to-day operations, at meetings and other company functions.

—Set specific goals for reducing the volume or toxicity of waste streams.

—Commit to implementing recommendations identified through assessments, evaluations or other means.

—Designate a waste minimization coordinator at each facility to ensure effective implementation of the program.

—Publicize success stories. It will trigger additional ideas.

—Reward employees that identify cost-effective waste minimization oportunities.

—Train employees on aspects of waste minimization that relate to their job. Include all departments, such as those in product design, capital planning, production operations, and maintenance.

B. *Characterization of Waste Generation.* Maintain a waste accounting system to track the types, amounts and hazardous constituents of wastes and the dates they are generated.

C. *Periodic Waste Minimization Assessments.* Track materials that eventually wind up as waste, from the loading dock to the point at which they become a waste.

—Identify opportunities at all points in a process where materials can be prevented from becoming a waste (for example, by using less material, recycling materials in the process, finding substitutes, or making equipment changes). Individual processes or facilities should be reviewed periodically. Larger companies may find it useful to establish a team of independent experts.

—Determine the true costs of the waste. Calculate the costs of the materials found in the waste stream based on the purchase price of those materials. Calculate the cost of managing the wastes that are generated, including costs for personnel, recordkeeping, transportation, liability insurance, pollution control equipment, treatment and disposal and others.

D. *A cost allocation system.* Departments and managers should be charged "fully-loaded" waste management costs for the wastes they generate, factoring in liability, compliance and oversight costs.

E. *Encourage Technology Transfer.* Seek or exchange technical information on waste minimization from other parts of your company, from other firms, trade associations, State and university technical assistance programs or professional consultants. Many techniques have been evaluated and documented that may be useful in your facility.

F. *Program Evaluation.* Conduct a periodic review of program effectiveness. Use these reviews to provide feedback and identify potential areas for improvement.

Although waste minimization practices have demonstrated their usefulness and benefits to those generators that have implemented such programs, many others still have not practiced waste minimization. Today's guidance on effective waste minimization practices may help encourage regulated entities to investigate waste minimization alternatives, implement new programs, or upgrade existing programs. Although the approaches described above are directed toward minimizing hazardous solid waste, they are equally valid for design of multi-media source reduction and recycling programs.

EPA requests comments on all aspects of this guidance.

Date: June 2, 1989.

Willi... :L Reilly,

Administrator.

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BILLING CODE 6560-50-M

[3] S. Rep. No. 98-284, 98th Cong., 1st Sess. (1983)

ESTABLISHING A WASTE MINIMIZATION PROGRAM AT YOUR FACILITY

Harry M. Freeman, Chief
Waste Minimization Branch

Mary Ann Curran, WRAP Program Coordinator
Waste Minimization Branch

Risk Reduction Engineering Laboratory
Cincinnati, OH 45268

For presentation at the Conference, Waste Minimization in the Tri-State Area,
August 17, 1989, Cincinnati, Ohio

Introduction

There is underway today in manufacturing facilities in the United States and other industrial countries, a clear movement toward "waste minimization" as a means for reducing environmental problems caused by the generation, treatment, and disposal of hazardous wastes. In many respects this is only a continuation of efforts by industry to increase product yields and profits by reducing wastes. However, as it has become increasingly clear that there is a limit as to what can be achieved through "end-of-the-pipe" approaches to solving problems, waste minimization has become increasingly popular.

This paper offers several suggestions for implementing an effective waste minimization program. Included is a review of the EPA's recently issued guidance for establishing a waste minimization program.

Background

With the passage of the Hazardous and Solid Waste Amendments (HSWA) of 1984, the U.S. Congress established a national policy declaring the importance of reducing or eliminating the generation of hazardous waste. This policy statement is:

> The Congress hereby declares it to be a national policy of the United States that wherever feasible, the generation of hazardous waste is to be reduced or eliminated as expeditiously as possible. Waste that is nevertheless generated should be treated, stored, or disposed of so as to minimize present and future threat to human health and the environment.

In this declaration, Congress established a clear priority for reducing or eliminating the generation of hazardous wastes (a concept referred to as waste minimization) over managing wastes that were "nevertheless" generated.

EPA believes that hazardous waste minimization means the reduction, to the extent feasible, of hazardous waste that is generated prior to treatment, storage or disposal of the waste. It is defined as any source reduction or recycling activity that results in either: 1) reduction of total volume of hazardous waste; 2) reduction of toxicity of hazardous waste; or 3) both, as long as that reduction is consistent with the general goal of minimizing present and future threats to human health and the environment.(1)

The transfer of hazardous constituents from one environmental medium to another does not constitute waste minimization. Neither would concentration conducted solely for reducing volume unless, for example, concentration of the waste allowed for recovery of useful constituents prior to treatment and disposal. Likewise, dilution as a means of toxicity reduction would not be considered waste minimization, unless later recycling steps were involved.(1)

In a related action, the EPA published in the Federal Register on January 26, 1989, a proposed policy statement on source reduction and recycling. This policy commits the Agency to a preventive strategy to reduce or eliminate the generation of environmentally-harmful pollutants which may be released to the air, land, surface water or ground water. It further proposed to incorporate this preventive strategy into EPA's overall mission to protect human health and the environment by making source reduction a priority for every aspect of Agency decision-making and planning, with environmentally-sound recycling as a second priority over treatment and disposal.(2) The Agency's encouragement of waste minimization is an example of the pollution prevention policy for RCRA hazardous wastes.

<u>Current Federal Regulatory Requirements for Waste Minimization Programs</u>

Besides establishing the national policy, Congress also enacted several provisions in HSWA for implementing hazardous waste minimization. These include a generator certification on hazardous waste manifests and permits for treatment, storage, or disposal of hazardous waste. These certifications (effective September 1, 1985) require generators to certify two conditions: That (1) the generator of the hazardous waste has a program in place to reduce the volume or quantity and toxicity of such waste to the degree determined by the generator to be economically practicable; and (2) the proposed method of treatment, storage or disposal is that practicable method currently available to the generator which minimizes the present and future threat to human health and the environment.(1)

In addition, Congress also added a new provision in 1984 that requires hazardous waste generators to identify in their biennial reports to EPA (or the State): (1) The efforts undertaken during the year to reduce the volume and toxicity of waste generated; and (2) the changes in volume and toxicity actually achieved in comparison with previous years, to the extent such information is available prior to 1984.(1)

<u>Waste Minimization Approaches and Techniques</u>

Waste minimization is inevitably site-and plant-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 techniques can be grouped into four major categories: <u>inventory management and improved operations, modification of equipment, production process changes, and recycling and reuse.</u> 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. In practice, waste minimization opportunities are limited only by the ingenuity of the generator. In the end, a company looking carefully at bottom-line returns may conclude that the most feasible strategy would be a combination of source reduction and recycling approaches.(6)

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 matrial use.

Recycling and Reuse

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

Source: EPA/530-SW-87-026

Elements of a Waste Minimization Program

So, what is a "waste minimization program?" Understandably, the Agency has been asked this many times since the September 1985 date, after which generators were to have certified that they had one in place.

The generator has a wide latitude in structuring his or her program. Also, since Congress indicated in its accompanying report to HSWA that "economically practicable" is to be determined by the generator and is not subject to subsequent evaluation by the EPA, the generator has even more latitude in defining a program. The EPA has, in a June 12, 1989 Federal Register Notice, issued some non-binding guidelines as to what the elements of an effective waste minimization program might include. These elements are:

- Top management support
- Characterization of waste generation
- Periodic waste minimization assessments
- A cost allocation system
- Encourage technology transfer
- Program evaluation(1)

Top Management Support

The first step in developing a program is to establish a clear corporate policy. The full commitment from management of time, personnel and financing is extremely important. Lack of this commitment is often one of the most formidable obstacles to waste minimization. The chances for obtaining this commitment are often enhanced by outlining the potential incentives for waste minimization as shown in Table I.

Table 1

Waste Minimization Incentives

Economics
- Landfill disposal cost increases
- Costly alternative treatment technologies.
- Savings in raw material and manufacturing costs.

Regulations
- Certification of a WM program on the hazardous waste manifest.
- Biennial WM program reporting.
- Land disposal restrictions and bans.
- Increasing permitting requirements for waste handling and treatment.

Liability
- Potential reduction in generator liability for environmental problems at both onsite and offsite treatment, storage, and disposal facilities.
- Potential reduction in liability for worker safety.

Public Image and Environmental Concern
- Improved image in the community and from employees.
- Concern for improving the environment.

Source: Waste Minimization Opportunity Assessment Manual (EPA/625/7-88/003)

An appreciation of the necessity for top management support is summed up very well by G. J. Hollod: "Lack of senior management support will doom a waste minimization program from the start. Many managers in addition to the standard business functions have become occupied with other priorities in the environmental area like land bans, right-to-know and occupational health considerations. Waste minimization is competing with other environmental priorities but management must be convinced that waste minimization is a program that deserves priority and should be part of the "daily diet" for the line organization and not just another environmental headache left to the site's environmental coordinator."(10)

- - Make waste minimization a company policy.

The objectives of a waste reduction program are best conveyed to a business's employees through a formal policy statement or management directive. A business's upper management is responsible for establishing a formal commitment throughout all levels of the business.

An environmental policy statement or the business's operating guidelines might include the following points:

- Environmental protection is a production line responsibility and an important measure of employee performance. In addition, every employee is responsible for environmental protection in the same manner(s) he is for safety;

- Reducing or eliminating the generation of waste has been and continues to be a prime consideration in research, process design, and plant operations, and is viewed by management like safety, yield, and loss prevention; and
- Reuse and recycling of materials has been and will continue to be given first consideration prior to classification and disposal as a hazardous waste.(11)

As an example of such a policy the 3M Company of St. Paul, Minnesota has a part of its official environmental policy that the company will "prevent pollution at the source wherever and whenever possible." It might be noted that this company also has as part of its policy to "develop products that will have a minimum effect on the environment." While this is somewhat outside the goals of a typical waste minimization program, it is clearly within the goals of an overall pollution prevention program, and should certainly be considered by any company producing products that will ultimately end up in the wastestream.

- - **Set specific goals for reducing the volume or toxicity of waste streams.**

Quantitation helps. Some examples of waste minimization goals are:

The U.S. Department of Defense is committed to reducing its hazardous waste disposal rates by 50 percent by 1992 (3). The Dupont Company has stated that its wastes will be reduced by 35 percent by 1990 compared to 1982 values.(4)

As a benchmark for evaluation of waste minimization goals, a report on waste reduction issued by the Congressional Office of Technology assessment in 1986 states that "substantially more waste reduction is feasible and more will become feasible. Setting a national voluntary waste reduction goal of perhaps 10 percent annually for 5 years would be useful."(5)

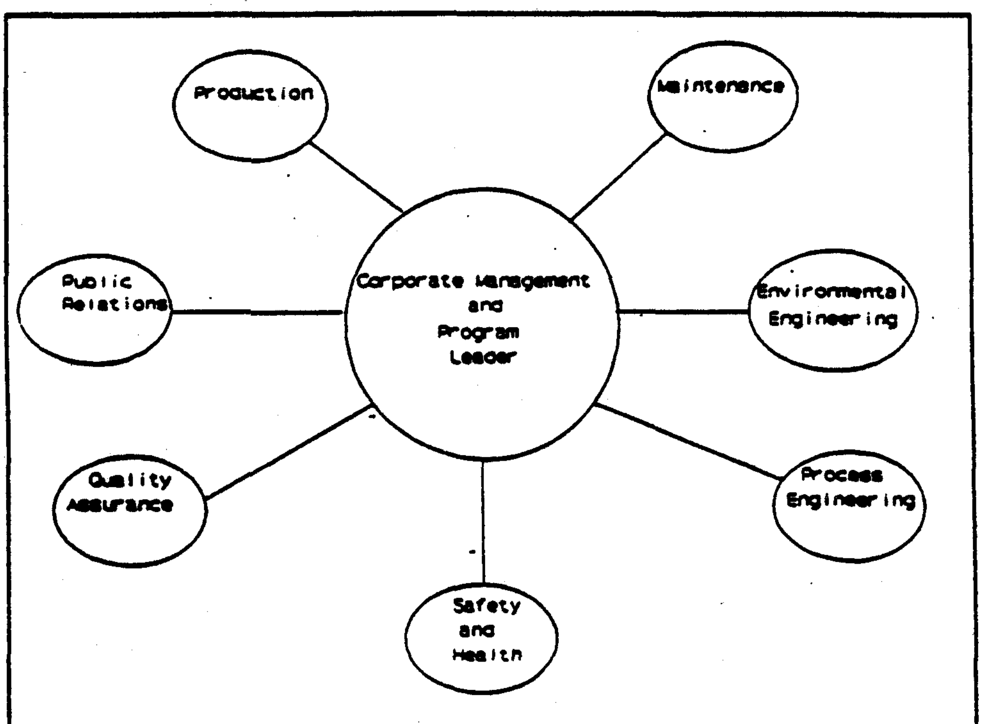
- - **Commit to implementing recommendations identified through assessments, evaluations or other means.**

A sure way to undermine a program is to not follow up on recommendations developed by a committed group of employees. Although it may be unreasonable to expect facility management to make wholesale commitments to accept recommendations, it is not unreasonable to expect management to commit to giving a high priority to considering such recommendations and then doing it.

- - Designate a waste minimization coordinator and select a team at each facility to ensure effective implementation of the program.

For a small facility with only a few waste streams, one person such as a plant manager, plant engineer, or environmental engineer may be responsible for the entire waste minimization program. For larger, highly integrated facilities with many different processes and emission sources, a team or task force might be established. As shown in Figure 2, team members should represent major departments that are involved in waste generation and management and different areas of expertise. A team may include members from production, facilities/maintenance, environmental engineering, process engineering, safety and health, and quality assurance departments. Your appointed minimization "champion" should lead the effort and coordinate all involved departments. Outside consultants and/or corporate staff should also be considered, depending on the company's nature, the facility's complexity, and available in-house skills.(7)

Figure 2
Suggested Waste Minimization
Team Organization



Source: National Association of Manufacturers, 1989.

A summary of functions that might be assigned to the waste minimization team are shown in Table 2.

Table 2

Functions of a Waste Minimization Coordination Team

- Define Objectives
- Review with Site Management
- Communicate to site
- Buy-in from generators
- Representation from areas
- Ongoing awareness and training
- Provide Resources
- Catalyze
- Coordinate
- Accounting System
- Upgrade projects
- Schedule reviews
- Conduct audits
- Summarize site progress
- Recognize

Source: Hazardous Waste Minimization (McGraw Hill, 1989)

- - **Publicize success stories.** - - Reward employees that identify cost-effective waste minimization opportunities; train employees on aspects of waste minimization that relate to their job.

Employees often cause the generation of waste and they can contribute to the overall success of the waste reduction program. Just as incentives are used to boost employee productivity, management should provide incentives for the development of useful waste reduction ideas. To utilize this important resource, many businesses give their employees incentives such as:

- Recognition awards for outstanding waste reduction projects and individuals, as well as for resource and energy conservation projects; and

- Bonuses or financial awards for innovative approaches to waste reduction.

Public recognition helps to inform the public of actions taken by the business to reduce and control hazardous waste. Recognition programs can be varied to accommodate each business, their level of involvement, and local attitudes. For instance, public recognition such as an award or certificate may be welcomed by many businesses. Other businesses, however, maintain a "low profile" as a matter of policy. In such cases, a letter from the Board may be preferred. The effectiveness of this program could be increased by combining it with other awards, such as an employee-of-the-month program, or a percentage of the cash savings realized by the suggestion. Regardless of the form of the incentives, employees should realize part of the benefits of their waste reduction ideas and efforts. In some businesses, meeting the waste reduction goals is used as a measure for evaluating the job performance of managers and employees.(11)

The Dow Chemical Company incorporates these elements into its widely recognized and very successful Waste Reduction Always Pays Program; through utilizing company newsletters to publicize waste reduction success stories, and through recognition for teams of employees that propose changes that lead to decreased waste generation. The company also strives to incorporate the principles of waste reduction into all of its training activities.

Characterization of Waste Generation

Maintain a waste accounting system to track the types, amounts and hazardous constituents of wastes and the dates they are generated. It has been our observation, and we might add the observation of many others active in encouraging waste minimization, that most generators do not really know what is in their wastestream, or what possibilities might exist for reducing the volume or toxicity of the streams through relatively simple means. Information about waste streams can come from a variety of sources. Some information on waste quantities is readily available from the completed hazardous waste manifests, which include the description and quantity of hazardous waste shipped to a TSDF. The total amount of hazardous waste shipped during a one-year period, for example, is a convenient means of measuring waste generation and waste reduction efforts. However, manifests often lack such information as chemical analysis of the waste, specific source of the waste, and the time period during which the waste was generated. Also, manifests do not cover wastewater effluent, air emissions, or nonhazardous solid wastes. Potential sources of information on waste streams are shown in Table 3.

Table 3
Sources of Waste Generators Information

- hazardous waste manifests
- biennial hazardous waste generator reports
- SARA Title III Section 313 environmental release reports
- environmental audit reports
- permits (RCRA Part B, National Pollution Discharge Elimination System (NPDES< etc.)
- lab reports/characterization data
- chemical inventory and usage records
- NPDES monitoring reports
- Material Safety Data Sheets (MSDSs)
- internal waste tracking system records
- production records

Source: National Association of Manufacturers, 1989

A useful form for conducting waste stream characterization is shown in Figure 3. This is from the EPA Waste Minimization Opportunity Assessment Manual (EPA/625/7-88/003).

In addition to providing a means for measuring the effectiveness of your program, there are currently three reasons why it is very important to track your progress in this area.

- First, HSWA requires that generators report on the progress of their waste minimization program with the biennial generator report.
- Also, EPA can make a minimization program and associated reporting a condition of a RCRA permit.
- Finally, SARA Title III reporting allows for minimization to be addressed, and although this is currently voluntary it may become mandatory.(7)

The tracking function or recordkeeping at a minimum should record and identify the generator or "owner" of the waste reduction method being used to reduce that particular waste stream. Table 4 shows a typical printout from a computer tracking program that has been used by the DuPont Company.(10)

One reporting function that would be of particular interest to any program is the tracking of the most successful or most often used waste minimization technique. Table 5 lists the validation codes for the typical waste minimization techniques that are used at DuPont. This information can be used by business managers and technical managers to inform manufacturing facilities in different locations of the country to what might be the most successful waste minimization technique to apply.(10)

FIGURE 3 Form for Conducting Waste Minimization Characterization.

Firm ________	Waste Minimization Assessment	Prepared By ________
Site ________	Proc. Unit/Oper. ________	Checked By ________
Date ________	Proj. No. ________	Sheet 1 of 1 Page __ of __

WORKSHEET

WASTE STREAM SUMMARY

Attribute		Description[1]					
		Stream No. ____		Stream No. ____		Stream No. ____	
Waste ID/Name:							
Source/Origin							
Component/or Property of Concern							
Annual Generation Rate (units ________)							
Overall							
Component(s) of Concern							
Cost of Disposal							
Unit Cost ($ per: ________)							
Overall (per year)							
Method of Management[2]							
Priority Rating Criteria[3]	Relative Wt. (W)	Rating (R)	R x W	Rating (R)	R x W	Rating (R)	R x W
Regulatory Compliance							
Treatment/Disposal Cost							
Potential Liability							
Waste Quantity Generated							
Waste Hazard							
Safety Hazard							
Minimization Potential							
Potential to Remove Bottleneck							
Potential By-product Recovery							
Sum of Priority Rating Scores		Σ(R x W)		Σ(R x W)		Σ(R x W)	
Priority Rank							

Notes: 1. Stream numbers, if applicable, should correspond to those used on process flow diagrams.

2. For example, sanitary landfill, hazardous waste landfill, onsite recycle, incineration, combustion with heat recovery, distillation, dewatering, etc.

3. Rate each stream in each category on a scale from 0 (none) to 10 (high).

Table 4

Typical Column Headers in Computer Printouts

Production Area	Waste Description	Hazardous Classification	Quantity Generated M lb/yr	Management Disposal Costs $M/yr	Minimization Method
V1023	Organic Acid	Flammable	2	5.5	Recycle
NR126	Polymers	Caustic	50	25	Sale
GA462	Spent Catalyst	Acidic	10	42	Reuse
ME621	Lab Solvent	Ignitable	0.5	1	Fuel
BU215	Acid Catalyst	Corrosive	40	16	Administrative Control

Source: Hazardous Waste Minimization (McGraw Hill, 1989)

Table 5

VALIDATION CODES FOR TYPICAL WASTE MINIMIZATION TECHNIQUES

10 :	Process Change
11 :	Modify Operating Procedure
12 :	Advanced Process Control
13 :	Substituted Chemicals
14 :	Use Higher Quality Materials
20 :	Recycle
21 :	Direct Use in the Process
22 :	Direct Use in Another Process
23:	Regeneration for Reuse
24 :	Use as a Fuel
25 :	Sale
30 :	Improve Waste Treatment
31 :	Waste Filtration
32 :	Waste Decantation
33 :	On-Line Treatment
40 :	Administrative Controls
41 :	Minimizing Washdown
42 :	Reduce Cleaning Frequency
43 :	Longer Turnaround Time
44 :	Improved Spill Control
45 :	Separate Hazardous from Nonhazardous
46 :	Discontinue Manufacture

Source: Hazardous Waste Minimization (McGraw Hill 1989)

Periodic Waste Minimization Assessment

An important element in a waste minimization program is to perform periodic waste minimization assessments, sometimes referred to as "waste reduction audit." Conducted by an in-house assessment team or with an independent outside expert, a waste minimization assessment is simply a structured review of potential opportunities to reduce or recycle waste. Its focus can be broad or narrow. Most find that it is usually more effective to select a few waste streams or processes for intensive assessment rather than to attempt to cover all waste streams and processes at once.

The USEPA has published a manual for conducting waste minimization assessments. This manual entitled Waste Minimization Opportunity Assessment Manual (EPA/625/7-88/003) is available free from the Waste Minimization Branch, USEPA, 26 W. Martin Luther King Dr., Cincinnati, OH 45268. The procedure recommended by the EPA is outlined in Figure 4.(9)

Waste minimization opportunity assessments are an extremely good way to focus attention on potential improvements. The reader is encouraged to obtain a copy of the EPA manual.

A Cost Allocation System

Departments and managers should be charged "fully-loaded" waste management costs for the wastes they generate. In addition to the actual disposal fee for a wastestream of interest, the generator should also consider other cost elements such as:

- Generator Fees/Taxes
- Transportation
- Onsite Storage and Handling
- Pre-disposal Treatment
- Permitting, Reports and Recordkeeping
- Emergency Preparedness and Site Cleanup Contingency
- Pollution Liability Insurance
- Raw Materials
- Operating and Maintenance Costs

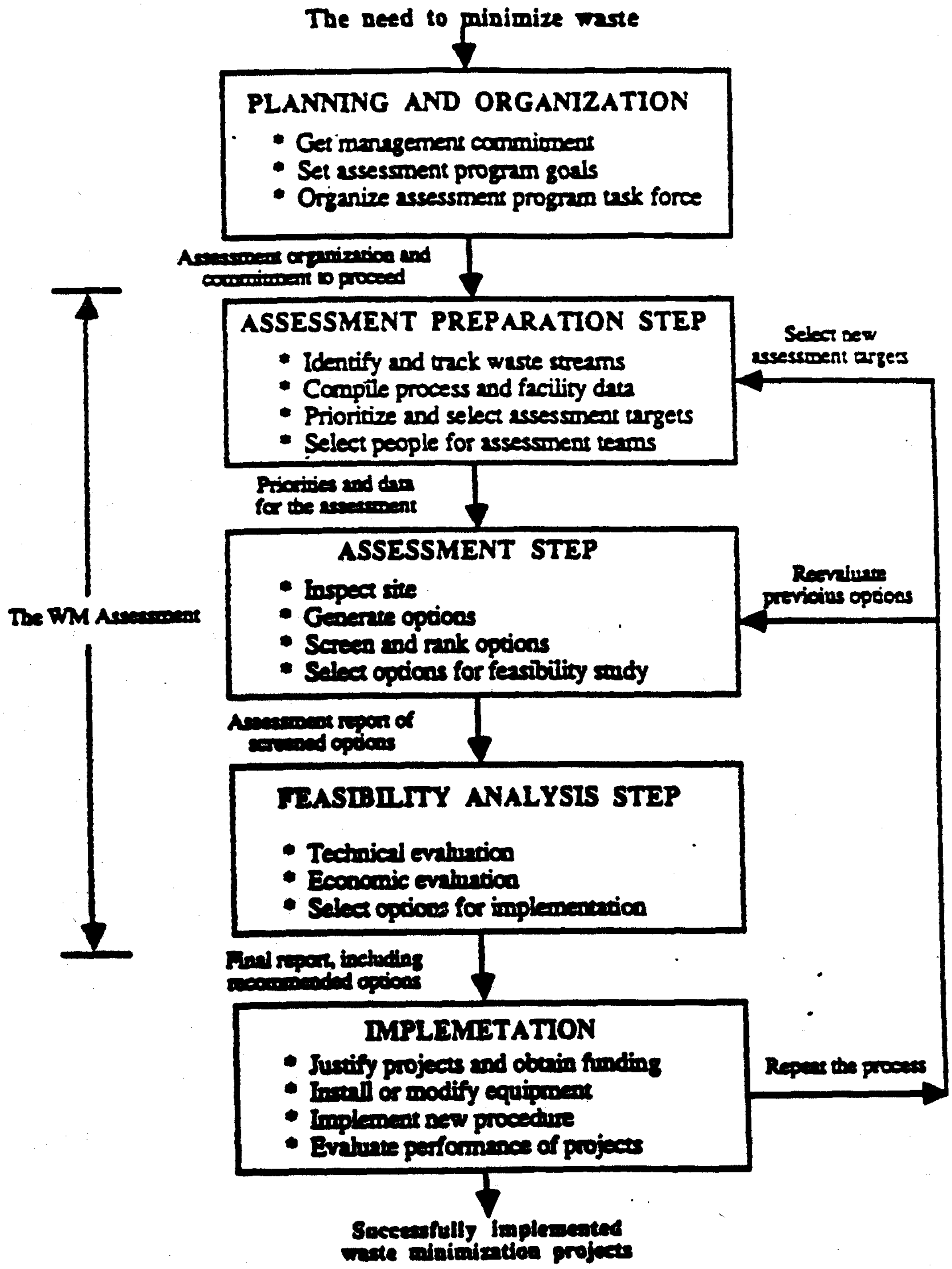
Encourage Technology Transfer

Seek or exchange technical information on waste minimization from other parts of your company, from other firms, trade associations, State and university technical assistance programs or professional consultants. Many techniques have been evaluated and documented that may be useful in your facility.

To facilitate the transfer of technical information EPA was mandated by the Congress to establish a national clearinghouse to provide easily accessible and reliable information on waste minimization/pollution prevention. The clearinghouse is to contain both technical information on how to identify and implement pollution prevention opportunities, and general information conveying the message that, "We, as a society, must begin to integrate pollution prevention into the way we design, build, buy and consume."

EPA's Pollution Prevention Information Clearinghouse (PPIC), which is supported by the Agency's Pollution Prevention Office as well as OR&D, has been created to fulfill this mandate. PPIC (pronounced pea-pick) is being pilot-tested by some 300-400 users this year and will be in full operation, accessible to all, in 1990. PPIC collects and disseminates technical and other information on pollution prevention through a telephone hotline and an electronic information exchange network. Indexed bibliographies and abstracts of reports, publications and case studies on pollution prevention will be available. PPIC will also include a calendar of pertinent conferences and seminars, information on federal and State activities and legislation, information on pollution prevention abroad, a directory of waste exchanges and lists of knowledgeable contacts within State organizations, trade associations and the EPA. Copies of various reports will be made available by the clearinghouse either by electronic transfer or through the National Technical Information Service (NTIS) or other sources.

Figure 4: THE WASTE MINIMIZATION ASSESSMENT PROCEDURE



Program Evaluation

Conduct a periodic review of program effectiveness. Use these reviews to provide feedback and identify potential areas for improvement.

Conclusion

We feel that waste minimization provides opportunities to deal more efficiently and effectively with wastes that are hazardous to human health and the environment. The program outlined in this paper is one way a company might pursue establishing a waste minimization program. They reflect the results of agency analyses conducted over the last several years and extensive interaction with private and public sector waste minimization program managers. However, it is recognized that programs must be tailored to fit various companies. We would leave you with a request, that since nothing happens until somebody does something, do something and incorporate a program that fits your facility.

References

1. Federal Register, Vol 54, #111/Monday June 12, 1989. EPA Draft Guidance for Hazardous Waste Generation on the Elements of a Waste Minimization Program.

2. Federal Register, January 26, 1989 (54FR 3845) Pollution Prevention Policy Statement.

3. Kaminski, J.A. "Hazardous Waste Minimization Within the Department of Defense." JAPCA Volume 38:1042-50, 1988.

4. Hollod, G. S. and R. F. McCartney. "Waste Reduction in the Chemical Industry." JAPCA 38:174-179, 1988

5. Serious Reduction of Hazardous Waste. Office of Technology Assessment-U.S. Congress. OTA-ITE-317.

6. Waste Minimization: Environmental Quality with Economic Benefits, USEPA, Washington, D.C. EPA/530-SW-87-026, 1987

7. Waste Minimization: Manufacturers Strategies for Success. National Association of Manufacturers, Washington, D.C. 1989

8. Schecter and Hunt,"Minimization of Hazardous Waste Generation." Chapter 5.1, Standard Handbook of Hazardous Waste Treatment and Disposal. Editor: H. M. Freeman, McGraw Hill, 1989.

9. Hanlon and Fromm, "Waste Minimization Opportunity Assessments," Chapter 5, in Hazardous Waste Minimization. H. M. Freeman, McGraw Hill, 1989 (in publication).

10. Hollod, "Implementing Waste Minimization Programs in Industry." Chapter 4 Hazardous Waste Minimizations. H. M. Freeman, McGraw Hill, 1989 (in publication).

11. Waste Reduction Assessment and Technology Transfer: Training Manual. TVA and University of North Carolina, Asheville, Environmental Quality Institute, 1989.

12. Waste Minimization Opportunity Assessment Manual, USEPA, Cincinnati, OH EPA/625/7-88/003, 1988.

WASTE REDUCTION IN THE CHEMICAL INDUSTRY: DU PONT'S APPROACH

G. J. Hollod and R. F. Mc Cartney

E. I. du Pont de Nemours & Co., Inc.
Wilmington, Delaware

ABSTRACT

Recognizing the need for minimizing the generation of hazardous waste, the chemical industry is experiencing a surge in the initiation of programs for reducing such wastes. The authors discuss some of the problems the industry is encountering with regard to waste reduction; then describe Du Pont's approach to waste reduction in terms of administrative and technical activities. They emphasize that, in addition to meeting business and regulatory needs, waste reduction makes good sense from a financial point of view.

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WASTE REDUCTION IN THE CHEMICAL INDUSTRY: DU PONT'S APPROACH

Dr. G. J. Hollod and R. F. McCartney

A better understanding of the dynamic interactions of chemicals and chemical by-products in the environment, which began to develop in earnest in the 1960's, has since focused national attention on the management of hazardous waste. This attention, intensified by a continually growing concern for the environment in which we live and work, has made the handling and disposal of hazardous waste the number one concern of the American public. An early response to such concern was to attack the problem at the end of the pipe. Subsequently, attention has shifted toward minimizing production of waste at its source. Today, it is generally agreed that minimization at the source is the most desirable, albeit most often a difficult, way to reduce waste.

INCENTIVES TO REDUCE WASTE

These developments, accompanied by the resultant regulatory and economic consequences, have made hazardous waste a major issue for industry as a whole, and for the chemical industry in particular. The disparate properties of chemical waste and the proliferation of regulations governing the handling of it have made its disposal exceedingly complex and costly. The total cost for managing waste is escalating at a rate of 30-50% lb/yr. Today it can cost in the range of $300-1500 dollars to incinerate one drum of hazardous waste.

These are indeed meaningful incentives to avoid producing waste. They most certainly will increase as regulations continue to define a larger universe of hazardous materials, and treatment capacities remain limited. The company that has an economically and environmentally acceptable plan for waste management may well be the low-cost producer; it could hold the key to the on-going success of a business. Reducing the generation of waste and improving the overall efficiency of the manufacturing process are fundamental to all successful chemical businesses.

Since waste reduction is so closely tied in with the day-to-day business functions and strategies, it is difficult to define it as an isolated target; it is actually related in someway to all business functions. Essentially anything that is not generating revenue and must eventually be disposed of should be a candidate for reduction.

The chemical industry, in concert with all industry, faces still another problem and that is the increasing attempts on the part of public interest groups and legislators to develop regulatory programs to manage and track waste. Such efforts require definition of waste reduction. This in itself is exceedingly difficult and fraught with hazard.

Several working groups have met, for instance at Keystone, Colorado and Woods Hole, Massachusetts, in attempts to define waste reduction. Similar conclusions were reached in all cases: that waste reduction is a very comprehensive and difficult to define subject. The risk of narrowly defining waste reduction for regulatory and possibly for enforcement purposes, especially in the early years of program development, may actually hinder industry's progress.

For example, if a definition of waste reduction becomes accepted for regulatory purposes, generators, in all probability, will focus their attention only on the defined wastes. Existing regulations and permiting processes for hazardous waste already provide a comprehensive framework for all wastes to be candidates for reduction. Industry should be encouraged to continue defining for itself those wastes generated by its businesses that are environmentally and economically important to reduce. The performance and success of industry's efforts should be communicated to the public, but the flexibility of selecting targets should be left to the generators.

Proposed regulation for tracking and reporting waste poses still another problem. It would be reasonable to report progress on waste reduction annually; however, there are several factors that make reporting complex. What wastes should be included? What should be the reporting period? What measures should be used--volume, weight? Should the data be normalized? On what basis? Where, or to what group(s) should the reports be submitted? How are they to be used? All these and other questions need to be considered and answered.

Recognizing the complexities of reporting and the ever growing demands of the environmental groups for reporting, Congress requested that the National Academy of Sciences (NAS) submit by 1991 a thorough evaluation of the utility of data collection systems. As part of the Superfund Amendments and Reauthorization Act of 1986 (Sec 313 (1)), the NAS will assess the value of a mass balance tracking program for general chemical waste management needs, waste reduction and for tracking releases. However, even with this legislative mandate, several states including Massachusetts (HB 6118) and Louisiania (HB 657, HR-1574), and the U. S. Congress (HR 2800) have developed legislation to require industry to submit mass balance-type information per waste reduction.

Any imposed reporting format will only satisfy the needs of those in favor of regulatory control. There certainly is a need to track and report progress to the external community; however industry should be allowed to benefit from this effort as well by being allowed to develop a tracking format best suited to its particular situation with regard to improving its waste management practices and to satisfying external reporting needs.

PROGRESS AND ENCOURAGEMENT

The chemical industry, well aware of the economic and regulatory incentives that have evolved, has responded to them. Even before regulations specific to waste reduction have been promulgated, the industry has come forward with a clear position. Furthermore, the chemical industry is perhaps the only segment of all U.S. industry to be in a position to report progress on waste reduction.

The industry's progress is reflected in the results of the annual surveys that the Chemical Manufacturers' Association have been conducting since 1981. These surveys cover the operations of 681 plants, which represent a major portion of the industry. Longer term trends are based on a core group of 301 plants that have participated in all of the five annual surveys. Analysis of the data from the core group shows that there has been a 50% reduction in solid hazardous waste since the first survey, and approximately a 20% reduction in the generation of hazardous waste water, during the same period.

In the keynote address at the meeting of the CMA in New Orleans in November, Dr. Robert C. Forney, Executive Vice President of Du Pont lent a note of encouragement to the industry when he said: "Rarely has the chemical industry been offered the opportunity to realize economic and public relations gains simultaneously with making great strides in improving the environment."

ONE HUNDRED EIGHTY FIVE YEARS OF CONCERN WITH WASTE REDUCTION

Du Pont has been cognizant of the importance of minimizing waste, and active in doing so, since it was founded in 1802. In the early days, managers and operators alike worked continually at making the manufacture of black powder cheaper and safer. It was readily recognized that the process waste was hazardous in a very immediate sense, and it was to everyone's advantage to keep it to a minimum. The same management philosophy and committment have continued throughout the history of the Company, and have served it well in dealing with ever more difficult and technically challenging problems.

In 1980, Du Pont adopted a policy which stated that we intend to--minimize the generation of waste to the extent that is technically and economically feasible." As the waste reduction effort matured through the '80s, we focused our attention on the three essential areas of the program. First, the organizational and technical resources necessary to do the job; second, a defined target of waste to reduce; and third, a means for tracking performance.

LEADERSHIP FROM THE TOP

In early 1984 a Corporate Committee was formed with a charter to coordinate common concerns and solutions for reducing waste, and for increasing the awareness of the potential opportunities and economic benefits associated with reduction, throughout the Company. The Committee has representatives from the most vital business areas in the Company, and reports to a senior level management group called the Manufacturing Committee.

The responsibilities for the waste reduction committee were established at the highest level of the Company's management, confirming their belief that the only way to get the job done is with committment and leadership from the top. The effect is that those immediately responsible for planning and implementing waste reduction efforts know that they are expected to take action, and that they will have support; but it also makes them aware that they have to sell their proposals to those at the top. They are aware, too, from their business experience that selling their proposals of such a high level can be done most effectively by basing them on both the environmental and financial benefits of the plan at hand.

Positioning of the organization between senior management and actual plant operations demonstrates the Company's intention to maintain responsibility for waste reduction within the line organization. Clearly, waste reduction cannot be a staff function, but must be intergrated into the main line of the manufacturing units to protect the business.

It is recognized that waste reduction must be institutionalized to the point that it becomes a primary choice for action in any business plan to insure that it gets the needed attention of the entire organization.

TARGETING, TRACKING AND REPORTING

To start the program at Du Pont, a uniform target of waste to reduce was defined in 1984. Most of the waste in the "DuPont Tabulated Waste" definition are in the RCRA category, but the definition is much broader than RCRA-defined waste alone (Table 1). Our definition targets those wastes most important for Du Pont to reduce. "Du Pont Tabulated Waste" includes solid waste treated or disposed of on and off-site, waste used as fuel, some recycled materials, waste injected into deepwells and waste water effluents.

This definition provides a consistency across the Company so that all plants are working toward a common goal, and the performance of all can be compared uniformly. As the business needs change and our waste reduction program develops, we may need to include other materials.

Once wastes have been targetted and a program has been implemented, then it becomes important to track performance. Tracking the progress of waste reduction is no different from tracking any other production variable. It is important in designing the tracking function, that one determine beforehand whether the data are to be used exclusively for internal corporate needs, or if they are to be shared with external groups. Clearly, the needs for a business manager to make a decision are different from the informational needs of a regulatory or public interest group.

There are many positive reasons why a company, as part of its overall waste management program, should implement a tracking system. Reliable information on volume of waste generated and the associated costs for managing it are essential to business and product managers' strategic decision making process.

A tracking system can be used to identify waste reduction opportunities which will ultimately lower operating cost and improve earnings. Such considerations as volume of waste, cost of handling, regulatory impact, product life cycle, marketing opportunities and basic manufacturing processes can be factored into an algorithmic function and coupled with a tracking system to identify opportunities. The identification process would allow any business team to maximize the technical and capital resources available and direct them to the most needed part of the business to improve its overall performance. While there are definite advantages to a tracking system for internal uses, caution must be used when providing tracking information to the external community.

Designing a reporting format for external use is fraught with potential interpretative errors, primarily because it is impossible to provide the outside world with all the information needed to make accurate evaluations. In view of the complexity and diversity of businesses in the United States, it is difficult to imagine that a meaningful uniform national data base could ever be designed and used to effectuate regulatory programs.

In Du Pont we have developed a dynamic computer data base which tracks all solid waste within the definition of "Du Pont Tabulated Waste" (Table 1). The data base uses Datatrieve, a Digital Equipment Corporation product. Datatrieve, which requires use of a VAX/VMS mainframe operating system, is an interactive language that organizes information into collections of interrelated data or data bases.

At present, the information is compiled at plant sites; then is sent, in written form, to a corporate office where it is entered into the system. This system is being upgraded to enable online computer entry. The primary quality control mechanism in the system is the "validated" tables which prevent data from being entered incorrectly. For instance, the validation codes for the waste minimization method being applied to reduce a particular waste are shown in Table 2. In addition, all Plant names, waste phase, EPA and State hazard codes, Chemical Manufacturers Association (CMA) waste category, disposal method and disposal location have all been assigned codes which are recognized by the system when data are entered.

The information can be retrieved from the data base in two ways: via standard report writing procedures and ad hoc procedures written to extract information for specialized requests. Several standard reports have already been written.

The most common standard report identifies the "owner" or the generator of the particular waste (Table 3). The volume as well as the waste reduction method being applied are also reported. A useful report to account for the cost of managing waste is called the Management Printout (Table 4). A business manager can utilize this information to identify which waste should be reduced first; also to compare waste generation rates for similar processes that may be located at different sites within the Company.

Comparison Reports (Table 5) are perhaps the most revealing about the waste reduction program, and the most effective for moving the waste reduction program into the line organizations. This reporting format can be used for periodic comparisons of of any or all recorded wastes generated in any or all areas of a manufacturing site; in similar businesses, departments or across the entire corporation. This reporting format is now being used to measure progress towards the Du Pont annual goal of reducing waste by 5% wet wt (lb waste/lb product) in 1987, and the longer term goal of 35% reduction by 1990, compared to the base year of 1982.

Two of the important parameters in the reporting format are normalization and periodicity. It is paramount to normalize the waste generation. For example, examination of the data for the waste labeled BAY 002 in Table 5 shows that the actual amount generated over the comparison period increased by 69%; however, it also shows that, when normalized for production, its rate of generation decreased by 28%. Normalization allows year-by-year comparisons without bias from production cycles. The reporting frequency will be on an annual bases, which is a balance between the need to develop meaningful trends, without over-burdening the manufacturing units.

IMPLEMENTATION AT THE SITE

The administrative aspects of waste reduction discussed to this point provide the impetus and direction for waste reduction within the Company, and they effect the actual reduction on the short term; but longer term, the major reduction will be achieved by application of technology. Those in the front line of the technical effort are the people at the sites.

All sites have an environmental coordinator who serves as a focal point for all environmental activity. He and the site environmental group are aware of what problems need to be addressed, and what programs are in place, or are contemplated. It is their job to "raise the flag" on what needs to be done, including the economic flag that will insure prompt action. The planning and implementation of the programs are the responsibility of the line organization.

The spectrum of the Company's businesses is so broad that the Company's functioning with respect to waste reduction cannot be described in terms of a "typical" site. For simplicity then, we'll focus our comments on those activities associated with the chemical segments of Du Pont's businesses.

Reducing hazardous waste is one of the first environmental initiatives to come along in the '70s - '80s that doesn't need to be interpreted or explained to line organization by legal counsel. Reducing waste and its associated economic benefits are recognized by the line organization as matters on which it should move forward agressively. Many of our sites have established site-wide waste reduction committees with representatives from each operating and business unit, and the plant manager.

SHORT TERM SOLUTIONS

There are many short term solutions that can be implemented now. Foremost among these is the establishment of training programs. Within Du Pont, such programs stress the need for reducing waste, understanding the differences between hazardous and non-hazardous waste, and the importance of keeping them separate.

Training the first-line supervisors and operators has already yielded large reductions in the generation of waste at a several sites. Typically, in the past, the operators have been told to "keep the area clean". Accordingly, the operators washed down the areas on a shift to shift, or day to day basis, not knowing that the the wash was generating a hazardous waste. Today, things are different. There are fewer washdowns; and, better yet, greater efforts are being made to avoid the need for washdowns. Changes like these can be made quickly; they require little, if any, capital investment; and they begin to pay off immediately.

LONGER TERM SOLUTIONS

Longer term solutions are more difficult to achieve. They usually require a better understanding of the process, more sophisticated technology, and substantial capital investment.

Since this paper is focused on chemical businesses, we limit the discussion that follows to the chemical engineering aspects of waste reduction, realizing, of course, that waste reduction overall is dependent on many technical disciplines.
The production of waste from a chemical process is basically a function of the process design and the manner in which it is operated. The design, of course, includes the selection of raw materials, the manner in which they are reacted or processed, and the manner in which the products are separated from the by-products.

Chemical engineers are uniquely qualified for waste reduction because their training encompasses chemistry, physics, biology, engineering and economics, all the disciplines essential for solving the problems involved. Wastes are generally complex mixtures of many materials present in one or more phases. The problems of handling them are even more complex. While some wastes lend themselves to easy separation and recovery via the conventional unit operations of chemical engineering, others require in-depth understanding of its more sophisticated areas--reaction kinetics, thermodynamics, fluid mechanics and fine particle technology.

CORPORATE TECHNICAL RESOURCES

While site personnel at Du Pont primarily utilize the resources immediately available to them, they also have ready access to internal and external consulting and environmental services. Among the internal services is the Chemical & Environmental Consultant Section of the Engineering Department. This organization consists of some 150 chemical and environmental engineers whose expertise ranges from reaction engineering to water, waste and geological engineering. In addition, the Engineering Department has an Engineering Test Center which has expertise and facilities for air quality testing, waste water sampling and characterization, and testing of biological and chemical treatment methods.

CHEMICAL ENGINEERING APPROACHES

It would be advantageous at this point to describe how we go about using waste reduction technology. It is well recognized that waste from chemical processes can be minimized in at least four general ways:

- by modifying the process to minimize its generation;
- by recyling it, preferably to the process in which it is generated;
- by converting it to useful, and in many cases valuable, by-products; and
- by changing its nature to make it less toxic and voluminous for ultimate disposal.

The following examples from Du Pont experience illustrate each of these ways, and cite to some extent the role of chemical engineering in solving the problem.

PROCESS MODIFICATION

In 1950, Du Pont, which had been manufacturing nylon from "coal, air and water" since 1939, shifted it source of hydrocarbon to the petroleum based butadiene, and developed a process to convert it to adiponitrile, an intermediate used in the manufacture of nylon. This process, while environmentally "cleaner" in general, had a disadvantage in that it produced the equivalent of ten tank cars of a concentrated sodium chloride brine for every tank car of adiponitrile. The brine, contaminated with low concentrations of metals and cyanides, today, would be a RCRA hazardous waste. Years of research were rewarded in the early 1970's when Du Pont discovered a new catalyst system that made it possible to produce adiponitrile from butadiene without producing the by-product brine. The resultant process gave a higher yield, thereby reducing the organic waste substantially, and it reduced the aqueous waste by 50%.

The task of designing the new process posed numerous problems for the chemical engineers involved. It required much larger reactors to accommodate the slower reaction rates with the new catalyst; design of a totally new kind of extraction system to recycle the catalyst; and a more extensive refining train to recover the product. But it did reduce the waste.

RECYCLE

In the manufacture of a relatively new polyarymide fiber, a substantial quantity of waste, called pump-out solution is generated in the spinning process. From startup of the plant in the early 1980's until 1987, this waste, which consists of 20% polymer and 80% concentrated acid, was disposed of by burning, or by sending it to a hazardous waste landfill. Though referred to as "solution", this waste is a relatively hard solid in the form of large "chunks." The initial approach to reducing it was to grind the chunks to small particles and extract the acid for recycle. Eventually, it was found that all of the ground particles--polymer as well as acid--could be recycled to the process. The grinding process, which is rather intricate because of the unusual chemical and physical properties of the solid, was developed in cooperation with OH Materials, an environmental services company. The result is that Du Pont has essentially eliminated a noisesome problem and is realizing large savings in raw materials and disposal costs.

CONVERSION TO USEFUL PRODUCTS

Adipic acid, another major nylon ingredient is manufactured by air oxidation of cyclohexane. Like most oxidations, this one produces a spectrum of by-products including succinic and glutaric acids. Until recently, these materials were burned in the plant powerhouse. While this resulted in fuel savings, it was realized that the individual components of the waste had an inherently higher value; but they were part of a complex mixture which was difficult to separate, and evaluations showed that separation wouldn't be economical.

As a result of a team effort on the part of chemists, chemical engineers and marketing people, Du Pont is now converting these materials to a carefully controlled mixture of esters which are being sold as DBE, which is much in demand in the paint and furniture industries.

CHANGING THE CHARACTER OF WASTE

Although the new process for producing adiponitrile mentioned above made a substantial reduction in the organic and aqueous waste loads, it generates a large volume of spent catalyst solids that are being disposed of by containment in a hazardous waste landfill. This waste was one of the largest volume solid wastes emanating from the plant, until the simple expedient of installing a large belt filter has now made it pcssible to reduce the volume by 35%. This has resulted in a substantial savings in disposal costs, and will serve as an adequate means for disposal, while work is in progress aimed at recovering the bulk of the ingredients involved in an economically and environmentally sound way.

TARGETING OPPORTUNITIES

Reducing waste is often looked on as an onorous task, and most certainly additional cost. But experience has shown, in many cases, that it can yield savings well in excess of its cost, and often can generate substantial new income; hence it may be looked on as an opportunity.

When a site embarks on a waste minimization program the opportunities sometimes become readily apparent; but, more often, there is a need to examine the overall waste situation in depth. This is facilitated within Du Pont through use of the corporate waste data base mentioned previously. Each site, having contributed to it, has it's own data base which it can use to "target opportunities." The best of such opportunities are those which yield the dual benefit of improving the competitive position of the site's businesses and increasing the protection of the environment at the same time.

We are also looking for opportunities for reducing waste from processes which are used in more than one department or at more than one site, with the help of the waste data base. For example, we recently targeted the "10 Most Wanted" wastes generated within the Company--wanted in the sense that the FBI uses to identify the most dangerous criminals. The search was made on the basis of several criteria, primarily volume and cost. The information generated is now being used to focus attention on reducing these wastes and extracting values from them with the help of direct corporate support.

PURSUING THE OPPORTUNITY

From a chemical engineering point of view, waste minimization can be handled in much the same way as process development. One needs to define the problem: What are its dimensions? Its implications? Analysis follows: What options are available? What are the opportunities within each option? What obstacles? What are the chances for success? What information needs to be developed? Is needed technology available, or must it be developed experimentally? What are the economics?

There's no best way to obtain answers to these questions. Each problem or situation dictates its own needs. Those engaged need to be flexible in dealing with them.

SUMMARY

Reducing waste to remain competitive has been an important ingredient in all successful businesses in the past; in the future, it will be absolutely essential. The chemical industry has made substantial progress in responding to the economic and regulatory incentives as they have evolved; and it recognizes that much more intensive effort will be needed in the future. Du Pont, cognizant of the importance of reducing waste since its beginning, has intensified its efforts to respond to the accelerating needs of the present, especially for reducing hazardous waste. It has a functioning waste reduction organization in place, and able leadership at the top levels of management. It also has the resources in its capable and dedicated technical personnel to fulfill its committment "--to minimize the generation of waste to the extent technically and economically feasible."

TABLE 1

DU PONT TABULATED WASTE

Type of Waste	RCRA Hazardous	Non-RCRA
"Solids" treated or disposed off-site (including wastewaters)	Yes	Yes
"Solids" treated or disposed on-site (except for wastewaters, see below)	Yes	Yes
Barged to Sea	Yes	Yes
Deep Welled	Yes	Yes
Total influent to on-site wastewater treatment facilities	Yes	No
Total influent to POTW	Yes	No
Used for fuel	Yes	No
Recycled:		
Used as an ingredient in an industrial process to make a product if not first reclaimed.	No	No
Used or reused as an effective substitute for commercial products.	No	No
Spent material that is reclaimed but not returned to the original manufacturing process by pipe.	Yes	No

TABLE 2

VALIDATION CODES FOR TYPICAL WASTE MINIMIZATION TECHNIQUES

"10" : Process Change

"11" : Modify Operating Procedure
"12" : Advanced Process Control
"13" : Substituted Chemicals
"14" : Use Higher Quality Materials

"20" : Recycle

"21" : Direct Use in the Process
"22" : Direct Use in Another Process
"23" : Regeneration for Reuse
"24" : Use as a Fuel
"25" : Sale

"30" : Improve Waste Treatment

"31" : Waste Filtration
"32" : Waste Decantation
"33" : On-Line Treatment

"40" : Administrative Controls

"41" : Minimizing Washdown
"42" : Reduce Cleaning Frequency
"43" : Longer Turnaround Time
"44" : Improved Spill Control
"45" : Separate Hazardous from Nonhazardous
"46" : Discontinue Manufacture

TABLE 3

TYPICAL COLUMN HEADERS IN COMPUTER PRINTOUTS

Production Area	Waste Description	Hazardous Class.	Quantity Generated M, lb/yr	Management Disposal Cost $M/yr	Minimization Method
VI023	Organic Acid	Flammable	2	5.5	Recycle
NR126	Polymers	Caustic	50	25	Sale
GA462	Spent Catalyst	Acidic	10	42	Reuse
ME621	Lab Solvent	Ignitable	.5	1	Fuel
BU215	Acid Catalyst	Corrosive	40	16	Admin. Contr.

TABLE 4

MANAGEMENT PRINTOUT

Production Area	Waste Description	Annual Volume General M, lb/yr	Density	On-Site Cost $M/yr	Off-Site Cost $M/yr	In Storage year-end M, lb
ME625	Polymer	7.5	2.3	2	4	3.1
BX212	Still Bottoms	85	5.3	317	4	100
MA631	Solvents	21	1	225	302	85

TABLE 5

COMPARISON REPORTS

Study Waste Code	Base Yr Quant. M lb/yr	Comp. Yr Quant. M lb/yr	% Change	Base Yr Wst/Prod Ratio	Comp. Yr Wst/Prod Ratio	% Change
FAY001	72.20	187.00	+ 159	240.67	267.14	+ 11
BAY002	51.20	86.50	+ 69	170.67	123.57	- 28
PAY003	4.70	5.90	+ 26	15.67	8.43	- 46
GBC004	23.00	40.00	+ 57	63.00	65.00	+ 3

WASTE REDUCTION CASE HISTORIES:

WHAT'S WORKED, WHAT HASN'T, AND WHY

Daniel D. Kraybill, P.E.
Sam Mehta
David L. Thomas, Ph.D.

Hazardous Waste Research and Information Center
Savoy, Illinois 61874

INTRODUCTION

The Illinois Hazardous Waste Research and Information Center (HWRIC) was formed within the state's Department of Energy and Natural Resources (ENR) in 1984. The Center's mission was to combine research and education; information collection, analysis, and dissemination; and direct technical assistance to industry, agriculture, and communities in a multidisciplinary effort to help solve Illinois' hazardous waste problems. Even in its enabling legislation, the Center was directed to support waste reduction research and to conduct educational programs to further the exchange of information to reduce the generation of hazardous waste. Over the last several years, HWRIC has developed a strong waste reduction program. Aspects of this program and the progress of Illinois industry in reducing its waste is summarized in a series of articles.[1, 2, 3]

Briefly, the Center's waste reduction activities include:

1) Providing technical assistance to industries to help them eliminate the production of hazardous waste and improve their waste management practices.

2) Developing an interactive computerized waste management tool, the Multi-Option Model (MOM), to increase generators' knowlege of the wide range of options for reducing, recycling, and treating industrial waste.

3) Sponsoring an annual matching fund program of $100,000 for recycling and reduction technologies (RRT).

4) Encouraging waste reduction/minimization through presentation of an annual Governor's Innovative Waste Reduction Award (here after referred to as the "Governor's Awards").

In addition, HWRIC and the Illinois EPA have received one of USEPA's RCRA Integrated Training and Technical Assistance (RITTA) grants, which will expand these activities. In particular, HWRIC will be developing a waste reduction training program and will be providing technical support to IEPA's intern program to place engineering students in industrial facilities to help these facilities develop waste reduction techniques and test new technologies.

In response to the Governor's Awards discussed above, we have received waste reduction plans and descriptions of progress from a number of industries and other groups. We have also worked with a number of industries on their waste reduction projects through our Industrial and Technical Assistance Program. This paper first discusses incentives and disincentives for waste reduction and then discusses how one college and five industrial facilities developed their waste reduction plans and examines their successes and failures. We have also examined various approaches that these and other companies have taken to waste reduction and the pros and cons of each. We hope these case studies will help others initiate and develop effective waste reduction programs.

INCENTIVES AND DISINCENTIVES FOR WASTE REDUCTION

Several factors affect decisions regarding waste management and waste reduction at the plant level. The standards set by regulatory bodies usually dominate and they provide the motivation for most companies to install equipment needed to meet the standards. Companies recognize, however, that the most economical way to reduce pollution is to minimize the release of raw materials, by-products, and other valuable materials into the waste stream. Less waste means less treatment of waste, as well as less replacement of process materials. Housekeeping and attention to details that can result in minimal discharges are often overlooked. For example, reduction of drag-out rates in electroplating is an excellent way to reduce waste at the source, and to reduce the cost of wastewater treatment. However, a plater who is doing a high-volume business may feel that the line cannot be slowed down to allow for more dripping time. Also many platers depend on high drag-out rates to keep their plating tanks free of contaminants. Less drag-out may result in contaminated plating solution and/or more rigorous cleaning requirements.

Despite potential drawbacks, the incentives and disincentives for waste reduction are many. A few of these incentives are listed below.

<u>Economic Benefits</u>

Waste reduction practices are usually undertaken because of economic need. Reducing the amount of waste generated, or switching from generating a hazardous to a nonhazardous waste will mean lower disposal costs. Reuse of materials within the plant will reduce the cost of new raw materials.

<u>Productivity</u>

Waste reduction will often result in improved process efficiency. In many cases these improvements will pay [illegible] disposal.

Worker Safety

Replacing hazardous raw materials with less- or nonhazardous materials will improve safety conditions and provide other benefits such as better worker morale, lower insurance rates, reduced absenteeism, and easier compliance with OSHA regulations.

Regulations

Many generators initiate waste reduction programs to avoid the time and trouble of complying with regulatory requirements for hazardous waste management. Waste reduction can remove small quantity generators from most or all RCRA requirements.

Liability

Long-term liability is one of the best reasons to avoid hazardous waste generation. This benefit is often difficult to quantify, and, therefore, may not be considered when making decisions about whether to generate waste and how to dispose of it. Long-term liability is a much-feared problem but often it is not adequately factored into corporate cost accounting.

Despite the above incentives, there are some disincentives to waste reduction that should be considered.

Lack of Capital

Any significant change in an industrial process will usually involve investment in capital equipment, which requires paying additional overhead (the monthly payment for whatever you buy) for an extended period of time. Many firms, particularly small ones, do not want to pay additional overhead if it is not necessary. The fear of capital commitment often outweighs the possibility of greater future profit. Also, capital is simply not available in many cases.

Product Quality

Generators are in the business of producing and selling a product, and providing the best quality product at the cheapest cost is often their greatest concern. If it is suggested that a new raw material or a different type of process be used in their operation to reduce waste, they will be very reluctant to change, particularly if they already make a good product using existing methods.

Customer Fear

Customers will also be skeptical about changes in product quality. For this reason it is very helpful, if possible, to involve customers when evaluating waste reduction options that may affect product quality.

Immediate Production Needs

Because plant operators are concerned most with making a product, they are reluctant to spend time evaluating new projects, even if it might provide them with a payoff. Unless they see an advantage in committing time to a waste reduction program, they will not give it a high priority.

Regulation

Environmental regulation can be both an incentive and a disincentive to waste reduction. Many firms reduce wastes to avoid regulation. Some regulations, however, may discourage waste reduction. For example, some waste reduction practices may be considered hazardous waste treatment activities and could subject the generator to extensive regulation. Additionally, regulations that apply to media other than solid waste may come into play with some waste reduction practices. In Illinois for instance, solvent stills, no matter how small, are required to have air pollution permits.[4, 5]

Inertia

In general, many people take the attitude "if it ain't broke, don't fix it." If a process or operation is running well, people tend to leave it alone.

Many of the above disincentives can be grouped into a general fear of unknown outcomes, which are of legitimate concern. A poorly conceived or implemented waste reduction program could have serious repercussions for the person or company who undertook it.

DEVELOPMENT OF A WASTE REDUCTION PROGRAM

The most essential element for undertaking a waste reduction program is an organized approach to evaluation and selection of alternatives. The USEPA has recently published The EPA Manual for Waste Minimization Opportunity Assessments, which outlines a format for evaluating industrial processes for their waste minimization potential. It is a generic manual, intended to apply to many types of industries[6]. A number of industry-specific waste minimization manuals are also available (see Table 1).

The USEPA manual gives a method for identifying problems in a facility. It indicates the personnel needed to carry out such an operation and the necessary resources. In some cases, particularly at smaller plants, the full audit procedure outlined in this manual may not be practical. In these cases a simple problem-solving format can be employed, and these basic elements are in fact included in the USEPA manual and most other manuals in one form or another (Figure 1).

1) Problem Definition--This is the most important phase in developing a waste reduction plan. In the case of a large plant, there may be a nebulus definition such as "waste

disposal costs are much too high" or "we are opening ourselves up to too much future liability." In a small plant or in a specific section of a larger plant, it may be a specific problem such as "we are generating too much cleanup waste on line B" or "the line personnel complain about working with solvents." It is important to set initial goals. It is also important to realize that the goals and even the problem definition may change as the project progresses.

2) Fact Finding--This part of the process will vary in complexity, depending upon plant size. For a large plant, a comprehensive audit is necessary. For small plants with few waste streams it may be a more simple process. It is important to realize that the first and second phases of the process will interact. As facts are gathered, the original problem may need to be redefined.

3) Evaluation of Alternatives--Once the problem has been defined and facts about its causes collected, alternatives for solving the problem must be evaluated. In the beginning of this phase, as many solutions as possible should be included. Solutions that may not seem practical or that appear too simple initially, may in fact be the best solutions when all factors are considered. Some of these factors are (1) achievement of stated goals, (2) overall economics, (3) availability of capital, (4) environmental protection, (5) safety, for workers and the surrounding community, (6) product quality, (7) how changes affect other plant operations, and (8) regulatory impacts.

4) Implementation--Once a course of action has been chosen, it is essential that immediate action be taken in an organized manner. Implementation of the action should be coordinated carefully with all individuals affected by it. It is also essential that assistance with unfamiliar aspects be obtained.

5) Follow up--Any change in a production operation will almost certainly affect other aspects of that operation, and there will be unexpected outcomes from these changes. Plant operation must be examined closely to identify these changes and the adjustments in procedures that must be made to avoid negative outcomes. Followup is a continuous process because new, but usually smaller, problems result.

CASE STUDIES

Following are examples of waste minimization activities undertaken in Illinois. The information was gathered from Governors Award applications and from personal interviews with company personnel. In some cases, names of the firms involved are withheld.

MPI Label Systems--Monee, Illinois

MPI Label Systems is a midwest firm that manufactures pressure-sensitive labels using a flexographic printing process. In 1985, it purchased Fagan Labels of Monee. The firm currently employs ten people at its Monee plant, the company's smallest.

At the time of its purchase, Fagan Labels had already done some conversion of its operations from using solvent-based inks to using water-based inks. Shortly afterward, MPI personnel decided to convert completely to using water-based solvents for three reasons:

1) Regulatory burden--There were too few staff members to handle the management requirements and paper work burden that regulations associated with solvent wastes required.

2) Economics--When the cost of waste management for solvent-based inks was factored in, water-based inks were less expensive to use.

3) Employee safety--Water-based inks involved fewer potential health problems and provided a safer and more pleasant working environment, because of their lack of flammabilty and less offensive odor.

The organization and planning required to convert to water-based inks in a plant of this size were minimal. Two people, the plant manager and one employee with a particular interest in the process, were involved in most of the problem assessments and decisions. The existing wastes that needed to be eliminated were easily defineable. The only hazardous wastes they disposed of were contaminated solvents from equipment cleaning between runs.

The presence of a large water-based ink manufacturer nearby facilitated the conversion process as did improvements in water-based inks. The conversion necessitated only one process change: the substrate (the surface to be printed on, usually polyester film or laminated foil) had to be top-coated with an acrylic resin. Obtaining such material was somewhat difficult at first, but this type of product has now become quite common.

Plant employees welcomed the change because the water-based inks provided a much more pleasant working environment. The change was also accepted by customers, who encountered few problems with the new product.

MPI changed from generating a hazardous waste that required time-consuming management and expensive disposal to generating a waste that can simply be sewered.

While all MPI facilities are in the process of changing over to water-based inks, MPI-Monee, its smallest plant, is the first to make a complete changeover. Their small size was an advantage, because they had an easily defineable waste to deal with and they did not not have a large management hierarchy to work through; the plant manager was able to make decisions and carry them through. Because water-based inks are quickly becoming the standard for this particular industry this is a good example of the market place responding to an industrious waste management needs with a new product.

Illinois Benedictine College--Lisle, Illinois

Illinois Benedictine College (IBC) is a private liberal arts college in Lisle, a western suburb of Chicago. It enrolls 2500 students in undergraduate, graduate, and professional programs. It's chemistry department employs six professors, who teach about 55 students per semester in its organic chemistry curriculum.

Four years ago, the professor and lab technician in charge of the organic chemistry laboratory cleaned out the lab storage areas and collected a quantity of expired chemicals, experimental residuals, and miscellaneous other wastes that required disposal as hazardous waste. The bill for disposal of these materials came to $5000, about 1/4 of the entire operating budget for that laboratory. Both the management and the academic staff wished to avoid further unexpected costs of this type, and a program was undertaken to reduce the amount of hazardous waste generated in this laboratory.

Dr. David Rausch, the professor in charge of organic chemistry, was asked by the department head to study the possibility of using microscale glassware procedures to reduce the amount of experimental residuals produced. Dr. Rausch and Michael O'Grady, Laboratory Supervisor, directed three students in the development of microscale experiments and techniques, using Pike-Mayo Microscale Organic glass kits and other selected glassware. Results of initial experimentation indicated that the glassware could be manipulated by students and that near theoretical results could be obtained. Reductions in waste generation of 90-99% were obtained (Table 3).

Based on the results of this initial experimentation, IBC decided to purchase 14 glassware kits for its organic chemistry lab. They also acquired semiautomatic pipetting systems and new electronic balances. Gas chromatographs were donated by a local industrial firm that was replacing them with new instruments for their own labs. The total cost to IBC was approximately $30,000. The savings from avoided disposal costs and reduced chemical useage resulted in a payback of approximately five years for this capital investment.

One unexpected problem arose. The traditional storage drawers in the laboratory were not appropriate for storing the new glassware kits and a new system had to be designed. This added an unexpected cost of $3,500.

Some resistance was encountered from the academic staff at first, but once the benefits of the new system were apparent, this subsided. A higher level of skill was required from the students in order to manipulate the smaller glassware, but experimental times were actually decreased, allowing professors to add to course curricula.

All organic chemistry curricula at IBC have now been converted to microscale techniques. IBC is the first college in Illinois to accomplish this.

In addition to the glassware techniques, IBC has also implemented a formal centralized inventory system for the chemistry department and modified its purchasing practices. This is intended to eliminate large purchases of chemicals and to preclude the possibility of chemicals deteriorating or becoming unuseable while shelved. They also recycle in the laboratory, reusing the residues from some experiments from year to year.

IBC staff have presented several papers on microscale glassware techniques at national conferences. They are putting on microscale technique workshops for high school chemistry instructors through the Teachers Inservice for DuPage Educators (TIDE) program, and serve on a National Helpline Network for teachers needing help in developing microscale chemistry techniques.[8]

GE Plastics--Ottawa, Illinois

GE Plastics (until recently Borg-Warner Chemicals) of Ottawa is a manufacturer of three component (or ABS) plastics formulated from acrylonitrile, butadiene, and styrene. It employs approximately 450 people at this location. A few years ago, Borg-Warner personnel made the decision, based upon increasing disposal costs and the environmental staff's observations of state and federal regulatory trends, to conduct extensive waste minimization and reduction activities. These activities consisted of two components: (1) the formation of a waste minimization program within the plant, and (2) extensive process modifications that were intended to use raw materials more efficiently and thus reduce waste generation.

A waste minimization team formed in late 1986 consisted of 16 plant employees. The team included at least one person from management and one from the line employees from each area of the plant. These employees possessed an average of over 20 years experience.

All team members were required to go through training, not in waste minimization techniques, but in the concept of working and functioning as a team. They were given training in brainstorming, setting priorities, and teamwork in general.

After training, the team was assigned the task of identifying all waste streams within the plant. Not only were hazardous wastes identified, but also nonhazardous solid wastes of all types, including sources of wastewater that could be reduced or eliminated. Wastes were identified both by work area and by job function (wastes generated by each employee as they performed their daily duties). An extremely large list (over 100 pages) was generated, and this led to the setting of priorities for which wastes would be dealt with.

The team then decided for individual plant areas which wastes were the most likely candidates for minimization or reduction. These decisions were made using the following criteria:

1) Combinability--Wastes with the potential to be bulked with wastes from other plant areas were given priority.

2) Volume--Large-volume wastes were generally given priority over small-volume wastes, although this was not always the case.

3) Reuse/Recycle Potential--This was the ultimate waste minimization method for most of the wastes identified. As it turned out, there were many opportunities for saving raw materials for reuse.

4) Economics--Economics, although important, was not an overriding factor. Reduction of potential liability from environmental problems resulting from waste disposal and worker safety were more important. Since the potential future cost was difficult to quantify, more leeway was given in economic analysis of some of the proposed projects. The largest capital expenditure to date, a building to house the collection facilities for nonhazardous waste recycling operations, has a computed return-on-investment (ROI) of approximately five years, a period considerably longer than desired for most production projects.

Very little resistance was encountered during the implementation of this program. GE personnel attributed this to the fact that employees at all levels of the plant were involved in developing the program and in the decision-making process it involved. The problems encountered were attributed mostly to employee "inertia," but this soon passed.

The waste minimization project is ongoing at GE Plastics, and ideas and suggestions from plant personnel are received and evaluated on a regular basis. Ideas submitted by employees are evaluated by the waste minimization team using roughly the same criteria mentioned previously. The suggestion is first investigated by members of the team using the forms in Figures 2 and 3. After an investigation to identify the waste, how it resulted, and possible remedies to its generation is made, a waste summary is assembled. A decision is then made by the waste minimization team members and personnel in the area generating the waste whether or not to proceed with implementing the suggested waste minimization proposal.

The only exception to this rule is for projects exceeding $50,000. Such projects require the approval of the plant manager. GE personnel have estimated that cost savings from these projects (listed as Rework Off-Spec Product and Segregate/Sell Waste in Table 2) save the company $619,000 per year.

As stated earlier, Borg-Warner also changed their product formulation to increase production efficiency and reduce waste generation. The program took four years of research, pilot-scale work, full-scale implementation, and a great deal of capital expenditure. It was not without its problems, which included customer resistance, scale-up problems, and unanticipated wastewater treatment problems.

Customers showed some resistance to the new product, because some of its characteristics, specifically its color and some structural characteristics, were changed. Overcoming this problem required close work with the customers to further develop the product to suit their specifications and also required some good salesmanship.

The scale-up problems largely resulted from attempting full implemention based on experimental results obtained from a small (bench-scale) pilot system. No intermediate scale tests were attempted. Serious problems were encountered with equipment breakdowns, plugged lines, and resultant down time of an on-line production system. Production loss and unanticipated capital expenditures were high.

The process modifications also induced unexpected problems in the wastewater treatment (WWT) plant, and evidence that problems can come from unexpected sources. The process modifications implemented reduced the chemical oxygen demand (COD) load to the GE WWT plant to the extent that the biomass was not receiving a sufficient food supply to support itself. It was necessary to call in a consultant to assist in modification of the plant and its operating parameters. This was another significant unanticipated cost of implementing the process modifications.

Despite the problems encountered, GE personnel still considered this phase of their waste minimization activities to be successful. Waste generation from these processes was reduced from 58lb/1000 lb of production to 11 lb/1000 lb of production. The changes resulted in savings of $196,000 per year in disposal costs and $1.1 million per year in additional production.[9]

Plating Firm--Chicago, Illinois

In recent years, electrolytic ion transfer units (EITUs) have been introduced to the electroplating industry. These units have sound scientific and technical foundations, but management and maintenance of them have had disappointing results, partly because of membrane clogging.

This Chicago plating firm is a well-maintained electroplating job shop that plates hard chrome on steel. Major parts are plated rolls and shafts. The company decided to close the loop on its plating line by installing counter-current rinsing followed by an EITU. Installed equipment cost, including the agitation unit and recirculation pump, was about $21,000. The company saved about 6000 lbs. of chromic acid ($7,000 value) and water use charges were down from $1,200/month to $200/month. Operation and maintenance costs, including electricity, were less than $1,000 per year. However, after a year of operation the membranes were so clogged that it wasn't possible to recirculate the chromic acid. New membranes would have cost about $10,000. The EITU was eventually disconnected. The clogging was probably due to excessive iron in the rinse waters from the steel parts and plating tanks. It's hard to tell how much longer the membranes would have survived had the tanks been lined with a chromic acid resistant liner or if a filtering device had been connected prior to the recovery unit. In this case the company didn't lose any money, but the owner says he won't recommend this technology unless membranes were made less susceptible to plugging.

Plating Firm--Cicero, Illinois

This plating firm, established Cicero in 1920, was a pioneer in plating on plastics in the late 1960's. Seven or eight years ago an ion exchange system was installed to bring the discharge to the sewer in compliance and recirculate the rinse waters. Water use was reduced by 80% and the discharge met the Chicago Metropolitan Sanitary District's discharge criteria. For the first few years the exhausted ion exchange columns were picked up and replaced with fresh ones by the company that designed and installed the system. The installer regenerated the resins at its own facilities. However, when the installer decided to abandon the regeneration business, the plating firm had to do regeneration in-house. They regenerated the two cation columns that removed the heavy metals from the effluent before discharge to the sewer. Now the company was faced with disposal of 300 gallons of regenerant that was a hazardous waste because of heavy metals and low pH. The designer had suggested to the company that regenerant could be rendered nonhazardous by plating the metals out. However this wasn't attempted because of a number of management and personnel problems.

When the company was sold in the summer of 1987, a number of items were neglected or ignored that eventually lead to the demise of the company in late 1987. Some typical problems were:

- The activated carbon filter, which should have been located in front of the ion exchange columns, was missing.
- Spray nozzles on stagnant rinse tanks were missing, inoperable, or partially functioning.

-- The system needed to adjust pH levels during the ion exchange process was missing or inoperable.

-- Resin in most columns was exhausted and contaminated with foreign matter.

The recirculated rinse water evidently wasn't rinsing properly. In addition, operators ran hoses from the water faucets to the rinse tanks causing them to overflow.

Meat Processor--Chicago, Illinois

Historically, Chicago industries have had little or no concern about the cost of water and its disposal. However, in recent years costs have gone up; with a 48% surcharge for sewer usage the cost of water has gone up from $0.70 to $1.17 per thousand gallons in 1980. This medium-sized processor annually used 7.5 million gallons of water. Because of this and advise from an industrial hygienist, the processor decided to conserve water and thereby reduce wastewater production.

Wastewater in the plant was being generated in three major areas:

1) clean-up operations in the meat processing area,
2) from product cooling showers during summertime, and
3) in equipment-cleaning operations.

The wastewaters were conveyed to a gravity settling tank, which was originally used in the industry for collecting soluble grease. The settling tank design was centered around the skimming aspects of the tank, and little consideration was given to sludge resulting from the removal of settled solids. Such gravity-settling tanks typically remove between 20-30% of the biochemical oxygen demand (BOD) and 40-50% of the grease.

Water conservation was implemented by using the following methods:

-- Water spray nozzles that give high velocity spray, reduce water flow, and can be turned on and off at the point of application were installed in the meat-processing area for clean up,

-- Dry cleanup in the plant was instituted before a wet cleanup,

-- Screens were installed in the drains to catch meat scraps and other materials, and

-- Special detergents and cleaners were used to reduce water usage and produce a more hygienic area.

These measures did cut down the water use by about 30%; however, using less water can sometimes create other problems. Generally, wastewater discharge standards require meeting limitations of contaminants in terms their concentration in the water expressed as milligrams per liter. If water conservation is practiced without a corresponding reduction in the quantity of pollutants or modifications in the pretreatment system design, the discharge water concentration limits set by the local POTW will be exceeded. In this case the grease discharges from the smokehouses remain unchanged and no design changes were made in the gravity-settling unit. This resulted in plant effluent discharge to the sewers exceeding the fats, oils and grease (FOG) limit set by Chicago Metropolitan Sanitary District. The plant manager now is considering the installation of a dissolved air flotation unit to bring the effluent within compliance.

DISCUSSION

The several waste minimization projects described herein illustrate some of the incentives and disincentives for industries trying to reduce waste, some problems they encountered in trying to implement waste reduction programs and the strengths and weaknesses of some of their approaches.

Economics was a motivating factor in all six cases. While cost savings were not always quantified, there was in all cases a perceived potential for a positive payback. The two firms that computed return on investments, IBC and GE Plastics, showed payback periods of around five years, which is not considered acceptable by many businesses. However, economics was not the only concern of these firms. Worker safety and potential future environmental liability were also important factors. Both of these factors have potential economic impacts. Although difficult to quantify, they need to be considered if rational decisions will be made.

Productivity was a concern from the standpoint of both improved production efficiency and more efficient use of raw materials. Production efficiency was not always improved by waste reduction techniques. The Chicago plating company bought a new piece of process equipment which, as it turned out, caused problems requiring labor to maintain. The meat-packing company initiated water-saving techniques that were more labor intensive than simply cleaning their process equipment with a hose. In both cases, however, the gain was initially perceived to be worth the additional trouble.

More efficient use of raw materials was an important motivation in nearly all of the cases. Raw material savings, either water savings or reuse of plating baths, was an easily-accepted concept by most of these firms.

Worker safety was a concern in some cases. In particular, NFI Labels and IBC sited concerns about worker (or student) exposure to organic solvents. For NFI Labels, this was one of the driving forces in their raw material changeover. The switch to water-based solvents provided a safer and more pleasant working environment for their employees.

Environmental regulations were an important consideration in all cases, but in different ways. GE Plastics has taken an active approach to potential regulatory burdens. They devoted staff time to consider what was "coming down the road" in the environmental regulatory area, and modified their operations as they deemed appropriate. Most of the other firms lacked staff to do regulatory planning and as a result, have dealt with regulatory concerns in a reactive rather than proactive manner.

MPI Labels undertook its raw material changeover in part to avoid filling out manifests and annual reports. With only ten employees in the plant, that job fell to the plant manager. The burden of keeping up with the regulations may have had a great role in moving the project along.

In the case of both plating firms, waste reduction measures were driven by both sewer ordinances and the RCRA regulations. Platers have long been required to limit the concentration of heavy metals in their outfalls to sewage treatment works. This has usually been accomplished by chemically precipitating the metals into a metal hydroxide sludge disposed of by landfilling. Under the RCRA regulations[10] these sludges were considered hazardous, which made their disposal much more expensive. More recently, landfill ban regulations enacted under the authority of HSWA[11] have severly restricted disposal options for these sludges and have forced platers to seek other methods of managing their residuals. One of the methods pursued has been to not generate the residuals to begin with.

Potential environmental liability was a concern among all firms. As previously stated, this can be viewed as an economic factor not readily quantifiable. Although subjective, potential liability is perceived as a threat by most of these firms and has motivated them to undertake projects that may not have adequate payback periods to justify them from a production point of view.

Disincentives such as those previously outlined also existed. Lack of capital is an ongoing problem in any business, but in these cases seemed to be less of a problem for larger companies. GE Plastics was able to invest large amounts of capital in fundamental changes to their production processes. Not all of these firms enjoyed such a luxury. The investment of $30,000 in the case of IBC or of $21,000 in the case of the Chicago plating company is a serious matter for a small company. In many cases, small firms cannot obtain capital at any price, because they are considered too great of a risk. Of these firms, MPI Labels was in the best situation. They needed little or no capital to change their process and saved money almost immediately.

Product quality was not a problem with most of these firms. GE Plastics had some initial quality problems, but solved them with proper follow up. Customer fear, as it relates to product quality, was not a serious problem. The problems that did occur, however, required careful coordination with customer needs.

Impacts on immediate production needs were a problem in several cases. GE Plastics spent a great deal of time doing developmental work at full scale that would have been better done at the pilot scale. Their regular production schedule was impacted adversely.

IBC had the luxury of developing its experimental techniques during the summer semester. A commercial laboratory might find such developmental time unavailable and unacceptable.

The Chicago plater's chrome recovery system is no longer operational, in part because they simply did not have time or did not see the value of carrying out the required developmental work.

Regulations have also had a negative impact on some waste reduction processes. GE Plastics considered and rejected some potentially beneficial waste minimization projects because they feared becoming a RCRA treatment, storage, and disposal (TSD) facility. The meat-packing facilities made the classic error of putting themselves out of compliance with sanitary district ordinances by reducing one part of their waste stream but not another.

Inertia, here defined as a lack of willingness to change the way things are done in a plant, was not a serious factor in any of these cases. All the firms perceived waste reduction or minimization as a good option for handling their environmental problems.

The success or failure of any waste minimization project is heavily dependant not only on the merits of the technologies involved, but also on the way in which the technology is chosen and implemented. The decision process can be divided into five segments: (1) problem definition, (2) fact finding, (3) evaluation of alternatives, (4) implementation, and (5) follow-up. Most of the projects examined here, both the successes and failures, had some problems that could have been avoided by rigorously following a decision methodology. All of those that experienced success did so because they took the time to use a rational decision process to evaluate their actions.

IBC went through a very rational development process for their experimental techniques. The $3,500 cost of the new storage system, about 10% of the total project cost, could have been a serious matter in a commercial laboratory. GE Plastics had the most formalized and also the most effective decision process of any of these firms. The approach of involving all areas of the plant and all levels of employees in the decision-making process has added not only to the success of most of these projects, but to general employee morale.

The Chicago plater's project failed in two areas: they did not learn that the chrome recovery system was sensitive to iron contamination, and they failed to follow up and fix the problem once they knew about it. The system could probably still work if they took action to protect it from iron. It is common, however, for small companies to lack the resources to properly develop a new system such as this or to install and operate such a system.

The Cicero plating shop was simply poorly run. They had many problems aside from their inability to implement a waste reduction system and eventually went out of business.

The meat packing company really hasn't failed in its waste reduction efforts yet. They failed to fully define what their problem with wastewater really was, but they were quite effective in their implementation of water reduction methods. If they can follow up and reduce their grease emissions, they will still have a successful waste reduction program.

CONCLUSIONS

In conclusion, companies must look at individual processes within a plant and anticipate the impacts of waste reduction changes on the processes, products, and other sections of the plant. The necessity of looking at the "big picture" becomes more important in larger facilities and in those with more complex processes and waste streams.

Waste reduction projects should be viewed somewhat differently from regular production projects, in terms of computed payback periods. While most waste reduction measures pay for themselves, they do not always do so quickly enough to satisfy many business managers. Many of the financial benefits of waste reduction, specifically reduced environmental liability and liability for the safety of workers, are difficult to quantify in a way that can be inserted into an economic equation. It would be foolish, however, to ignore these factors when making business decisions.

When embarking on a project of this sort, owners and operators must learn to expect unanticipated outcomes. Follow-up is almost always required to implement changes successfully.

Facilities should involve as many of the plant personnel in the process as possible. A system such as that used by GE Plastics succeeded in identifying many more waste reduction opportunities than if they had decided in the front office that waste needed to be reduced. Input is needed from both management and line personnel. In the words of GE Plastics engineer, Bob Miller, "Waste reduction is initiated from the top down, and implemented from the bottom up."

Finally, it is important to know when to get help and where to get it. Many waste reduction publications covering a variety of different industries are now available (Table 1), and many states have initiated waste reduction programs similiar to that of HWRIC. A good waste audit and the development of a sound waste reduction plan can go a long way to ensure that those waste reduction programs implemented will succeed.

PEOPLE MANAGEMENT: THE FORGOTTEN ELEMENT IN WASTE REDUCTION

Gary E. Hunt

North Carolina Pollution Prevention Program
Department of Environment, Health, and Natural Resources
Raleigh, North Carolina 27611-7687

Technology alone cannot reduce waste, only trained and motivated people can. Over the years, the Pollution Prevention Program staff has observed this time and again. We have seen drag-out tanks being dumped to drain, barrel holes plugged and dragging out gallons of solution, racks being rested on the floor to drain, recovery units sitting on shelves, two-inch hoses used to rinse parts; and the list goes on. The technologies on how to reduce waste have been written and rewritten in the literature since the late 1800's. In fact, Clarence Roy said it all when he wrote "never has so little been done by so many who know so much."(1) No matter what the size of the firm or preventive technologies used, a waste reduction program is only effective when everyone from the CEO down to the line operator is enthusiastically involved.

The following sections overview some of the people-oriented methods which have been successfully employed by companies to make waste reduction programs effective. These examples come from a variety of companies, producing a wide range of products. This is because many of the best examples are from industries outside of metal finishing. However, all of the methods discussed are directly applicable to metal finishing firms.

Corporate Commitment

A written corporate policy on waste reduction is the first step a company should make. It must show top management's commitment to waste reduction and establish a framework for developing an effective program within the company. The policy should state the company's commitment to waste reduction, establish guidelines, and lay out the responsibilities for the program. It must be made clear that it is everyone's responsibility to reduce waste. Some policies have set specific goals, while others have let the goals be set by individual plants or by program staff. Either way, the goals must be reachable, and a method of tracking waste reduction should be established in the policy statement. An example of one company's waste reduction policy is shown in Figure 1.

Next, management must show its commitment by providing the resources needed to get the job done. A written statement will mean very little if personnel and funding is not made available. A senior level person should be given the authority and resources needed to develop, implement, and monitor the reduction program. In smaller companies this may be part of an existing job, while in larger firms whole waste reduction departments can be created. Whatever the case, where a waste reduction program has been successful, the person leading it has been a "champion" for the program.

FIGURE 1

EASTMAN CHEMICALS DIVISION WASTE MINIMIZATION POLICY

VISION

ECD is recognized by our employees, the community, the chemical industry, and regulatory agencies as a leader in waste minimization.

OBJECTIVE

To minimize waste through source reduction, sale/reuse/recycle, reclamation and treatment.

WASTE DEFINITION

Any material that must be recovered, treated, disposed of, or is discharged to the environment.

PRINCIPLES

Accountability and responsibility rest with the waste generator.

Performance is directed to meeting or exceeding current and anticipated regulations and public interests.

The current level of waste can always be reduced.

All wastes are minimized; however, special emphasis is given to RCRA hazardous wastes and SARA Section 313 chemicals.

The hierarchy of waste minimization is:
1. Source reduction
2. Sale/reuse/recycle
3. Reclamation
4. Treatment

Land disposal and/or off-site treatment is minimized.

ELEMENTS

Active management leadership and involvement are evident at all levels.

Resources consistent with expectations are available and used to achieve waste minimization goals.

All employees understand and are involved in waste minimization.

Goals and action plans for waste minimization are included in every organization's annual planning process.

Waste Management decision making is expanded to include all present and future costs and benefits.

Successes and creative solutions are recognized and reinforced.

Waste is measured at the point of generation and the point of discharge.

Improvement in one media (land, water, or air) is not made at the expense of another.

A compatible information system among ECD plant sites audits waste production and discharge and documents waste minimization.

A common communication system shares capabilities within ECD and successes internally and externally.

Waste minimization projects should have environmental and/or cost benefits.

SOURCE 10

The waste reduction concept must be integrated into all levels of a firm's operating practices. The company must think waste reduction when making product or operational decisions. For example, something as simple as increasing drain time can have a significant impact on waste generation. On an automatic line this will require reprogramming, which could reduce the production rate. A careful analysis of the process may be able to squeeze out the needed time. If production has to be reduced a bit, then an analysis of the savings in waste generation vs. the cost of lost production or additional equipment should be done. The use of additional equipment or extra manpower could be, in the long run, very cost effective.

A company must show to its employees that waste reduction is important. Poor operational practices such as excessive drag-out, routine dumps of process tanks, continuous leaks and spills, and excessive water use will show to employees that generating waste is "just fine". This will lead to the continuation of excessive waste generation and the related costs. Also one of the problems with end-of-pipe treatment or recovery systems is that it gives the line operator the impression that it is alright to put waste to the drain as a "technology" will take care of it. In-process reduction or recovery will help to eliminate this notion.

Waste Survey

The sources of the wastes and the reason they are generated must be known before any corrective action can be taken. In many cases, plant management has little or no idea where the waste originates. Thus, before a reduction program can be developed a waste survey must be undertaken to locate and quantify all waste sources. The steps in conducting such an assessment have been described in detail in a number of publications.(2,3,4) One thing to keep in mind is that line operators are the best source of information on causes and solutions to waste problems. However, in many cases they are not asked. Engineering and chemical analyses cannot substitute for the knowledge of the person who operates a production step.

One beneficial approach in conducting a waste survey is to videotape the production operation. This may help focus in on a problem area which otherwise would be overshadowed by a complex production operation. For a smaller process area the camera can be set up to tape part of a shift. The tape can be used both to help identify problems and as a training tape for proper operational procedures. One company showed the tape to several different work groups within the plant. One was made up of line operators, one of maintenance personnel, and one of engineering personnel. Each viewed the tape to identify short and long-term waste reduction methods in their respective area of expertise. The tape then served as a source of detailed information which could be stopped or repeated to identify reduction opportunities which otherwise may have been overlooked. It also can be used for training purposes and as documentation of waste reduction.

One firm took a unique approach and set up a permanent waste survey program called "Water Watcher" to conserve water and raw materials. People from Quality Assurance were rotated through this job. A person was assigned the duty of observing the manufacturing process and working with line operators locating any leaks, spills, drips, etc. A person from maintenance was also assigned to this team and responded to Water Watch requests first. This ensured that any problem was rapidly identified and fixed. The quick correction of a problem helps show the company's commitment to waste reduction.(9)

The above discussion leads directly into using employee's to identify reduction options. Quality circles, study groups, natural unit teams, and the like all draw on one common factor--the line workers know their operation best. However, management has to provide them with the training, guidance, and resources to get the job done. Much has been written on this subject in the last few years, and it has been successfully used by a number of companies to reduce waste generation and improve product quality. The key to any of these groups is that the leader has to be trained in how to conduct productive idea generation sessions. Also, management must fully support the activities of the groups as well as seriously review and comment on their recommendations.

Training

In many cases new operators are trained by old operators thus passing on operational procedures. This "Susie teaches Billy" approach has to be replaced with a comprehensive training program on waste reduction. For a program to be effective, all levels of personnel should be included, from the line operator to the corporate executive officer. The goal of any program is to make the employee aware of waste generation, its impact on the company and the environment, and ways it can be reduced. Top level managers have to be made aware of the costs, problems, and liabilities of waste management and the economic benefits of waste reduction. Line managers have to understand the effect of their process line on waste generation, how it can be reduced, how the technologies work, and ways to educate and motivate their employees.

The majority of the training should be directed at the line operators. Some possible program elements are shown in Table 1. The training program should emphasize management's commitment to waste reduction, the beneficial impact of reduction on job security, and improvements to the local environment. Along with some type of presentations (i.e. speakers, videos, slides, etc.), simple written materials which state how waste can be reduced at each job station should be developed. All employees should attend refresher sessions on a regular basis. All new workers should undergo the training; which could be done as part of an established worker right-to-know training program for new employees.

As discussed previously, a company must show its commitment to waste reduction by putting it into practice on the process line. A training program will quickly fail if the employees see that the company is not serious. For example, talking about extended drain time in a manual rack line is of little use if drip bars are not installed.

To show how effective a training program can be, one company reduced their sewer surcharge from $11,000 per month to $35 per month just through a simple training effort. This was done by having one person conduct a series of programs for all shifts over the course of several days. The program presented an overview of what waste is; how it affects the employee, company and environment; and how waste can be reduced at the job station. A more formal program has been developed which includes an introduction video, slide tape show, and written materials for each job station. Each training session starts with a short video which introduces the theme of the session "BOD Buster™". A slide tape show then overviews how reducing waste would be good for the worker, the company, and the town's environment. It also details waste reduction methods which must be used at each process area, thus showing how workers can get their BOD in shape at each process area. A speaker will then re-emphasize the importance of waste reduction and any questions will be answered. Finally, simple yet specific fact sheets will be handed out which detail the steps an operator at each work station must take to reduce waste.(6)

A furniture manufacturer took a rather unique approach. Working closely with the line operator, video equipment was used to record their spray technique. The tape was later reviewed by the operator and training personnel to identify problem areas and provide corrective procedures. The operator was videotaped again later so that the operator could see the improvements. The company estimates that coating use and the associated waste generation costs were reduced by about 10%. This represented a savings of about $60,000 per year in coating costs alone. Savings were also realized through reduced waste from spray booth clean-out and reduced air emissions.(7)

Motivation

Even the best training program may not succeed unless there is some form of incentive or motivation program. This can take the form of slogans and posters, a suggestion program, awards, or contests. All of the methods used to keep safety or quality assurance programs going will work here. The specific program will vary from company to company. However, if an awards program or a contest is set up it must be fair and impartial.

One successful incentive program set up by a North Carolina company is known as the People Against Waste or P.A.W.™ program. This is an employee suggestion program which has a number of components. The success of this program hinges on the prompt, detailed response sent to each employee submitting a waste reduction suggestion. No suggestion is considered too small for a response. This personal response is coupled with a visible award, a P.A.W.™ lollipop, and the employee being recognized in a newsletter. At the end of the month top ideas receive additional recognition and award, such as a percentage of cost saving from waste reduction, gift certificates for steak dinners, or P.A.W.™ caps. This program has been in effect approximately 18 months and has only cost $3,000. Savings resulting from P.A.W.™ suggestions have more than paid for the program.(8)

TABLE 1: Elements in a Waste Reduction Training Program

1. Explain the need for waste reduction and emphasize benefits to employee and community.

2. Explain the direct effect that an employee can have on improved work and living environment.

3. Express management's commitment to waste reduction.

4. Explain waste management terminology in simple terms.

5. Present general overview of environmental regulations which impact the facility.

6. Examine improved operational practices for reducing waste generation. Illustrate good and poor operating practices utilizing slides or video. Use positive language, i.e. a better way of doing things, not "this is what you have to do."

7. Solicit ideas for waste reduction methods and explore possible solutions to identified problems.

Source: 5

Information Exchange

Procedures for disseminating information on successful waste reduction projects within a company should be established. Many times we have seen one plant use an excellent waste reduction technique while its sister plant knows nothing about it. A good information exchange program will keep employees informed about waste reduction efforts and results. Publicizing the waste reduction program, its results, and any outstanding achievements or awards will help maintain the program's momentum and the employee awareness needed for further success.

Companies have used a number of methods to get the word out. Small firms have used a central bulletin board to post program results and upcoming events. Plant or company-wide newsletters or fact sheets are another good publicity tool. These also make excellent handouts to the public or press. Companies such as Dow Chemical and 3M have developed one-page glossy summaries of their successful reduction project. These outline, in simple terms, the need for the project, the method used to reduce waste, and the results in amount of waste reduced and cost savings. In larger companies, the waste reduction program office can coordinate the dissemination of technical information between plants, thus acting as a central clearinghouse.

Another area where the program results should be publicized is the public and press. The public should be made aware of the steps companies have taken to reduce waste generation and the results that have been achieved. This should be done both corporate-wide and at individual facilities. Good public relations about waste reduction, with emphasis on the corporate commitment, is important in the days of the public's "NIMBY" attitude. Distributing newsletters, fact sheets, or press releases about successful projects is one way to inform the public. Other ways include applying for a state's Governor's Award for Excellence in Waste Management; developing a video presentation of a firm's waste reduction program; and presenting talks to local organizations, colleges, or workshops.

Tracking Results

Tracking waste generation is not a "people management method"; however, it provides the basis for measuring progress. This information can then be presented to the employees to show the actual effect they are having on waste reduction. This will provide direct feedback to the employees. The waste can be tracked on a production-based value, such as pounds of waste per pound of product, pounds of waste per amphour or pounds of waste per dollar sales. This will eliminate any production-related variation. The values can be charted and posted for all to see.

The waste generation values can also be used to evaluate the reduction program's effectiveness. Based on this evaluation, modifications can be made in the program to increase its effectiveness. A waste reduction program should be viewed as ever changing and growing.

Summary

Waste reduction is a large area and only some of the highlights have been discussed in an attempt to show that managing people is as important as managing waste. No successful waste reduction program has used technology alone. In fact the best programs rely more on people than technology. A waste management plan must be an integrated effort to use people and techniques to first reduce waste, then treat what is left, and then finally dispose of any treatment residue.

References

1. Roy Clarence, In-Plant Conservation, American Electroplaters' Society, 1980.

2. Ontario Waste Management Corporation, Industrial Waste Audit and Reduction Manual, Ontario Waste Management Corporation, Toronto, Canada, 1987.

3. U.S. Environmental Protection Agency, Manual for Waste Minimization Opportunity Assessment, EPA 600/2-88/025, U.S. Environmental Protection Agency, Cincinnati, Ohio, 1988.

4. California Department of Health Services, Hazardous Waste Reduction Checklist and Assessment Manual for the Metal Finishing Industry, Alternative Technology Division, Department of Health Services, Sacramento, California, 1989.

5. Roy Carawan, James Chambers and Robert Zall, Management Control of Water Use and Wastes in Food Processing, AM-186, Agricultural Extension Service, North Carolina State University, Raleigh, North Carolina, 1979.

6. Pollution Prevention Program, Case Studies and Technical Assistance Raleigh, North Carolina.

7. Jerome Kohl, et al, Managing and Recycling Solvents in the Furniture Industry, North Carolina Board of Science and Technology, Raleigh, North Carolina, 1986.

8. Stephanie Richardson, "Waste Reduction in Food Processing--A People Management Issue", editor, Karl Thome-Kozmiensky, Proceedings of Recycling International, West Berlin, Germany, 1989.

9. Dave Markel, "Perdue's Water Watcher Team", presented at the Workshop on Pollution Source Reduction for Food Processing Plants, Greensboro, North Carolina, 1989.

10. McCoy Davidson, "Waste Minimization at Eastman Chemicals Company" presented at Conference on Waste Minimization Techniques for the Chemical Industry, Mississippi State, Mississippi, 1990.

WASTE MINIMIZATION

SECTION 8:

SOURCES OF WASTE MINIMIZATION INFORMATION AND ASSISTANCE

ADDRESS AND PHONE NUMBERS FOR MANUAL BIBLIOGRAPHY

The following are available from:

Bureau of National Affairs
1231 25th Street NW
Washington, DC 20037
800-372-1033

Chemicals and the Community: New Law, New Responsibilities. Margaret E. Kriz.

Superfund II: A New Mandate. David J. Hayes and Conrad B. MacKerron.

The Clean Water Act of 1987. Mary J. Houghton.

The Environmental Reporter.

The following are available from:

California Department of Health Services
Alternative Technology Section
Toxic Substance Control Division
714/744 P Street
PO Box 942732
Sacramento, CA 94234-7320
916-324-1807

Guide to Solvent Waste Reduction Alternatives.

Hazardous Waste Reduction Checklist - Automotive Repair Shops Book 1.

Hazardous Waste Reduction Checklist - Automotive Repair Shops Book 2.

Ventura County Environmental Health - Hazardous Waste Minimization Program Results and Case Studies.

Ventura County Environmental Health - Hazardous Waste Reduction Guidelines for Environmental Health Programs.

Waste Audit Study: Automotive Paint Shops.

Waste Audit Study: Automotive Repairs.

Waste Audit Study: Commercial Printing Industry.

Waste Audit Study: Paint Manufacturing Industry.

Waste Audit Study: Pesticide Formulating Industry.

Waste Audit Study: Printed Circuit Board Manufacturers.

The following is available from:

Center for Hazardous Materials Research
University of Pittsburgh Applied Research Center
320 William Pitt Way
Pittsburgh, PA 15238
412-826-5320

Hazardous Waste Minimization Manual For Small-Quantity Generators in Pennsylvania.

The following is available from:

Chemical Manufacturers Association
2501 M Street NW
Washington, DC 20037
202-887-1106

A Manager's Guide to Title III.

The following is available from:

Emergency Planning and Community Right-to-Know EPA Hotline
800-535-0202

Title III Fact Sheet: Emergency Planning and Community Right-to-Know.

The following are available from:

Environmental Quality Institute
University of North Carolina Asheville
One University Heights
Asheville, NC 28804-3299
704-251-6104

"Excerpts from a speech by Mary McDaniel - Director of the Southeast Waste Exchange"
Final Report Waste Management Workshop for Vehicle Maintenance Businesses. **Cam Metcalf.**

Hazardous Communication Program for Marion Machine Company. Cam Metcalf.

The following is available from:

Institute for Local Self-Reliance
2425 18th Street, NW
Washington, DC 20009
202-232-4108

Proven Profits From Pollution Prevention: Case Studies in Resource Conservation and Waste Reduction. Donald Huisingh and et. al.

The following is available from:

Minnesota Technical Assistance Program
University of Minnesota
PO Box 197 Mayo
420 Delaware Street SE
Minneapolis, MN 55455
612-625-4949
800-247-0015 (MN only)

MnTAP (Minnesota Technical Assistance Program). Technical Information Packet.

The following is available from:

National Fire Protection Association
Battery March Park
Quincy, MA
617-770-3000

Hazardous Waste: A Fire Department Guide to Small Quantity Generator Rules.

The following are available from:

North Carolina Department of Human Resources
Solid and Hazardous Waste Management Branch
PO Box 2091
Raleigh, NC 27602-2091
919-733-2178

Focus-Waste Minimization. William Paige, ed.

"Upcoming New Land Ban Requirements". *Focus: Waste Minimization*. Bill Pitchford, ed.

The following is available from:

North Carolina Department of Labor
Division of Occupational Safety and Health
214 West Jones Street
Raleigh, NC 27603
919-733-4880

North Carolina Occupational Safety and Health Hazard Communication Standard.

The following are available from:

North Carolina 's Pollution Prevention Pays Program
Department of Natural Resources and Community Development
512 North Salisbury Street
P.O. Box 27687
Raleigh, NC 27611
919-733-7015

Developing and Implementing a Waste Reduction Program.

Selected References on Developing a Waste Reduction Program.

The following are available from:

North Carolina State University
Industrial Extension Service
Raleigh, NC 27695-7902
919-737-2303

Hazardous Waste Management for Small Generators.

Managing Used Oil as a Hazardous Waste 1986.

Managing Used Oil 1987.

The following is available from:

Olgetree, Deakins, Nash, Smoak and Stewart
PO Box 31608
Raleigh, NC 27622
919-787-9700

Understanding the New Emergency Planning and Community Right-to-Know Programs of Superfund (Title III).

The following is available from:

TVA
Waste Management Environmental Services Program
Division of Land and Economic Resources
2A8 Old City Hall
601 West Summit Hill Drive
Knoxville, TN 37902
615-632-6430

"Toxic Air Pollution Control Through the Clean Air Act." Hazardous Materials/Waste Manager. Joseph W. Phillips.

The following are available from:

United States EPA
Asbestos and Small Business Ombudsman
401 M Street, SW (A-149C)
Washington, DC 20460
800-368-5888

Industry Specific Fact Sheets.

Understanding the Small Quantity Generator Hazardous Waste Rules: A Handbook for Small Business. EPA/530-SW-86-019.

Waste Minimization: Environmental Quality with Economic Benefits. EPA/530-SW-87-026.

The following is available from:

United States EPA
Center for Environmental Research Information (CERI)
Publication Office
26 Martin Luther King Drive
Cincinnati, OH 45268
513-569-7562

The EPA Manual for Waste Minimization Opportunity Assessments. EPA /600/2-88-025.

The following are available from:

United States Department of Transportation
Federal Highway Administration
Office of Public Affairs
HOA-1
400 7th Street SW
Washington, DC 20590
202-366-0660

1987 Emergency Response Guidebook. DOT P 5800.4.

A Guide to the Federal Hazardous Materials Transportation Regulatory Program. DOT 1-83-12.

The following are available from:

United States Government Printing Office
Superintendent of Documents
Washington, DC 20402
202-783-3238

"Emergency and Hazardous Chemical Inventory Forms and Community Right-to-Know Reporting Requirements: Clarification of Reporting Dates for Newly Covered Facilities" Federal Register August 4, 1988.

"Hazard Communication: Final Rule." Federal Register: November 25, 1983.

"Hazard Communications: Final Rule." Federal Register: August 24, 1987.

"Land Disposal Restrictions for First Third Scheduled Wastes; Final Rule." Federal Register August 17, 1988.

"National Emission Standards for Hazardous Air Pollutants; Amendments to General Provisions." Federal Register October 8, 1987.

Code of Federal Regulations Title 40 Parts 170-179.

Code of Federal Regulations Title 40 Parts 50-80.

Code of Federal Regulations Title 40 Part 260-281.

Code of Federal Regulations: Title 40 Part 300.

Code of Federal Regulations: Title 29 Part 1910.1200.

Code of Federal Regulations: Title 40 Parts 100-140 and 400-470.

Public Law 94-580 - Title III - Solid Waste Disposal.

Report to Congress: Minimization of Hazardous Wastes: Executive Summary.

The following is available from:

United States OSHA Publications Office
Room N3101
Washington, DC 20210
202-523-8667

Chemical Hazard Communication, OSHA 3084 (Revised).

The following is available from:

Waste Systems Institute of Michigan, Inc.
470 Market SW, Suite 100
Grand Rapids, MI 49503
616-451-8992

Forming a Small Quantity Generator Cooperative: A Model Guidance Document.

The following are available from:

Roy F. Weston, Inc.
Weston Way
West Chester, PA 19380
215-692-3030

The Resource Conservation and Recovery Act.

The Superfund Amendments and Reauthorization Act of 1986.

EXPANDED BIBLIOGRAPHY

The following are available from:

American Institute of Chemical Engineers
1707 L Street N.W.
Washington, DC 20036
202-223-0650

Hazardous Waste Management.

Section 112 : Hazardous Air Pollutants Clean Air Act.

Technological Needs for Improved Management of Hazardous Wastes.

The following are available from:

American Petroleum Institute
1220 L Street Northwest
Washington, DC 20005
202-682-8000

Cleaning Petroleum Storage Tanks.

Interior Lining of Underground Storage Tanks.

Removal and Disposal of Used Underground Petroleum Storage Tanks.

The following are available from:

Bureau of National Affairs
1231 25th Street NW
Washington, DC 20037
800-372-1033

Chemical Regulation Reporter.

Right To Know Planning Guide.

National Audiovisual Center.

<u>*1986 Media Resource Catalog*</u>. Capitol Heights, MD: National Audiovisual Center, 1986.

National Audiovisual Center
8700 Edgeworth Drive
Capitol Heights, MD 20743-3701
301-763-1896
800-638-1300

The following are available from:

National Technical Information Service (NTIS)
5285 Pont Royal Road
Springfield, VA 22161
703-487-4650

<u>*Waste Minimization Audit Report: Case Studies of Minimization of Solvent Wastes and Electroplating Wastes at a DOD Installation*</u>. NTIS PB88-166780.

<u>*Waste Minimization Audit Report: Case Studies of Minimization of Mercury-Bearing Wastes at a Mercury Cell Chloralkali Plant*</u>. NTIS PB88-166798.

<u>*Waste Minimization in the Printed Circuit Board Industry: Case Studies*</u>. NTIS PB88-173372.

The following are available from:

NC Pollution Prevention Pays Program
512 North Salisbury Street
P.O. Box 27687
Raleigh, N.C. 27611
919-733-7015

<u>*Pollution Prevention Bibliography by Industry Category.*</u> Gary Hunt and Roger Schecter. (2500 citations).

<u>*Developing and Implementing a Waste Reduction Program.*</u> NC PPP.

<u>*Selected References on Developing a Waste Reduction Program.*</u> NC PPP.

<u>*A Small Quanity Generator Report.*</u> Judy Lund.

<u>*Hazardous Material Spills in North Carolina: An Analysis of North Carolina's Hazardous Material Spill Records 1980-1985*</u>.

<u>*Health Effects of Toxic Substances and Hazardous Waste*</u>.

Managing and Minimizing Hazardous Waste Metal Sludges. Jerome Kohl and Brooke Triplett.

State and Federal Regulation of Hazardous Materials Transportation: A Review of Current Programs and Recommendations for State Governments.

The Hazardous Waste System. US EPA.

Waste Line.

Who Knows? Selected Information Resources On Land Use.

NC State University.
Industrial Extension Service School of Engineering Catalog of Services. Raleigh, NC: NC State University, 1987.
North Carolina State University
Industrial Extension Service
College of Engineering
Box 7902
Raleigh, NC 27695-7902
919-737-2358

Novick, Sheldon M., Donald Stever, Margaret G. Mellon, ed.
Law of Environmental Protection. New York: Clark Boardman Co. Ltd, 1987.
Clark Boardman Co. Ltd.
435 Hudson Street
New York, NY
(800) 221-9428

Ontario Waste Management Corporation.
Industrial Waste Audit and Reduction Manual. Toronto, Canada: Ontario Waste Management Corporation, 1987.
Ontario Waste Management Corporation
2 Bloor Street West, 11th Floor
Toronto, Ontario M4W 3E2
416-923-2918
800-268-1179

Savitt, Charles C. publisher.
Annual Environmental Sourcebook. Covelo, CA: Island Press, 1988.
Island Press
PO Box 7
Covelo, CA 95428
800-628-2828 Ext. 416

Sinclair, Tom.ed.
Institute for Environmental Studies News. Madison, WI: University of Wisconsin-Madison, 1988.
Institute for Environmental Studies
550 North Park St., 25 Science Hall
Madison, WI 53706
608-263-5599

Spraying Systems Company.
Spray Nozzle Maintenance Handbook. Wheaton, IL: Spraying Systems Co., 1987.
Spraying Systems Company
North Avenue
Wheaton, IL 60188
312-665-5000

Troy State University.
Waste Management Digest. Troy, AL: Center for Environmental Research and Service, 1988.
Troy State University System
Center for Environmental Research and Service
Troy, AL 36082
205-566-4424

United States EPA.
Bibliographic Series : Waste Minimization : Hazardous and Non-Hazardous Solid Waste (1980 to Present). EPA/IMSD-87/007. Washington: US EPA Headquarters Library, 1987.
United States EPA Headquarters Library
401 M Street S.W.
WAshington, DC 20460
202-382-5921

United States EPA.
EPA Journal. Washington: United States Government Printing Office.
Superintendent of Documents
Washington, DC 20402
202-783-3238

United States EPA.
EPA's Information System Inventory. Washington: US EPA Information Resource Management, 1988.
United States EPA
Information Resource Management
401 M Street S.W.
Washington, DC 20460
202-475-9344

United States EPA.
OSWER Training Course Catalog. Washington: US EPA - Office of Solid Waste and Emergency Response, 1988.
United States EPA
OSWER Training Coordinator
Office of Solid Waste and Emergency Response
401 M Street S. W.
Washington, DC 20460
202-382-4515

United States Office of Technology Assessment (OTA).
Serious Reduction of Hazardous Waste. OTA-ITE-317, and *Serious Reduction of Hazardous Waste: Summary*. OTA-ITE-318. Washington: OTA, 1986.
Office of Technology Assessment
Congressional and Public Affairs Office
U.S. Congress
Washington, DC 20510-8025
202-224-9241

Worobec, Mary Devine.
Toxic Substances Controls Primer: Federal Regulations of Chemicals in the Environment. Washington: Bureau of National Affairs, 1984.
Bureau of National Affairs
1231 25th Street NW
Washington, DC 20037
800-372-1033

The following are available from:

United States EPA
Public Information Center (PIC)
401 M Street, S. W.
Washington, DC 20460
202-382-2080

Assessment of Incineration as a Treatment Method for Liquid Organic Hazardous Wastes: Summary and Conclusions.

Environmental Progress and Challenges: EPA's Update. EPA-230-07-88-033.

Municipalities, Small Business, and Agriculture: The Challenge of Meeting Environmental Responsibilities. EPA 230-09/88-037.

Solving the Hazardous Waste Problem: EPA's RCRA Program. EPA/530-SW-86-037.

Trends in the Quality of the Nation's Air. EPA-87-019.

The following are available from:

United States EPA
RCRA Information Center
Office of Solid Waste (WH-562)
401 M Street, S. W.
Washington, DC 20460
202-475-9327

Land Disposal Restrictions Summary: Volume II, California List Wastes.
Land Disposal Restrictions Summary: Volume I, Solvents and Dioxins. EPA/530-SW-87-019A.

OSW Documents in Demand: A Catalog of Hazardous and Solid Waste Publication. EPA/530-SW-87-0166.

Questions and Answers on Land Disposal Restrictions for Solvents and Dioxins. EPA/530-SW-87-020.

The New RCRA: A Fact Book.

Waste Minimization Benefits Manual: Phase I: Draft. (Contact Ronald McHugh for more information. 202-382-2689).

The following are available from:

United States EPA Small Business Ombudsman
401 M Street S.W. (A-149C)
Washington, DC 20460
800-368-5888

Abstracts of Phase I and Phase II Awards : Small Business Innovation Research Program 1987.

Abstracts of Phase I and Phase II Awards : Small Business Innovation Research Program 1983-1985. EPA/600/9-86/005.

Explaining Environmental Risk.

The following are available from:

United States EPA
Underground Storage Tank Docket
Office of Solid Waste
401 M Street S.W.
Washington, DC 20460
202-475-9720

Financial Responsibility for Petroleum Underground Storage Tanks.

Regulations for Underground Storage Tanks: Your Financial Responsibilities-Draft.

Underground Tank Installation Checklist. UST2-1-SB-330. Marcel Moreau.