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November 20, 1991

LODGE MANUFACTURING COMPANY
HAZARDOUS WASTE REDUCTION PLAN

Management Commitment

The management of Lodge Manufacturing Company is committed to the reduction of hazardous waste and firmly supports the goals set by the Tennessee General Assembly in the Tennessee Hazardous Waste Reduction Act of 1990. That policy reads as follows: "Wherever feasible, the generation of hazardous waste is reduced or eliminated as expeditiously as possible. Waste that is generated should, in order of priority, be reduced at its source, recovered and reused, recycled, treated, or disposed of so as to minimize the present and future threat to human health and the environment."

At Lodge Manufacturing Company we are interested in the welfare of the local community and we feel that we are morally and ethically bound to help protect our environment. The reduction or elimination of hazardous waste is one way of environmental preservation. We also believe that the reduction or elimination of hazardous waste will reduce our expenses especially in hazardous waste handling, disposal, and potential liability risks.

With this belief and commitment, Lodge Manufacturing will set its goals at MORE than 25% reduction of hazardous waste by June 30, 1995, which is the State of Tennessee goal.

Bob Kellermann, President

Henry Lodge, Executive Vice President

Bill Kellermann, Vice President

CASE STUDY
LODGE MANUFACTURING COMPANY
HAZARDOUS WASTE POLLUTION PREVENTION PLAN

OBJECTIVE AND SCOPE

The objective of Lodge Manufacturing Company is to exceed the 25 percent reduction of hazardous waste by June 30, 1995 by reducing the total volume and/or toxicity of hazardous waste produced at the facility. Although the scope of this plan includes all hazardous waste streams which number three, the primary objective will be the reduction of the Cupola Flue Gas Emission Control Waste (waste stream #1). This waste stream accounted for over 95 percent of the total kilograms of hazardous waste produced at our facility in 1989. Waste streams #2 and #3 are Safety-Kleen products that are recycled.

As a company, we at Lodge Manufacturing want to make sure that our employees are committed to reducing hazardous waste. Our committees will be comprised of those most directly involved and responsible for making reduction goals possible. These selected individuals will be involved in decision-making planning and implementation processes.

POLLUTION PREVENTION ASSESSMENTS

WASTE STREAM #1: Cupola Flue Gas Emission Control Waste. EPA Waste Code D006. TSDF Handling/Waste Management Methods: T21 (Chemical Fixation), S01 (Container), D80 (Landfill)

Point of Origin: Cupola Stack

Subsequent Handling/Treatment/Disposal: The dust is collected in 55-gallon drums for no more than 90 days, mixed with cement to render it non-hazardous, tested, and then released for disposal in an approved landfill.

Physical and Chemical Characteristics: A gray dust containing lead and cadmium as the hazardous chemicals.

Quantity: 1989: 46,468 kilograms for the year generated
1990: 78,060 kilograms for the year generated

Rate of Generation Based on Tons of Metal Melted: 1989: 6.87 kg/ton
1990: 10.09 kg/ton

Variations in Generation Rate: Varies with production rate and air rates used to control firing.

Potential for Contamination or Upset: Low as dust is collected and stored until mixing in 55-gallon drums.

Cost to Manage or Dispose: $16,847 per year. All permits for this item at this time are excluded from fees.

Toxic Materials: Lead, Cadmium

Waste Stream Accounting: Waste stream #1, Cupola flue gas emissions control waste is considered hazardous due to lead and cadmium levels. Hazardous waste disposal costs including treatment to render non-hazardous and costs of hauling to an approved landfill is based on an averaged cost per ton using labor, machine usage, material for mix, and transportation cost.

Environmental Liability and Oversight Costs Estimate: Unknown potential of possible RCRA or Superfund cleanup costs that could be imposed. Oversight costs in fines could range from $5,000 to $50,000 per day violation.

1989 and 1990 disposal costs: $16,847 per year which is an average of hauling and landfill costs for the non-hazardous mixture and includes estimated labor and materials costs for the mix.

WASTE STREAM #2: Safety-Kleen 105 Parts Washing Solvent. EPA Waste Code D001. DOT Description 1255. DOT Hazard Class Flammable Liquid. TSDF Handling/Waste Management Method. T63 (Solvents Recovery), S01 (Container).

Point of Origin: Maintenance

Subsequent Handling/Treatment/Disposal: Safety-Kleen services by replacement every six weeks. The product is recycled by Safety-Kleen into a light weight oil which is then marketed.

Physical and Chemical Characteristics: Petroleum Napha, Flammable Liquid, Hydrocarbon Solvent, Ignitable.

Quantity: 1989 total processed by Safety-Kleen was 1,003 pounds.
1990 total processed by Safety-Kleen was 1,351 pounds.

Rate of Generation Based on Tons of Metal Melted: 1989: 0.0674 kg/ton
1990: 0.0794 kg/ton

Variations in Generation Rate: None as the units are changed out on a 6-week schedule by the Safety-Kleen Company.

Potential for Contamination or Upset: Low as self-contained. Oil that is washed off parts is all that would be gained.

Cost to Manage or Dispose: 1989: $1,121.64
1990: $1,468.87

Toxic Materials: C9-C13 Saturated Hydrocarbon, Toluene, Xylene, Ethyl Benzene, C8+Aromatics, Chlorinated Solvents, 1,1,1 Trichloroethane, Tetrachloroethylene.

WASTE STREAM #3: Safety-Kleen Immersion Cleaner and Cold Parts Cleaner 699. EPA Waste Code F002. DOT Description 1760. DOT Hazard Class ORM-E.

Point of Origin: Maintenance

Subsequent Handling/Treatment/Disposal: Safety-Kleen services by replacement every 12 weeks. The product is recycled by Safety-Kleen into a light weight oil which is then marketed.

Physical and Chemical Characteristics: Organic Solvent Waste Compound, Cleaning Liquid, Corrosive.

Quantity: 1989 total processed by Safety-Kleen was 180 pounds.
1990 total processed by Safety-Kleen was 180 pounds.

Rate of Generation Based on Tons of Metal Melted: 1989: 0.0121 kg/ton
1990: 0.0105 kg/ton

Variations in Generation Rate: None as the units are changed out on a 12-week schedule by the Safety-Kleen Company.

Potential for Contamination or Upset: Low as self-contained. Oil that is washed off parts is all that would be gained.

Cost to Manage or Dispose: 1989: $418.06
1990: $468.17

Toxic Materials: Aromatic 150, N-Methyl - 2 Pyrrolidone, Diproprylene Glycol, Methyl Ether, Monoethanolamine, Oleic Acid.

CASE STUDY

- Lodge Manufacturing Company
  - South Pittsburg, Tennessee
  - SIC: 33
  - Employees: 212
  - Product: Cast iron skillets
- Waste Stream 1: Cupola flue gas, EPA waste code D006
  - Management method: onsite chemical fixation, landfill
  - Point of origin: cupola stack
  - Characteristics: gray dust containing lead and cadmium
  - Quantity generated: 78,060 kilograms per year
  - Management costs: $16,847 per year
  - Toxic material: lead, cadmium

CASE STUDY--CONTINUED

- Waste Stream 2: Safety-Kleen 105 parts washing solvent, EPA waste code D001
  - Management method: solvents recovery
  - Point of origin: maintenance
  - Characteristics: petroleum napha, flammable liquid, hydrocarbon solvent
  - Quantity generated: 1,351 pounds in 1990
  - Management costs: $1,469
  - Toxic material: C9-C13 Saturated Hydrocarbon, Toluene, Xylene, Ethyl Benzene, C8+aromatics, Chlorinated Solvents, 1,1,1 Trichloroethane, Tetrachloroethylene

CASE STUDY--CONTINUED

- Waste Stream 3: Safety-Kleen immersion cleaner and cold parts cleaner, EPA waste code F002
  - Management method: solvents recovery
  - Point of origin: maintenance
  - Characteristics: organic solvent waste compound, cleaning liquid, corrosive
  - Quantity generated: 180 pounds in 1990
  - Management costs: $468
  - Toxic material: Aromatic 150, N-Methyl - 2 Pyrrolidone, Dipropylene Glycol, Methyl Ether, Monoethanolamine, Oleic Acid

DEVELOPMENT OF INSPECTOR ASSESSMENT PLANNING

- Information needed for pre-assessment
- Information needed at onsite inspection
- Information needed at post-assessment

INCORPORATING POLLUTION PREVENTION IN ENFORCEMENT SETTLEMENTS: FEASIBILITY OF POLLUTION PREVENTION ALTERNATIVES

Successful pollution prevention programs rely on innovation. Just as facilities producing a common product utilize different technologies and have variations in operating procedures, successful pollution prevention strategies may vary somewhat between facilities utilizing common technology and, in general, will be as diverse as production/manufacturing operations are diverse. There are, however, some useful ways of categorizing pollution prevention activities so that the feasibility issues may be collectively considered.

This training course focuses on pollution prevention projects being incorporated into enforcement settlements. Beyond this, however, commonly cited driving forces for pollution prevention may be characterized as ordinary economics, compliance liability, reduction, and improved community and public relations. Ordinary economic incentives include reduced operating costs, such as those for raw materials and for waste management services; other ordinary economic incentives include additional income from recovered by-products, etc. Compliance incentives include achieving current as well as future regulatory requirements. Liability reduction is achieved through reduced handling and processing of current waste streams; the avoidance of long-term liability occurs with reduced reliance on treatment and disposal alternatives. The value of good community and public relations is difficult to quantify but has a real value; an example of this occurs in the siting of new facilities where public input to the permit process is necessary.

Successful pollution prevention demands attention to eight aspects of manufacturing.[1] These aspects are:

Product design
Process design
Plant complexity
Information and control systems
Human resources
Research and development
Customer-supplier cooperation
Organization

Although environmentally sound product design is usually associated with consumer products, the principals apply to manufacturing/production processes. Environmentally sound product design focuses on preventing products from entering the environment, easing removal of the product from the environment, and design for reuse or reprocessing.

The gaseous, liquid, and solid waste streams generated by a manufacturing/production facility are dictated by process design and operation. Waste streams may be characterized as "intrinsic" or "extrinsic." Intrinsic wastes are inherent to the fundamental process configuration, while extrinsic wastes are associated with the auxiliary aspects of the process. There may at times be some wastes that are somewhat in between. The primary categories listed from most intrinsic to most extrinsic are:[1]

Unreacted raw materials
Impurities in the reactants
Undesirable by-products
Spent auxiliary materials: catalyst, oils, solvents, etc.
Off-specification materials
Maintenance waste and materials
Material generated during startup and shutdown
Materials from process upsets and spills
Materials from product and waste handling sampling, storage, or treatment
Fugitive emissions

The intrinsic waste streams from production/manufacturing facilities utilizing similar process configuration will be similar; the extrinsic waste streams from their operation may differ greatly, depending on local operating procedures.

Typical progression in the incorporation of pollution prevention into an industry's waste management strategy usually begins with a pollution prevention audit and employee training followed by progression through three phases of pollution prevention activities. Phase I activities are operations-oriented usually focusing on extrinsic wastes; these common sense activities include good housekeeping, inventory control, waste separation, and simple recycling. Phase I activities often involve very little capital investment and tend to produce high return on investment (ROI). Phase II activities are equipment-oriented activities usually focusing on extrinsic wastes; these activities involve the addition of new equipment and/or the modification of existing equipment. The ROI for Phase II activities is typically less than that of Phase I activities and may involve including less tangible economic

incentives such as long-term liability, public relations, etc., to improve the economic justification for the activity. Phase III activities are process-oriented, usually focusing on reduction of intrinsic wastes through fundamental process changes, changes in raw materials or catalysts, or reformulation of the product. The ROI for Phase III project is typically lower than that of Phase I or Phase II activities; introduction of Phase III activities are more likely to occur when a process unit is being replaced or a new unit installed.

A great deal of attention has been placed on the design and operation of production/manufacturing facilities. Thoughts on the remaining items on the original list of eight items are

- The size and complexity of production facilities typically increase as more of the by-products are processed into products

- Effective information and control systems aid in pollution prevention by effectively tracing routinely generated wastes, monitoring and controlling the process so that wastes from process upsets are minimized, process optimization, and optimal scheduling of maintenance activities.

- Effective pollution prevention requires involvement at all levels. Employees must be dedicated, rewarded, and trained.

- Research and development contributes to pollution prevention through identifying new processes or modifying existing processes to produce less waste, identification of new separation technology, and identifying sources contributing to waste production or impeding effective recycle operations.

- Close cooperation between the customer and suppliers of equipment and raw materials offers opportunities to further pollution prevention.

- A successful pollution prevention program requires support and commitment from all levels within the firm and must involve top management.

Pollution prevention is a new component of process design and operation. The feasibility issues are closely related to the category of the activity (i.e., Phase I, II or III) and the general acceptance of this approach. For pollution prevention to have a maximum impact, it must be accepted by management, engineers, and operators.

REFERENCES

1. Berglund, R.L., and C.T. Lawson. (September 1991). "Preventing Pollution in the CPI." *Chemical Engineering*.

FEASIBILITY ANALYSIS

- Pollution prevention strongly relies on innovation

- Technical and economic analyses are closely related to category of activity (Phase I, II, or III)

- Financial considerations vary from ordinary to difficult to quantify

- Technical considerations vary from ordinary to issues such as cross-media pollution

DRIVING FORCES FOR POLLUTION PREVENTION

- Ordinary economics
  - reduced costs
  - income
- Compliance
  - current requirements
  - future requirements
- Liability reduction
  - short-term
  - long-term
- Community and public relations

IMPORTANT ANALYTICAL ASPECTS

- Successful pollution prevention demands attention to eight aspects of manufacturing/production
  - Product design
  - Process design
  - Plant complexity
  - Information and control systems
  - Human resources
  - Research and development
  - Customer-supplier cooperation
  - Organization

ENVIRONMENTALLY SOUND PRODUCT DESIGN

- Usually associated with consumer products but principles apply to manufacturing/production facilities

- Focuses on:

  - Preventing products from entering environment

  - Easing removal of product from environment

  - Design for reuse or reprocessing

CLASSIFICATION OF WASTE STREAMS

- Intrinsic wastes are inherent to the fundamental process configuration

- Extrinsic wastes are associated with auxiliary aspects of the process

PROCESS DESIGN

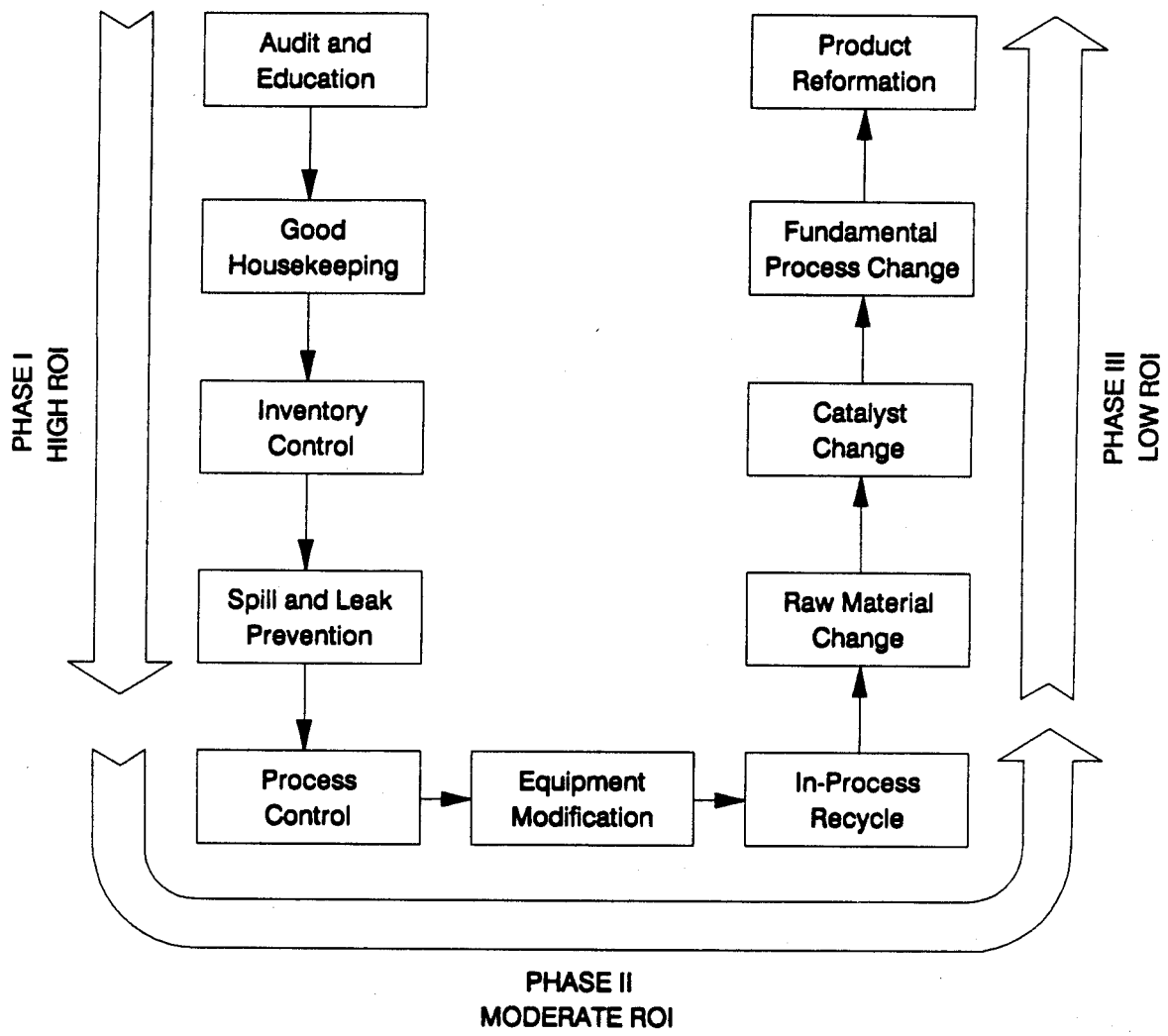
- Typical production/manufacturing facilities generate a number of solid, liquid, gaseous waste streams.

- The primary categories are:

  - Unreacted raw materials
  - Impurities in the reactants
  - Undesirable by-products
  - Spent auxiliary materials (e.g., catalyst, oils, solvent, etc.)
  - Off-specification materials
  - Maintenance waste and materials
  - Material generated during startup and shutdown
  - Materials from process upsets and spills
  - Material from product and waste handling sampling, storage or treatment
  - Fugitive emissions

TYPICAL INDUSTRY POLLUTION PREVENTION PROGRESS

- Phase I Activities
  - Operation-oriented activities
- Phase II Activities
  - Equipment-oriented activities
- Phase III Activities
  - Process-oriented changes



PHASES OF SUSTAINED POLLUTION PREVENTION ACTIVITIES WITH EXAMPLES

PLANT CONFIGURATION

- Complete utilization of all by-products leads to large and complex facilities

- Plant design for ease of maintenance can reduce fugitive emissions ($\sim$ 25% of total releases)

INFORMATION AND CONTROL

- Optimize yield and minimize undesirable by-product formation

- Monitors process conditions to minimize upsets

HUMAN RESOURCES

- An effective long-term pollution prevention program requires employers to:
  - Designate responsibility for an on-going program
  - Rank pollution prevention issues and continue to re-evaluate technical/economic feasibility as disposal costs and regulations change
  - Be able to periodically assess pollution prevention opportunities
  - Provide incentives for ideas and improvements that reduce pollution

-- RESEARCH AND DEVELOPMENT

- Effective R&D is the key to an ongoing pollution prevention program

- R&D must:

  - Find new process and process modifications that reduce waste generation

  - Seek new separation technology to purify and separate waste streams

  - Improve analytical techniques to detect unwanted materials and to pinpoint the source

  - Support existing operations in incremental improvements in pollution control

SUPPLIER AND CUSTOMER COOPERATION

- Pollution prevention may be promoted by cooperation between supplier and customer

  - Reduction of fugitive emissions by improved material handling components

  - Removal of troublesome components from raw material feeds employment of "just-in-time" philosophy

ORGANIZATION

- Pollution prevention must receive support and commitment from all levels within firm

- Accurate and appropriate measurement of waste reduction savings by accounting department is needed so benefits are visible

KEY FINANCIAL CONSIDERATIONS
TYPICAL ESTIMATES OF FIXED CAPITAL INVESTMENT

- 4-5 times cost of purchased equipment
- Typical direct operating costs
  - Process materials
  - Operating labor
  - Power and utilities
  - Maintenance and repair
  - Operating supplies
  - Laboratory expenses
  - Catalysts/solvents

TECHNICAL CONSIDERATIONS

- Technical evaluation details varies with category of activity (i.e., Phase I, II, or III)

- Typical technical considerations include:
  - Process safety
  - Product quality questions
  - Perturbations in operating procedures, work flow, and production rates
  - Additional labor requirements
  - Availability of utilities
  - Production outage
  - Special expertise required for operation or maintenance
  - Cross-media pollution problems
  - Availability of reliable vendors
  - Necessary research and development

CONCLUSIONS

- Pollution prevention is a new component of plant design and operation.

- The feasibility issues are closely related to the phase of the activity (i.e., Phase I, II, or III) and to the general acceptance of this approach.

- For maximum impact, pollution prevention must be accepted by management, engineers, and operators.

IMPLEMENTATION AND EVALUATION OF POLLUTION PREVENTION IN ENFORCEMENT SETTLEMENT PROJECTS

For pollution prevention measures that have been shown to be both technically and economically feasible, it is necessary to make decisions on which measures to implement. For this purpose, it is desirable to rank the proposed measures in accordance with a set of selection criteria. Criteria used may vary with company priorities and may include magnitude of waste management cost reduction, staff and capital availability, measure complexity and degree of interruption of manufacturing operations, and level of favor with management.

Initially, it is usually advantageous to first implement simple measures since these can achieve meaningful results with relatively little effort and can be used to stimulate employee interest in pollution prevention.

For more substantial measures to be implemented, it is desirable to assign management responsibility, establish funding authorization, and allocate space as required before proceeding. Next, it is necessary to design system changes, select implementation personnel, and schedule and complete system or process modifications. Lastly, following implementation, the system or process will need to be operated for performance optimization.

In order to truly achieve pollution prevention, it is necessary that an implemented measure actually produce an at-the-source reduction in the quantity of a pollutant produced in a manufacturing operation. For this reason, it is essential that measurable results be obtained. Although simple in concept, the reliable measurement of the reduction in a waste stream at a particular point in a process can be a formidable undertaking since in most plants few mass flows are measured accurately on a regular basis. Therefore, it is commonly required to add instrumentation and improve data collection methods in order to demonstrate results convincingly. In particular, it may be necessary to develop one or more appropriate methods to account for waste stream variations with production rates so that pollution prevention measure success is not associated with decreasing production during any reporting period.

For the incorporation of pollution prevention in EPA enforcement settlements, timely and effective implementation and follow-up evaluation must be assured. Although violator agreement requirements may change

during a period of program evolution, some guidelines may be suggested. Certainly, an acceptable implementation plan should address all of the essential components listed above (in paragraph 3) without exception. Also, it is essential for the proposer to clearly describe how and in what time frame reductions in a waste stream will be measured and documented. The time frame for waste stream measurement associated with a compliance agreement should be sufficiently long to meaningfully average time variations in production rates. But it should not be administratively burdensome to EPA. In particular, it may be quite sufficient in a typical case to require waste stream quantification for six months after which the violator could be required to submit a certified report of documented pollution prevention success before a case is closed. Of course, in certain simple cases, such as when the plan calls for the complete elimination of a waste stream, it may be sufficient for the plant to certify that the measure has been implemented and tested to the extent necessary to assure that the modified process results in no hesitation to continue operation with the change in place.

CATEGORIZATION OF MEASURES FOR IMPLEMENTATION

- "Simple" measures
  - Easy to justify economically
    - low implementation cost
    - large annual savings
      - payback under one year
  - Minimal changes to or disruption in production
  - Low labor intensity: implementation and on-going operations
  - Low risk of measure not meeting predictions

CATEGORIZATION--CONTINUED

- "Not simple" measures
  - Difficult economic justification on basis of cash flows
    - high level of savings uncertainty
    - payback likely exceeding two years
  - Capital cost requires use of external financing
  - Significant changes to or disruption in production required
  - High labor intensity: implementation and/or ongoing operations
  - High risk of measure not achieving desired results
    - developmental/trial studies may be needed for unique applications

POLLUTION PREVENTION PROJECT -- IMPLEMENTATION STEPS

- Differentiate between simple and more substantial measures
- Implement simple measures immediately
- For more substantial measures, assign management responsibility
- Establish project funding authorization
- Allocate space as required
- Design system changes
- Select implementation personnel
- Schedule and perform implementation work
- Operate system for testing and performance optimization
- Assign personnel responsibility for day-to-day operations
- Collect and evaluate measurement performance data

DESIGN OF SYSTEM CHANGES FOR POLLUTION PREVENTION

- Design requirements
  - No characteristics leading to violation of environmental laws or regulations
  - Minimize disruptions to production and degradation of product quality
  - Minimize waste generation during construction and during system "shake-down"
  - Documentation of system design operational procedures including trouble-shooting
  - Measurable results
  - No cross-media transfer

DESIGN--CONTINUED

- Selection of design team
  - In-House: convenient, relatively inexpensive
  - Outside engineering consultants
    - objectivity perspective
    - broad experience in pollution prevention
    - competitive bidding to lower costs
    - firm deadline for project completion
    - guaranteed performance results
    - provide in-house training, on-going technical advice

EVALUATION OF POLLUTION PREVENTION MEASURES

- Requirements for effective evaluation
  - Actual physical measurement of relevant mass flows
  - Analysis methods to account for time variation in production and related mass flows
- Identification of quantities requiring measurement
  - Develop an adequately detailed process flow diagram for complete mass flow accounting
  - For each sub-process generating waste, list all raw materials, product, and waste streams
  - Identify individual feed streams for presently combined waste

EVALUATION--CONTINUED

- Regularly measure identified waste-related mass flows
  - Calibrate and utilize existing flow metering systems
  - Install new measurement systems as needed
    - solids: scales
    - liquids: anemometers, rotameters, electromagnetic, ultrasonic
    - gases: positive displacement devices, anemometers, rotameters
  - Train personnel in measurement and data recording techniques

- Data interpretation and analysis
  - Develop waste indices normalized to production rate changes
  - Spreadsheet, other computer-based accounting

PREDICTING WASTE REDUCTION MEASURE EFFECTIVENESS

- Possible results
  - Total elimination of a waste stream (e.g., process change)
  - Eliminate one or more waste streams but introduce new waste streams
  - Partial reduction in a waste stream
- Hierarchy of bases for predictions
  - Pilot studies in plant
  - Implementation data from other plants (case studies)
  - Research laboratory results
  - Analytical (modeling) studies
  - Estimates based on analysts experience

PREDICTING--CONTINUED

- Factors affecting pollution prevention measure efficiency
  - Maximum reduction possible
  - Variation in operating conditions
    - production rates
    - product mix
    - system operator competence
    - quality of equipment maintenance

EXAMPLE OF LITERATURE DATA USEFUL IN THE QUANTIFICATION OF POLLUTION PREVENTION PROPOSALS

Expected Transfer Efficiency of Various Painting Methods

Painting Method	Transfer Efficiency
Air-atomized, conventional	30 to 60%
Powder coating	90 to 99%
Air-atomized, electrostatic	65 to 85%
Pressure-atomized, conventional	65 to 70%
Centrifugally-atomized, electrostatic	85 to 95%

Source: "Calculations of Painting Wasteloads Associated with Metal Finishing," EPA, June 1980

CASE STUDY
LODGE MANUFACTURING COMPANY
FEASIBILITY ANALYSIS

WASTE STREAM #1: Cupola flue gas emission control waste

Option #1: Reduction plan to eliminate the use of scrap in the process and utilize 100 percent pig iron to reduce or eliminate lead and cadmium in the resultant dust. This option would increase the raw material costs of the product by over 50 percent and therefore would not be economically feasible for the expected results theoretically obtained in reduction. For this reason this option was not selected.

Option #2: Improved technology of induction melting systems will allow the replacement of the Cupola system with an increased reduction of hazardous chemicals over any other system known. The induction melting system is the best available technology on the market for the processing required. This option has been selected as the best available technology for maximum hazardous waste reduction as existing foundries using these systems have in most cases eliminated the need for a baghouse. The effect will be positive for the environment and should also be considered positive in public safety and health. No negative effects of this system are known.

WASTE STREAM #2: Safety-Kleen 105 parts washing solvent

Option #1: To reduce the amount of hazardous waste generated by increasing the change schedule provided an extension of time would not diminsh cleaning effectiveness. This would reduce the amount of waste generated by one shipment per year or 240 pounds. This would result in a 24-percent reduction of 1989 generation.

Option #2: To substitute with a non-hazardous cleaner such as an alkaline, aqueous cleaner, or a citrus-based terpene cleaner that would not affect sewer discharge permits and at the same time be economical.

CASE STUDY--CONTINUED

WASTE STREAM #3: Safety-Kleen immersion cleaner and cold parts cleaner

Option #1: To replace with Safety-Kleen 105 and thereby eliminate the waste stream.

Option #2: To replace with a less or non-toxic cleaner that would not affect sewer discharge permits and at the same time be economical.

CASE STUDY
LODGE MANUFACTURING COMPANY-
FEASIBILITY ANALYSIS

Waste stream #1: Cupola flue gas emission control waste

- Feasibility option #1
  - Process and use 100% pig iron to reduce or eliminate lead and cadmium in dust
    - would increase raw material cost by 50%
    - not economically feasible
- Feasibility option #2
  - Improved technology: induction melting system
    - proven technology used by similar industries
    - improved public health and safety

CASE STUDY--CONTINUED

Waste stream #2: Safety-Kleen 105 parts washing solvent

- Feasibility option #1
  - Increase change schedule
    - if cleaning effectiveness is undiminished, 24% reduction could be achieved
- Feasibility option #2
  - Substitute non-hazardous cleaner (e.g., alkaline, aqueous cleaner, or citrus-based terpene cleaner)

Waste stream #3: Safety-Kleen immersion cleaner and cold parts cleaner

- Feasibility Option #1
  - Replace with non-hazardous cleaner and eliminate waste stream
  - Replace with less toxic cleaner

TECHNOLOGY SELECTION: REDUCTION OF ORGANIC CHEMICAL EMISSION FROM A COMMERCIAL PESTICIDE MANUFACTURING FACILITY

Industrial pollution prevention has been incorporated into several aspects of the chemical engineering curriculum at The University of Tennessee. One is an industrial internship program. This technology selection example focuses on a case from a pilot internship project sponsored by a pesticide manufacturer. This project involved synthesis and evaluation of waste management strategies for reduction and potential recycle of gaseous emissions from a pesticide formulation facility. These waste management strategies included pollution prevention options as well as waste treatment and disposal options.

As a quick refresher, pollution prevention is one of several waste management options. A comprehensive list of these options include:

A. Source reduction: reducing the amount of wastes as the source through changes in the processes that generate them.

B. Recycling: reusing and recycling wastes as substitutes for feedstocks or ingredients for industrial processes.

C. Treatment: destroying, detoxifying or neutralizing wastes.

D. Disposal: discharging wastes into ambient water or air or injecting or disposing wastes into or onto the land.

Item A of this list is generally regarded as pollution prevention. The development of waste management strategies utilizing pollution prevention options generally requires a higher level of innovation than strategies based on treatment or disposal. There are usually a large number of design constraints when employing pollution prevention options for waste management, and an intimate knowledge of the waste generating process is normally required.

In general, evaluation and ranking of waste management alternatives is strongly influenced but not completely dominated by capital cost requirements and annual operating costs. Many less tangible considerations, such as public trust and goodwill, future changes in environmental rules and regulations, and

liability for waste treatment and disposal, are difficult to quantify but are of extremely high importance in decisions regarding selection of waste management options.

The case study presented here is from a pilot internship project sponsored by the pesticide manufacturer: This project involved formulation and evaluation of waste management strategies for reduction of gaseous emissions from a pesticide production facility. This is part of the company's internal pollution prevention program. These waste management strategies included pollution prevention options as well as waste treatment and disposal options. Potential alternatives were screened based on technical feasibility with final ratings and recommendations based substantially on the estimated annual operation costs (depreciation was treated as a fixed cost) and the hierarchy of waste management options presented previously.

CASE STUDY BACKGROUND

The pesticide manufacturing process involves the addition of active ingredient (AI) and chemical binding agent (CBA) onto clay. Raw clay is shipped via rail car to the site. The clay is unloaded into silos for storage.

The clay is first heated and screened to remove oversize particles. The heated clay is stored in a weigh hopper and is fed into a batch, rotary drum blender. In the blender, the liquid chemicals are fed into the blender, and the entire batch is thoroughly mixed. The completed batch is dumped into another hopper and is held as feed to the elevator. The product is then transferred to the storage bins where it is analyzed. Out-of-specification material is sent back for rework while the acceptable product is forwarded to the prime hopper. The product is screened as it leaves the prime hopper to remove oversize particles before final packaging.

Throughout the entire clay handling, blending, and product handling steps, dust and fines are generated. To minimize the industrial hygiene concerns for the workers, the dust must be contained. This is done by pulling a slight vacuum on all of the pieces of equipment using an air blower. A separate air system exists for the far clay handling to avoid contamination with the process chemicals. Enough air velocity is maintained to entrain the dust particles. In addition, there has been a recent project to increase the air flow on all of the equipment to aid in the removal of fines (particles larger than dust but still much smaller than the desired product).

The air from the blower on the main process is contaminated with low levels of the process chemicals. Some of these contaminants are odorous impurities contained in the "as received" AI. A charcoal bed exists to remove these odor-causing impurities. Before the charcoal bed (in the suction side of the blower), there are two filtering steps to remove entrained dust. A final polishing filter removes any extremely small dust particles that manage to pass through the charcoal bed.

The charcoal bed and the raw clay blower were recent modifications to the process. As part of routine testing to determine the performance of this equipment, air samples were taken for evaluation and found to contain significant levels of the CBA in the air. There was quite a variation in the initial analytical results (50-500 ppm), but all were much higher than expected.

In addition, the charcoal bed intended to remove process odors is loading with the CBA. This charcoal bed is not an acceptable option to remove the CBA since it is only partially effective.

Working material and energy balances were developed using process data obtained through a site visit and several communications. One of the reasons for performing a balance was to determine each process unit's contribution to the overall CBA emission.

The energy and mass balances indicated that during normal operation of the plant, the CBA concentration was higher than the target value of about 8 ppm. The balances also indicated that CBA is present in substantial concentrations in the gaseous effluent throughout the process.

A wide variety of separation techniques were considered as possible waste management options. These preliminary selections were made solely on the basis of each option's ability to perform the desired separation or destruction. The initial list of methods included absorption, adsorption, biodegradation, catalytic incineration, low temperature condensation, membrane separation, and thermal incineration. Based on preliminary screening, the following options were selected for further evaluation:

A. Absorption (continuous and stagewise)
B. Adsorption (clay and carbon adsorbents)
C. Biodegradation (soil bed/biofilter process)
D. Low Temperature Condensation
E. Thermal Incineration (with and without heat recovery)

Of these options, only adsorption onto the clay substrate and low temperature condensations were pollution prevention options. The other options were largely treatment or disposal alternatives.

These post screening options were evaluated based on the following design and economic criteria:

A. Reduction of CBA emission level to less than the target level.
B. Costing of major equipment items according to Walas, Ulrich, Matley et al., and Peters and Timmerhaus, and vendors estimates.[3,4,5,6] All costs were adjusted to 1991 dollars using CE plant index or Marshall and Swift equipment index.
C. Plant service costs obtained from the sponsor's sources.
D. Assumption of 15-year straight line depreciation and zero salvage value.
E. Lang factors used to calculate installation costs.[3,6]

ECONOMIC RESULTS OF CASE STUDY

The economic results of this study are summarized below. The options are presented in the order of increasing annual operating expense. These expenses include depreciation as a fixed cost. All costs have been converted to 1991 dollars assuming that the control system would be installed and commence operation during 1991.

TABLE 1

SUMMARY OF NORMALIZED OPERATING COSTS FOR EMISSION CONTROL OPTIONS (1991 DOLLARS)

Technology	Normalized Annual Operating Costs:
Soil bed oxidation/biofiltration	1.0
Stagewise gas absorption	2.3
Low temperature condensation	3.9
Adsorption onto activated carbon	13.3
Adsorption onto clay substrate	5.3
Incineration (35% TER*)	7.4
Incineration (95% TER)	5.0
Incineration (0% TER)	9.9

*TER = Thermal Energy Recovery

CASE STUDY RECOMMENDATIONS

Based on our preliminary study grade analysis, five waste management options exhibit sufficiently promising technical potential and sufficiently low operating costs to be considered further. Based on annual operating costs alone, the top alternatives are: soil bed oxidation/biofiltration, stagewise gas absorption, low temperature condensation, incineration with 95 percent TER, and fluidized-bed clay adsorption.

Based on the methods used in estimating the cost of each option, the accuracy of any of these estimates should be within ±30 percent. After discussions with the pesticide manufacturer, the list of alternatives was reduced to soil bed oxidation/biofiltration and adsorption onto the raw clay feed. The economics of adsorption onto the raw clay as it was fed to the process were enhanced by combining this operation with another planned system modification. The manufacturer alternately selected option soil bed oxidation/biofiltration for application.

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TECHNOLOGY SELECTION

- Production process
  - Facility is integrated into large-scale chemical production operation
- Pesticide manufacturing
- Media: Air

REDUCTION OF ORGANIC CHEMICAL EMISSIONS FROM COMMERCIAL PESTICIDE MANUFACTURING

- Case study from an honors internship project in industrial pollution prevention
- Undergraduate chemical engineering students from The University of Tennessee work with faculty members and engineers and chemists from corporate sponsor
- Projects are significant and challenging
- Recommendations are typically pursued by corporate sponsor

COMMERCIAL PESTICIDE MANUFACTURING PROCESS

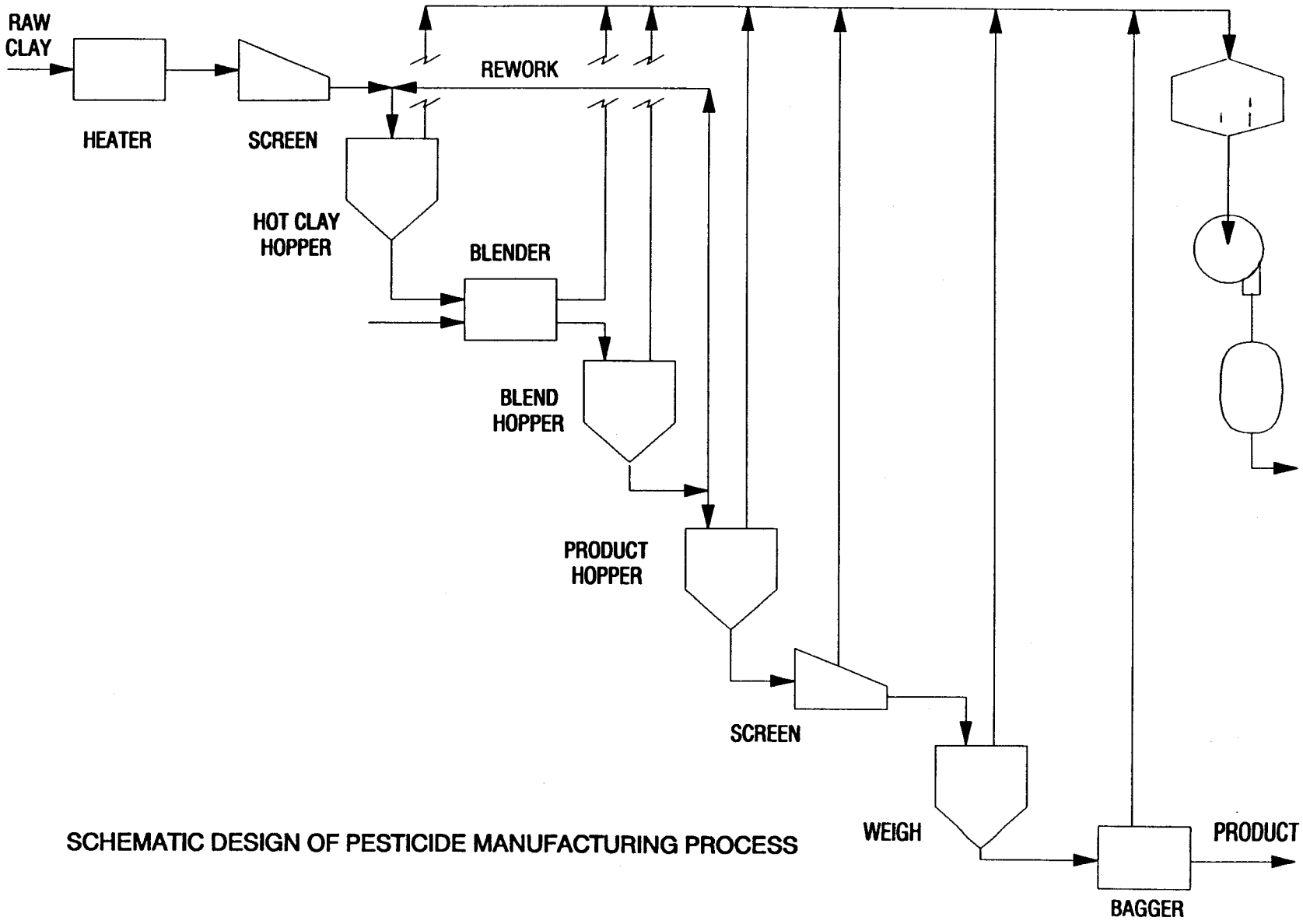
- Raw materials
  - Raw clay
  - Active ingredient (AI)
  - Chemical binding agent (CBA)
- Basic phenomena
  - Raw clay + CBA + AI → Granular Pesticide

SAFETY AND EMISSION CONTROL

- Employee safety
  - Process under slight vacuum for dust and process chemical control
- Existing emission controls
  - Dust removal by filtration
  - Odor control by carbon adsorption (odorous compounds are impurities in AI)
  - Partial control of other gaseous organic emissions by carbon adsorption

PESTICIDE MANUFACTURING PROCESS

- Raw clay heated and stored in hot clay hopper
- Heated clay screened and transferred to weigh hopper
- Heated clay, CBA, and AI fed to blender
- Batch is thoroughly mixed in blender and transferred to blend hopper
- Product is analyzed while in blend hopper
- Off-specification material transferred back to hot clay hopper
- Acceptable product transferred to product hopper
- Product is screened while in route to the weigh hopper
- From the weigh hopper, the product is transferred to the bagger for final packaging



SCHEMATIC DESIGN OF PESTICIDE MANUFACTURING PROCESS

PROBLEM STATEMENT

- Ventilation control system recently modified to reduce dust in product
  - Increased air velocity through process
- Increased CBA emissions were observed after modification
  - Carbon for odor control was only partially effective for CBA
- Objective of this study is to reduce gaseous CBA emissions to 400 lb/yr (~8 ppm), an estimated reduction of 98%
- Sound waste management practices should be followed

WASTE MANAGEMENT OPTIONS FOR CONTROL OF GASEOUS CBA EMISSIONS

Alternative	Pollution Prevention	Treatment
Soil bed oxidation/biofiltration		X
Aqueous absorption		X
Condensation	X	
Adsorption by activated carbon		X
Adsorption by raw clay	X	
Incineration (0% TER)		X
Incineration (35% TER)		X
Incineration (95% TER)		X

NORMALIZED ANNUAL COSTS FOR WASTE MANAGEMENT OPTIONS FOR GASEOUS CBA EMISSIONS (1991 DOLLARS)[+]

Soil bed oxidation/biofiltration	0.19
Aqueous absorption	0.43
Condensation	0.74
Adsorption by activated carbon	2.54
Adsorption by raw clay	1.00
Incineration (0% TER)	1.89
Incineration (35% TER)	1.41
Incineration (95% TER)	0.95

[+]Accuracy of estimate is approximately ± 30%

WASTE MANAGEMENT OPTIONS FOR CONTROL OF CBA EMISSIONS

- Recommendations for further study
  - Soil bed oxidation/biofiltration
  - Aqueous adsorption
  - Low temperature condensation
  - Incineration with 95% TER
  - Adsorption by raw clay
- Selection of options for further study by corporate sponsor
  - Soil bed oxidation/biofiltration
  - Adsorption by raw clay

TECHNOLOGY SELECTION: OPPORTUNITIES -- FOR POLLUTION PREVENTION IN PRINTING PLANTS

Printed media are ubiquitous in every day life, and it is not surprising that the printing industry is a significant source of environmental pollution. As described in a following table, printing operations include four major types of processes including rotogravure, lithography, letterpress and flexography, and screen printing, which differ in the manner in which ink is applied to a substrate. Wastes from printing operations are multimedia in character including air emissions of ink solvents, liquid waste inks and solvents, and solids, including primarily paper, among others. In view of the significant printing industry contribution to environmental pollution, EPA contracted with Radian Corporation (Contract No. 68-02-4286) for the preparation of a *Guide To Waste Minimization in the Commercial Printing Industry*. This manual, along with the more recently published *Guides to Pollution Prevention: The Commercial Printing Industry* (EPA Office of Research and Development, Pollution Prevention Branch, 1990), can be used as general guides for pollution prevention in the printing industry. Both documents include detailed discussions of component processes and some representative case study data.

In order to optimally illustrate typical findings resulting from a waste assessment of a printing plant, results from actual assessments of a number of medium-sized rotogravure printing plants have been used to derive data for a "generalized" hypothetical plant. An abbreviated process flowsheet illustrates that plant processes may include photographic, etching, and electroplating operations associated with the production of printing cylinders, in addition to the printing process itself. Typically, when printing cylinders are produced in-house, waste streams are numerous. However, in the usual case, the most notably large streams include ink solvent evaporative losses. With many waste streams to consider, quantification of each individual stream is often difficult. In a typically limited assessment, waste stream quantification in some cases may require estimation based on prior in-plant experience and direct observation of processes.

Waste reduction measures typically identified for the printing industry include both truly pollution prevention measures and a group of commonly recommended waste minimization actions reflecting some form of recycling. Projected financial payback for considered measures often spans a wide range. The timeframe of acceptable payback periods may vary considerably among

companies depending on management policy. Obviously, projects considered as part of an EPA enforcment settlement may be judged desirable with paybacks substantially longer than commonly found acceptable.

POLLUTION PREVENTION IN PRINTING PLANTS

- Media Impacted
  - Air
  - Hazardous Waste
  - Water

Source for figures: Jacobs Engineering Group, Inc. *Guide to Waste Minimization in the Commercial Printing Industry.* Cincinnati: Risk Reduction Engineering Laboratory, U.S. Environmental Protection Agency.

Figure 2-1. Printing Processes

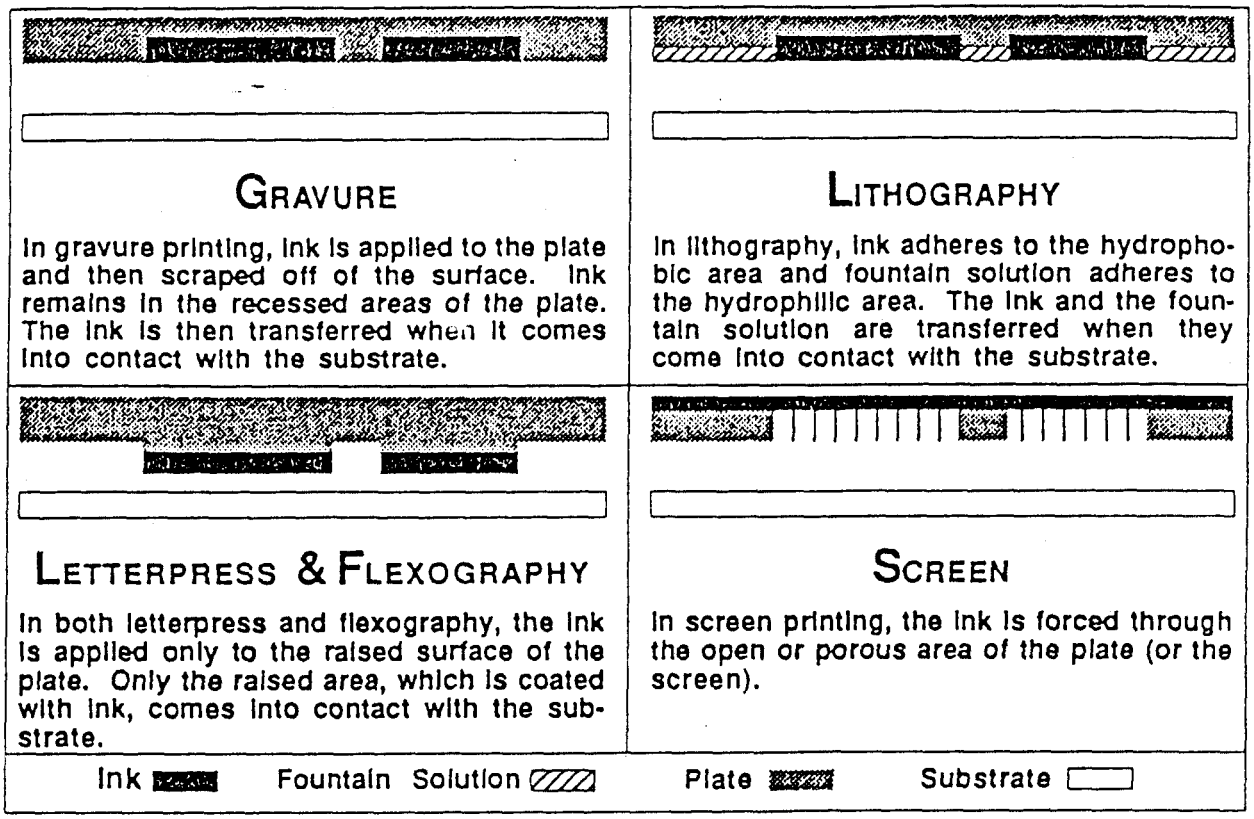
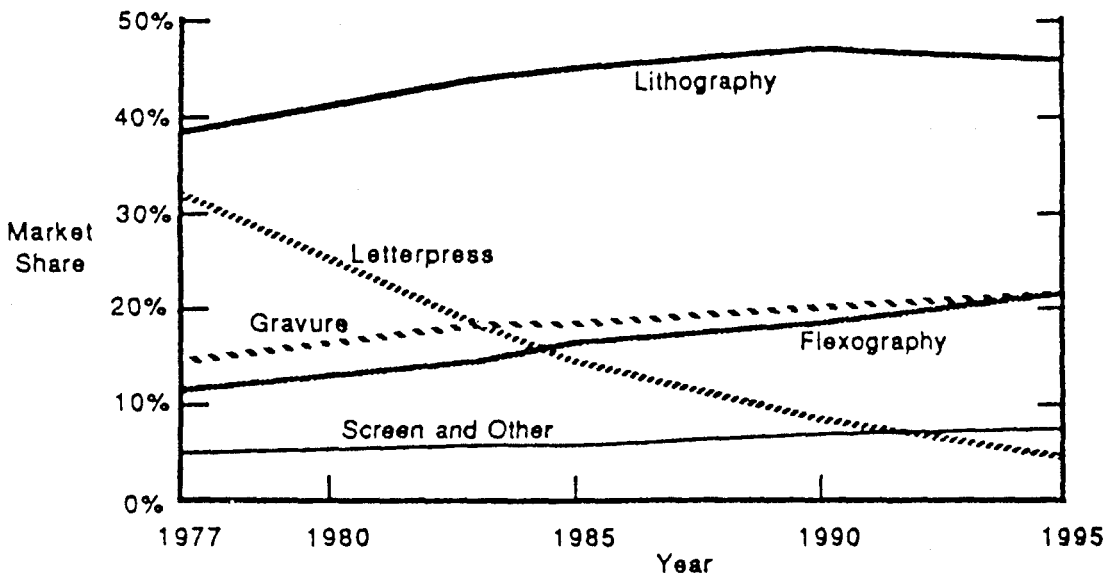
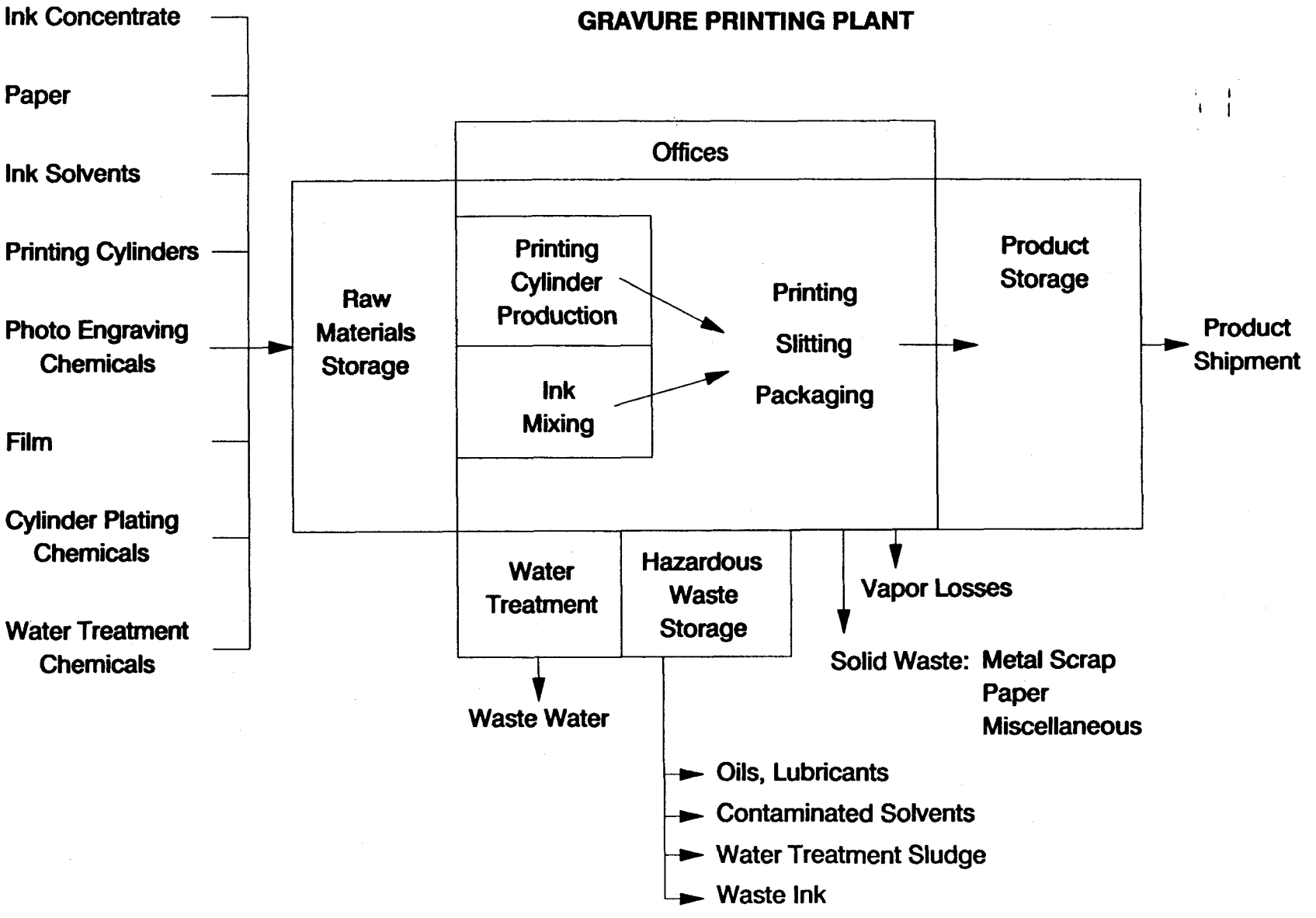


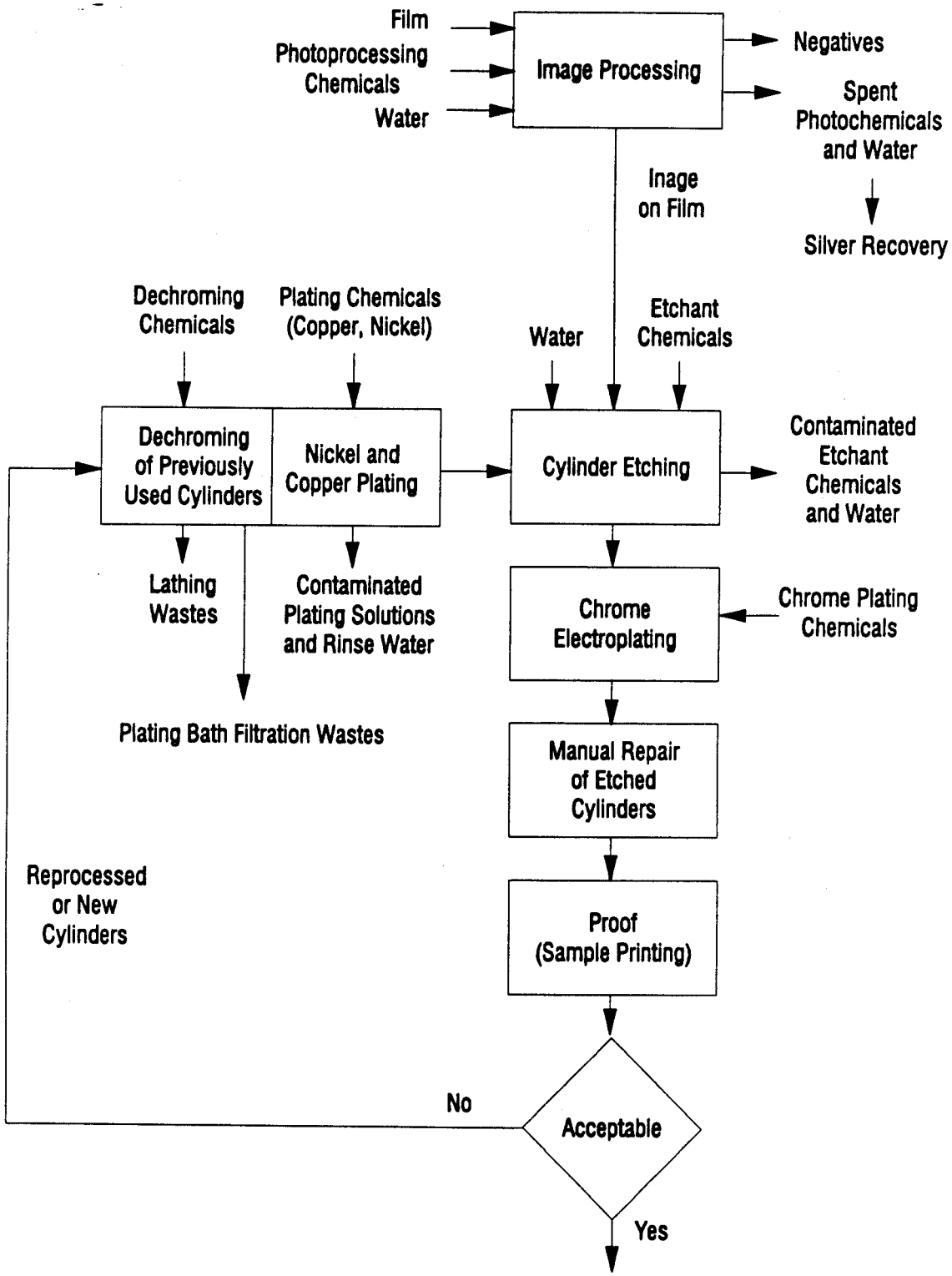
Figure 2.2. Market Share of Printing Processes



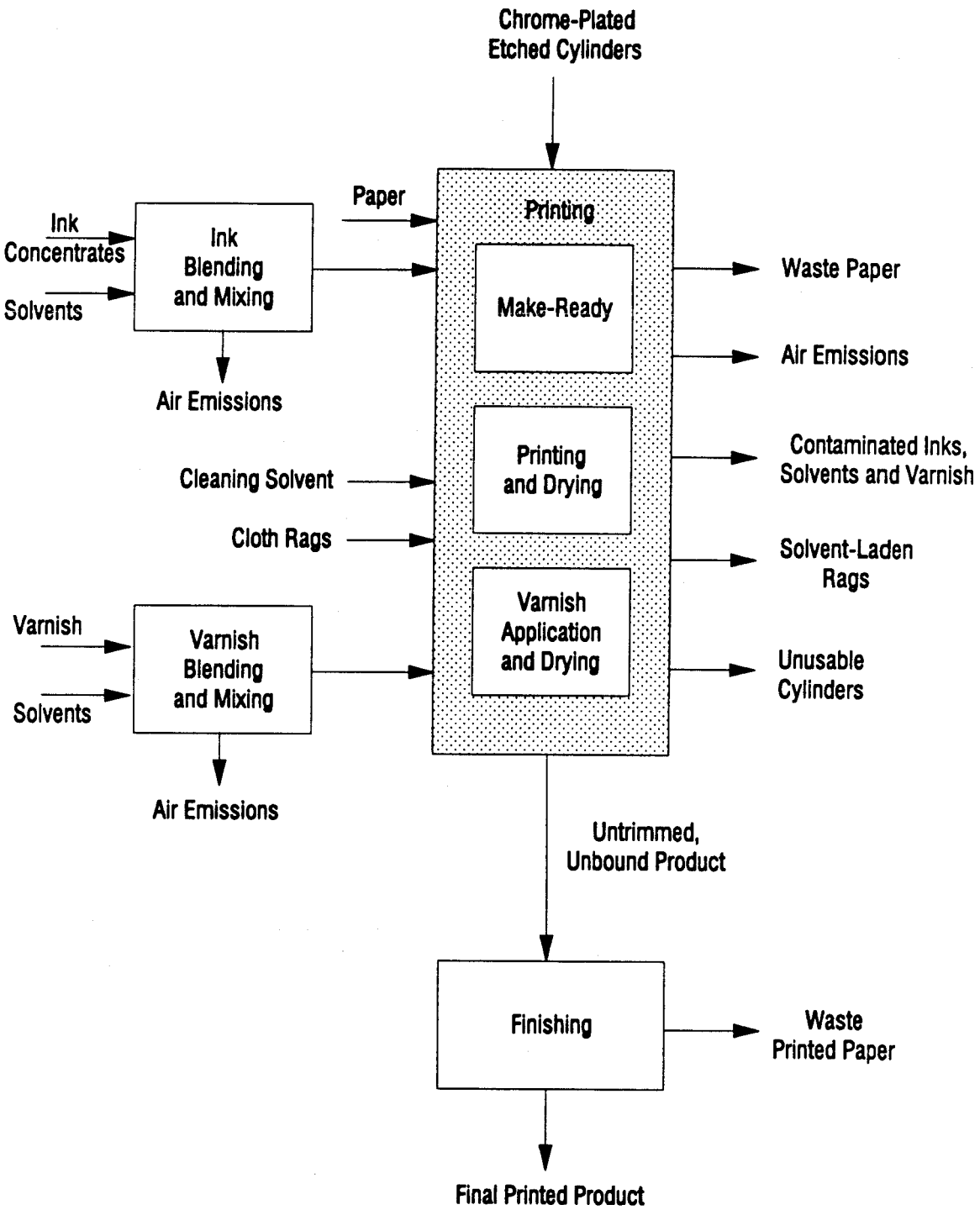
Source: Profit from Pollution Prevention (Campbell and Glenn 1982), Status of Printing in the USA (Bruno 1985).


GRAVURE PRINTING PLANT
Ink Concentrate
Paper
Ink Solvents
Printing Cylinders
Photo Engraving Chemicals
Film
Cylinder Plating Chemicals
Water Treatment Chemicals
Offices
Raw Materials Storage
Printing Cylinder Production
Ink Mixing
Printing
Slitting
Packaging
Product Storage
Product Shipment
Water Treatment
Hazardous Waste Storage
Vapor Losses
Solid Waste: Metal Scrap
Paper
Miscellaneous
Waste Water
Oils, Lubricants
Contaminated Solvents
Water Treatment Sludge
Waste Ink

GENERAL FLOWSHEET FOR ROTOGRAVURE PRINTING



GENERAL FLOWSHEET FOR ROTOGRAVURE PRINTING (PAGE 2)



TYPICAL WASTE STREAMS FOR A MEDIUM-SIZED ROTOGRAVURE PRINTING PLANT (PAGE 1)

Plant Process Source	Waste Stream Components	Typical Annual Production	Quantification Method
Printing Cylinder Machining and Electroplating	De-Chrome Tank Sludge (H)	500 lbs	Estimated
	Copper and Nickel Lathing Waste	5,000 lbs	Measured
	Combined Plating Tanks Filtrate Sludges (H)	5,000 lbs	Estimated
	Contaminated Cleaning Solutions	50,000 lbs	Mass Balance
	Cylinder Polishing Aqueous Effluent	75,000 lbs	Mass Balance
	Plating Rinse Water	200,000 lbs	Mass Balance
	Solvent-Wetted Paper Towels (H)	2,000 lbs	Estimated
	Waste Ink (H) (Proofing)	(minimal)	Estimated
	Evaporated Ink Diluting Solvent (Proofing)	(minimal)	Estimated

(H) Regulated Hazardous Waste

TYPICAL WASTE STREAMS FOR A MEDIUM-SIZED ROTOGRAVURE PRINTING PLANT (PAGE 2)

Plant Process Components	Waste Stream Components	Typical Annual Production	Quantification Method
Chemical Etching of Plated Cylinders	Spent Dye and Photoresist (H)	1,000 lbs	Mass Balance
	Evaporated Dye Solvent	100 lbs	Mass Balance
	Contaminated Developing Solution (H)	200 lbs	Mass Balance
	Waste Water from Developing Rinse Station	15,000 lbs	Mass Balance
	Obsolete Multiple Positive Patterns	2,000 lbs	Estimated
	Etchant Tank Sludge (H)	6,000 lbs	Estimated
	Contaminated Cleaning Solutions	30,000 lbs	Mass Balance
	Solvent-Wetted Cloth Rags (H)	5,000 lbs	Estimated
	Solvent-Wetted Paper Towels (H)	50 lbs	Estimated

(H) Regulated hazardous waste

TYPICAL WASTE STREAMS FOR A MEDIUM-SIZED ROTOGRAVURE PRINTING PLANT (PAGE 3)

Plant Process Source	Waste Stream Components	Typical Annual Production	Quantification Method
Printing	Ink and Varnish Mixing Solvent Evaporative Loss (Incinerated On-site)	20,000 lbs	Mass Balance
	Evaporated Ink and Varnish Application Solvents (Incinerated On-site)	500,000 lbs	Mass Balance
	Waste Solvent and Ink (H)	50,000 lbs	Estimated
	Ink Filters (H)	5,000 lbs	Estimated
	Varnish Waste (H)	20,000 lbs	Estimated
	Cleaning Solvent-Wetted Rags (H)	50,000 lbs	Estimated
	Ink-Contaminated Cleaning Solvent (H)	50,000 lbs	Estimated
	Depleted Caustic Solution Used in Varnishing Operations (H)	10,000 lbs	Estimated
	Waste Paper	1,500,000 lbs	Measured

(H) Regulated hazardous waste

IDENTIFIED POLLUTION PREVENTION/WASTE MINIMIZATION OPPORTUNITES

Recommended Measures	Waste Stream Components	Action Recommended	Typical Percentage Reduction of Waste	Net Cost Savings ($/yr)	Estimated Payback (years)	Type of Action
1. Install a still for in-house solvent recycling	Waste Flammable Liquid	Yes	90%	$150,000	0.2	In-House Recycling (Waste Minimization)
2. Automate ink and solvent mixing	Waste Flammable Liquid Ink Solvents Alcohol	Yes	75%	$50,000	3.3	Process Change (Pollution Prevention)
3. Install a waste water treatment system sludge dry-out oven	Waste Water Treatment Sludge	Yes	55%	$15,000	1.4	Process Change (Pollution Prevention)

IDENTIFIED POLLUTION PREVENTION/WASTE MINIMIZATION OPPORTUNITES

Recommended Measures	Waste Stream Components	Action Recommended	Typical Percentage Reduction of Waste	Net Cost Savings ($/yr)	Estimated Payback (years)	Type of Action
4. Use recovered solvent instead of virgin solvents for cleaning at press-side	Waste Solvent	Yes	90%	$10,000	Immediate	Process Change (Pollution Prevention)
5. Use copper lathing waste to reduce use of purchased copper nuggets in copper plating tank	Copper Lathing Waste	Yes	75%	$800	0.9	In-House Recycling (Waste Minimization)

IDENTIFIED POLLUTION PREVENTION/WASTE MINIMIZATION OPPORTUNITES

Recommended Measures	Waste Stream Components	Action Recommended	Typical Percentage Reduction of Waste	Net Cost Savings ($/yr)	Estimated Payback (years)	Type of Action
6. Reduce drag-out from copper plating bath	Plating Reagents Water Waste Water Treament Sludge	Yes	20%	$500	4.5	Process Change (Pollution Prevention)
7. Utilize cleaning tank lids to reduce solvent evaporative losses	Cleaning Alcohol and Solvent	Yes	50%	$500	Immediate	Housekeeping (Waste Minimization)

IDENTIFIED POLLUTION PREVENTION/WASTE MINIMIZATION OPPORTUNITES

Recommended Measures	Waste Stream Components	Action Recommended	Typical Percentage Reduction of Waste	Net Cost Savings ($/yr)	Estimated Payback (years)	Type of Action
8. Recycle treated water from waste water treatment facility for use in plating rinse tanks	Water	No	-----	-----	10	In-House Recycling (Waste Minimization)
9. Clean solvent-wetted cloth rags and reuse in clean-up operations	Solvent-Wetted Cloth Rags	No	-----	-----	5	In-House Recycling (Waste Minimization)

TECHNOLOGY SELECTION: ASSESSMENT -- FOR A SMALL, PROTO-TYPE, CIRCUIT BOARD MANUFACTURER[1]

INTRODUCTION

The company is engaged in the manufacture of proto-type, printed circuit (PC) boards. The facility covers about 6400 square feet, employs seven persons, and is a small, minority-owned business. The firm's marketing strategy focuses on quality, small production runs, and fast turn around time on orders. Turn around time for PC board manufacture can be as quickly as 24 hours. Production is estimated in the range of 300 to 400 square feet of circuit boards per month.

PC board manufacturing involves the imprinting of metal circuitry onto a board composed of non-conductive material (e.g., glass epoxy or plastic) through a series of operations characteristic of the particular method used. This small manufacturer uses the most predominant production method for the manufacturer of PC boards: conventional subtractive process. Subtractive production typically begins with copper-clad laminate board. The final stages of the subtractive process involve cleaning and application of selective metallic coatings for solderability and/or corrosion protection. Using this method, the PC board is subjected to the following operations:

- Cleaning and surface preparation (curing, sanding, drilling, and deburring). Airborne particulates generated during board preparations are collected using vacuum-bag system at the facility. The collected dusts, which contain fiberglass and copper, are then removed for disposal at the landfill as solid wastes.

- Catalyst application and electroless plating (scrubbing and cleaning, surface activation, etching, electroless plating, and catalyst application)

- Pattern printing and masking (panel plating, electroplating resist application, etching, pattern plating--resist application, and printing and developing)

- Electroplating (cleaning and rinsing, tin and lead plating, light etch and acid dip, stripping and rinsing, and copper electroplating)
- Etching

HAZARDOUS WASTES

This company is a small quantity hazardous waste generator. The firm uses a transportation manifest system and a permitted hazardous waste disposal firm. In 1988, the hazardous waste manifests indicated three shipments of waste to the disposal facility totaled 10,928 kilograms (D002, D008 copper corrosive material UN 1760). See Table 1 for hazardous waste information for 1988.

TABLE 1
HAZARDOUS WASTE SHIPMENTS 1988
3 Shipments[1]

	GALLONS	@	TOTAL COST
9/7/88	950	$0.25/gal	$482.00
5/10/88	800	$0.25/gal	$443.00
2/16/88	800	$0.25/gal	$462.00
	2,550[2]		$1,387.00

[1] All wastes listed as D002, D008 Copper-Corrosive Material UN 1760
[2] 10,928 kg

WATER USAGE

Recent water bills indicate an estimated water usage of about 4,300 gallons per day or 500-600 gallons per shop-time hour. The rinsewater from the facility is discharged to a POTW. The copper permit limit is 2.07 mg/l and the city has measured violations in which the copper concentrations have been in the 2.6 to 3.2 mg/l range. The permit limits for the other metals are rarely violated.

An initial thought might be to reduce the amount of water usage by reducing the rinsewater flows to the rinse tanks or through rinsewater reuse in the electroless plating line. However, to reduce the quantity of rinsewater without reducing the

amount of metals will result in higher concentrations and more violations. Therefore, the highest priority is to reduce the amount of metals in the rinsewater. It is important to remember that the limit of 2.07 mg/l copper imposed by the POTW is a very small quantity. With a flow of 5,000 gallons per day, this is equivalent to about 15 copper pennies in the company's discharge.

POTENTIAL SOURCES OF WASTE GENERATION

Potential waste sources include the following:

1. Breakage of containers with spillage occurring in the storage area
2. Possibly poor handling and spillage of chemicals in transfer
3. Copper and fiberglass waste from the drilling and cutting process
4. Photo chemicals
5. Chemicals used in the plating process
6. Chemicals in the rinse solutions going to waste in the electroless plating process
7. Chemicals in the rinse solutions going to waste in the electrodeposit process
8. Chemicals in the rinse solution from the etch machine
9. Chemicals in the rinse solution from the plate rinse and dry machine
10. Copper from the deburring machine
11. Scrap from circuit board rejects, trimmings, etc.
12. Usual trash such as paper, cups, drink cans, etc.

Of these sources of wastes, the main concern of management is the amount of copper being discharged in rinsewater to the POTW. It appears the greatest opportunities for reduction in this area of concern are found in the processes

outlined in items 5 through 10 above. The probable offenders would appear to be (in order) the etch machine, plating rinse solutions, the deburring machine, and wash and dry machine.

POLLUTION PREVENTION OPTIONS

Pollution prevention opportunities identified in order of highest to lowest priority included:

1. Dwell time of boards removed from process tanks containing copper in the plating process

2. Overhaul and proper maintenance of the etch machine

3. Extend plating bath life with good analytical procedures for chemical recharge

4. Reduce rinsewater flow rates

5. Ion exchanger (disposable or returnable containers) on rinsewater discharge of the etch machine

6. Addition of an ion exchanger for all plating waste streams after a program is established for rinsewater reduction

These opportunities and others exist in this facility for waste reduction.

The most common waste reduction practices which can be applied to the four main waste streams in the electroplating processes are similar to the cleaning wastes produced in many other manufacturing processes. Flow rates of pollutants and wastewater can be reduced by making modifications to the design and operation of plating baths and rinse systems. The goal is to reduce the total amount of plating solution that leaves the plating bath. When these modifications are properly implemented, less new plating chemicals must be purchased, less hazardous wastes are generated, and pollution control becomes less costly and less risky. Modifications in rinse technologies are sometimes relatively inexpensive, and they show a strong cost-benefit ratio (i.e., significant savings may be realized with little capital investment). Reduction options begin with simple housekeeping.

HOUSEKEEPING

- Periodically inspect tanks and tank liners
- Repair leaks around pipes, valves, tanks, pumps and seals, and heating coils
- Shut off rinses when not in use
- Inspect plating racks for loose insulation to help reduce drag-out
- Do not let incompatible wastes mix! The costs and risks increase significantly
- Use dry cleanup rather than water flooding wherever possible
- Install drip trays or boards
- Conduct an employee pollution prevention awareness program and reward employees' ideas that work

WASTE RINSEWATER

There are several methods available to reduce the amount and toxicity of waste rinsewater. These methods can be grouped into two major techniques:

- Drag-out reduction--reducing drag-out will result in a decrease of the heavy metal content of the ultimate waste (treatment sludge), and
- Rinsewater reduction--decreasing water consumption will decrease the volume of ordinary calcium and magnesium sludge that results when using hard water. The amount of heavy metal sludge produced remains the same. Therefore, decreasing the amount of rinsewater without reducing drag-out may result in a small, but more highly toxic, volume of treatment sludge.

DRAG-OUT REDUCTION

As a workpiece emerges from a plating bath, it carries some of the plating solution into the rinse. This carryover--drag-out--can be reduced. Minimizing the drag-out reduces the amount of rinsewater needed. Also, less of the plating solution metals leave the process, which ultimately produces savings in raw materials, and treatment and disposal costs. The amount of drag-out depends on the following factors:

- Surface tension of the plating solution
- Viscosity of the plating solution
- Physical shape and surface area of the workpiece and rack
- Speed of workpiece withdrawal and drainage time

Generally, drag-out reduction techniques include:

- Maximizing plating solution operating temperature to lower both the viscosity and surface tension of the solution. Disadvantages include: higher energy costs, higher chance for contamination due to increased make-up requirement, and more need for air pollution control due to higher evaporation rate.
- Reducing the plating bath chemical concentrations. Lowering the concentration will result in lower solution viscosity, and reduced rinsing requirement.
- Withdrawing workpiece at slower rates and allow sufficient solution drainage time. For example, 30 seconds usually allows most drag-out to drain back to the tank, and 10 seconds still permits good drag-out recovery in application where quick drying is a problem.
- Using surfactants or wetting agents in the process bath can lower a solution's surface tension enough to reduce drag-out by up to 50 percent. Only non-ionic wetting agents should be used. The use of surfactants is sometimes limited due to their adverse effect on the quality of the plate produced.

- Proper positioning of the workpiece on the plating rack to facilitate the dripping of the drag-out back into the bath. This is best determined experimentally, although the following guidelines are effective: orient the surface as close to vertical as possible, situate the longer dimension of the workpiece horizontally, and position the workpiece with the lower edge tilted from the horizontal so the runoff is from a corner rather than an entire edge.

- Improve drag-out recovery by utilizing drainage boards positioned between process and rinse tanks to capture the dripping solution and route it back to the process bath.

DRAG-OUT REDUCTION AT THIS FACILITY

By reducing the plating operations drag-out, the overall copper waste in the rinsewater will be drastically reduced. This could possibly reduce the amount of copper in the rinsewater to a low enough level that the other sources of copper (particularly the etch machine after overhaul) will not cause discharge violations in the plant's effluent.

In observing the operation of the electroless plating procedure there is not sufficient "hang-time" in the process to allow for adequate drainage of the solution as circuit boards are moved from tank to tank. This produces a high quantity of drag-out from the chemical tanks to the rinse tanks with a resultant high concentration of the chemicals in the rinsewater which discharges to the sewer. Furthermore, dragging rinsewater into the chemical tanks also causes dilution of the chemical tanks which results in increased chemical usage and costs.

According to literature, approximately 50 percent of the drainage is realized in 1 second, 75 percent in 5 seconds, and 90 percent in 10 seconds. If the operator at this facility will lift the rack from the solution tanks and holds it over that tank for at least 10 seconds, the drag-out will be reduced by approximately 200 percent. This can be facilitated by providing a hanger over each process and rinse tank to allow the PC board racks to be hung for the necessary drain time.

Obviously, the greater number of boards and the greater the unit area, the greater the total drainage. The 6 board cycle, 1.5 square foot, should be given a longer drainage time. Also, the differences on board surfaces seem to affect the ability of the liquid to drain from the boards as shown in Table 2.

TABLE 2

SURFACE	DRAIN RATE (Considering both sides of each board) ml/sec/sq ft
Finished product	1.41
Bare copper	2.01
Solder mask	3.51

RINSEWATER REDUCTION

Rinsewater reduction involves rinsing off the workpiece in the most efficient manner, using the smallest volume of rinsewater. Traditionally, a workpiece would be immersed into a single rinsing bath following a plating bath, and then moved on to the next step in the process. The rinse tanks that follow the plating process often account for as much as 90 percent of an average facility's total water use. Reducing the volume of rinsewater will lower the costs of water, energy, and disposal. Several methods exist which use less rinsewater than the traditional method, while still adequately rinsing the workpiece. These include:

- Counter-flow multiple tank rinsing can reduce rinsewater requirements by 66 percent with possible theoretical reductions of over 90 percent reported. In a three-tank, counter-current series system, the workpiece enters the first rinse tank, which has the most contaminated rinsewater. It is then moved to the second tank, and then to the last where it contacts fresh rinsewater before moving on to the next step in the process. The fresh rinsewater enters only the last (third) rinsing tank. The water then flows into the second tank, then into the first tank from which it is routed to treatment or to the plating tank as a make-up.

- Rinsewater reuse--Rinsewater picks up contaminants from the workpiece that was rinsed. The same water can be used again in a subsequent plating step if these contaminants do not interfere with the quality of that step.

- Still rinsing involves immersing the workpiece in a still (no inflow or outflow) rinse tank following the plating bath. The concentrations of the plating bath constituents build up until they become sufficiently high for the rinsewater to be used to replenish the upstream plating bath.

- Automatic flow controls control the rinse rate to as slow as possible to avoid variations associated with water line pressure changes and manual control by operator.

- Mechanical and air agitation of the rinsing bath increase the rinsing efficiency.

FLOW RATES AND RINSEWATER REDUCTION AT THIS FACILITY

Rinsewater flows were measured by using a stop watch and a plastic bucket (2.75 gallons) graduated in quarts. The bucket was dipped into the rinse tank and allowed to fill to the 11 quart mark. The bucket was then held so that the water in the bucket was at the same level as the water in the rinse tank. When the water level in the rinse tank stabilized to the top of the overflow weir, the bucket was removed from the tank and the stop watch was started. When the level in the rinse tank started flowing over the weir, the stop watch was stopped. Rinsewater flow was then computed as follows:

Rinsewater flow rate in gallons/minute=2.75 gallons/time in seconds x 60 seconds

Rinsewater flow rates on the electroless copper plating process line were as follows:

RINSE TANK	TIME (seconds)	RINSEWATER FLOW (gpm)
1. After Cleaner	73.8	2.24
2. After Sulfuric acid	75.0	2.20
3. After Sulfuric acid	68.2	2.42
4. After Catalyst	70.0	2.36
5. After Catalyst	76.6	2.15
6. After D I Water	72.7	2.27
7. After Electroless CU	63.4	2.60
	TOTAL	16.24

Assuming the three other rinse tanks in the plant that were not measured were flowing 2.25 gpm, then the approximate flow for all rinse tanks is 23 gallons per minute. Water usage at this rate yields an average 8-hour daily flow of 11,040 gallons. Therefore, it is important that rinsewater usage at this facility be controlled and used only as required. However, it is essential that these flows be maintained during times that the etch machine is in operation. Otherwise there exists a potential for a copper spike in analytical data on the waste stream.

Flows to the rinse tanks can be reduced by installing flow control valves on the inlets to the electroless plating line rinse tanks. Two other techniques are available that can improve the efficiency of a rinsing system and reduce the volume of rinsewater used. These techniques are air agitation and counter flow, multiple-tank rinsing. The first strategy (turbulence) to improve rinse efficiency involves rinse tank agitation. Agitation between the work piece and the rinsewater can be performed either by moving the work piece rack in the water or by creating a turbulence in the rinsewater. Since the facility operates hand rack lines, operators could easily move work pieces manually by agitating the hand rack. However, the effectiveness of this technique depends on understanding and cooperation from the various operators.

Agitating the rinse tank by using forced air or water is the most efficient method for creating effective turbulence during rinse operations. This is achieved by

pumping either air or water into the immersion rinsing operations. Air agitation provides the best rinsing because the air bubbles create the best turbulence for removing the chemical process solution from the work piece surface. This type of agitation can be performed by pumping filtered air into the bottom of the tank through a pipe distributor (air spargers).

The second strategy, multiple rinse tanks, can be used to provide sufficient rinsing while significantly reducing the volume of rinsewater used. The use of a multi-stage counter-current rinsing system can use up to 90 percent less rinsewater than a conventional single-stage rinse system. In a multi-stage, counter-current rinse system, work piece flow moves in an opposite direction to the rinsewater flow. Water exiting the last tank that the work piece is immersed into becomes the feed water to the next rinse tank ahead in line. This water overflows to feed the next rinse tank, and so on for the number of tanks tied into the line.

Counter-current rinsing in the electroless plating process line could be accomplished by leaving the seventh tank alone and then reversing the rinsewater flow in every other rinse tank preceding it in the process. This strategy does not require any additional space and could be accomplished with replumbing of the 1/2" PVC water feed lines. To enhance rinsewater counter flow, the last tanks in the rinse line may need to be raised slightly to provide a gravity flow.

SPENT PLATING SOLUTIONS AND SLUDGES

Plating solutions are not discarded frequently, but do require periodic replacement. Practices available for pollution prevention of spent plating waste include:

- Increase plating solution life--The lifetime of a plating solution is limited by depletion of constituents due to drag-out and/or the accumulation of impurities. The impurities buildup can be limited by the following techniques: use purer anodes, reduce drag-in by better rinsing, use deionized or distilled water instead of tap water for make-up, regenerate plating solution through impurity removal by more efficient filtering of the plating solution, and properly design and maintain racks. Corrosion and salt deposits on the rack will contaminate plating solutions by chipping and falling into the solution. Regular analysis of plating solutions can determine amounts of constituent depletion due to drag-out and evaporation. Addition of the proper amounts of plating solutions can extend the life of the

bath and reduce the amounts of hazardous waste for disposal.

- Returning spent plating solution to manufacturer--This requires on-site separation of solutions according to the metal in solution.

METAL RECOVERY TECHNIQUES

Techniques to recover metals from rinsewater before treatment include:

- Evaporation
- Reverse osmosis
- Ion exchange
- Electrolysis
- Electrodialysis

Many companies have installed such systems to recover metals from waste rinsewater and have found that the investment has paid for itself in one to five years. Strategic, in-line placement of metal recovery units, such as ion-exchange columns, can serve to remove metals from spent plating baths and waste rinsewaters. When the ion-exchange resin is regenerated, the metals can be recovered and used to provide plating solutions which can be recycled to the plating baths. The company is having an ion-exchange system designed with quoted costs for the turn-key system ranging from $15,000 to $30,000. When the ion-exchange resin is regenerated, the metals can be recovered and used to provide plating solutions which can be recycled to the plating baths. Complete elimination of copper, in the plant rinsewater effluent discharged to the POTW, may be accomplished by using an-ion exchange process.

[1] Report from Waste Reduction Assessment and Technology Transfer team, The University of Tennessee, Center for Industrial Services.

POLLUTION PREVENTION FOR PROTO-TYPE, PRINTED CIRCUIT BOARD MANUFACTURER

- Facility: 6400 square feet
- Employment: seven persons
- Small quantity hazardous waste generator
  - EPA waste codes: D002, D008 copper corrosive material
- Operations
  - Cleaning and surface preparation
  - Catalyst application and electroless plating
  - Pattern printing and masking
  - Electroplating
  - Etching

PRINTED CIRCUIT BOARD MANUFACTURER--CONTINUED

- Water usage
  - 4,300 gallons/day
- Discharge limits
  - Copper permit limit 2.07 mg/l (violations range in the 2.6 to 3.2 mg/l range)
- Potential sources of waste generation
  - Container breakage
  - Spills
  - Drilling, cutting process
  - Chemicals (photo, plating process)
  - Rinse solutions (electroless plating and electrodeposit processes, etch machine, dry machine)
  - Scrap
  - Solid waste

POLLUTION PREVENTION OPPORTUNITIES

- Dwell time of boards removed from process tanks containing copper in the plating process
- Overhaul and proper maintenance of the etch machine
- Extend plating bath life with good analytical procedures for chemical recharge
- Reduce rinsewater flow rates
- Ion exchanger (disposable or returnable containers) on rinsewater discharge of the etch machine
- Addition of an ion exchanger for all plating waste streams after a program is established for rinsewater reduction

HOUSEKEEPING

- Periodically inspect tanks and tank liners
- Repair leaks around pipes, valves, tanks, pumps and seals, and heating coils
- Shut off rinses when not in use
- Inspect plating racks for loose insulation to help reduce drag-out
- Do not let incompatible wastes mix! The costs and the risks increase significantly
- Use dry cleanup rather than water flooding wherever possible
- Install drip trays or boards
- Conduct an employee pollution prevention awareness program and reward employees' ideas that work

VOLUME AND TOXICITY REDUCTION OF WASTE WATER

- Drag-out Reduction
- Rinsewater Reduction

OTHER POLLUTION PREVENTION OPTIONS FOR WASTES

- Spent Plating Solutions and Sludges
- Metal Recovery Techniques

UNITED STATES

ENVIRONMENTAL PROTECTION AGENCY

ATLANTA, GEORGIA

In the Matter of: Barnhardt Manufacturing Company, Inc. 1561 Prospect Street High Point, North Carolina 24260, Respondent.	Docket No. EPCRA-IV-90-032 CONSENT AGREEMENT AND FINAL ORDER

CONSENT AGREEMENT

I. PRELIMINARY STATEMENT

Complainant, the United States Environmental Protection Agency (hereinafter "EPA") Region IV and Respondent, Barnhardt Manufacturing Company, Inc., by their undersigned representatives, hereby consent and agree as follows:

1. EPA initiated the above-styled proceeding for the assessment of civil penalties pursuant to Section 325 of the Emergency Planning and Community Right-to-Know Act of 1986, (hereinafter "EPCRA"), 42 U.S.C. 11045, by issuing a Civil Complaint and Notice of Opportunity for Hearing (hereinafter "Administrative Complaint"), Docket No. EPCRA-IV-90-032 dated September 28, 1990.

2. The Administrative Complaint charged Respondent with failure to submit a timely, complete, and correct Toxic Chemical Release Inventory Reporting Forms (also known as Form Rs) pursuant

to Section 313 of EPCRA, 42 U.S.C.A. §11023, and the regulations promulgated thereunder at 40 C.F.R. Part 372.

3. Respondent hereby certifies that it has now fully completed and submitted to EPA and to the State of North Carolina all of the required toxic chemical release forms in compliance with Section 313 of EPCRA. Respondent also certifies that, as of the date of execution of this Consent Agreement and Final Order, it is in compliance with all relevant requirements of EPCRA.

4. For purposes of this proceeding, Respondent admits the jurisdictional allegations set forth in the Administrative Complaint.

5. Respondent neither admits nor denies the factual allegations set forth in the Administrative Complaint, but enters into this Consent Agreement and Final Order in order to settle and conclude a disputed claim. Respondent's consent to this Agreement is not to be construed as an admission of liability, which liability is expressly denied by Respondent.

6. Respondent hereby waives its right to a hearing on any issue of law or fact set forth in the Administrative Complaint or this Consent Agreement and Final Order.

7. Each party to this action shall bear its own costs and attorney fees.

8. The terms and provisions of this Consent Agreement and Final Order shall be binding upon the Respondent, its officers, directors, agents, servants, authorized representatives, employees, and successors or assigns.

9. For the purposes of state and federal income taxation, Respondent shall not be entitled to and agrees not to attempt to claim a deduction for any penalty payment made pursuant to this Consent Agreement and Final Order. Any attempt to deduct any such penalty shall constitute a violation of this Consent Agreement and Final Order.

10. Respondent consents to the issuance of the Consent Agreement and Final Order hereinafter recited and consents for the purposes of settlement to the payment of a civil penalty as set forth in Paragraphs 13 through 20 herein.

II. FINDINGS OF FACT

11. EPA incorporates by reference the factual allegations contained in paragraphs 1 through 23 of the Administrative Complaint, Docket No. EPCRA-IV-90-032 and adopts them as Findings of Fact herein.

III. CONCLUSIONS OF LAW

12. In view of the above Findings of Fact, EPA finds that Respondent has violated Section 313 of EPCRA, 42 U.S.C. §11023 and shall be liable to the United States for a civil penalty pursuant to Section 325 of EPCRA, 42 U.S.C. §11045.

IV. ORDER

NOW THEREFORE, PURSUANT TO 40 C.F.R. § 22.18(c), IT IS HEREBY ORDERED, ADJUDGED and DECREED as follows:

13. Respondent is assessed a civil penalty totaling Eight Thousand Five Hundred DOLLARS AND NO/100 ($8,500.00).

14. Pursuant to that portion of the EPA's EPCRA Section 313 Enforcement Response Policy regarding other factors which justice may require, the penalty amount assessed in Paragraph 13 herein may be reduced by Two Thousand Five Hundred DOLLARS AND NO/100 ($2,500.00) contingent upon Respondent's performing the environmentally beneficial expenditures as described in paragraph 14. The conditions to be satisfied are as follows:

> Respondent shall within nine (9) months of the effective date of this Final Order, at a cost of Seven Thousand Five Hundred DOLLARS AND NO/100, complete a project for the testing of water-based adhesives which may be substituted for the solvent-based adhesives containing the 1,1,1-Trichlorethane which chemical was the subject of the above-styled matter. The specific requirements of said project are outlined in Exhibit "A" hereto, said Exhibit being incorporated herein by reference.

15. Credit of the amount identified in Paragraph 14 against the penalty assessed in Paragraph 13 is contingent upon Respondent's providing to EPA by February 28, 1992 an affidavit signed by an appropriate individual and relevant documentation verifying:

a. Completion of the environmental project identified in Paragraph 14;

b. The amount of the expenditure made in carrying out said project equal to or exceeding the amount specified for the project in Paragraph 14; and

c. Identification of adhesives tested and results obtained in Respondent's project set forth in Paragraph 14 herein. Said information shall be public information and Respondent expressly waives any and all proprietary, trade secret and/or confidential business information claims regarding said information in connection EPA and/or any third party. Respondent authorizes EPA to distribute said information as EPA may deem appropriate.

16. If Respondent satisfactorily complies with the conditions set forth in Paragraph 14 of this Order and within the specified timeframe, and if Respondent provides to EPA satisfactory documentation pursuant to Paragraph 15(a), (b) and (c) of this Consent Agreement and Final Order within the timeframes specified, the assessed penalty of Eight Thousand Five Hundred DOLLARS AND NO/100 ($8,500.00) as set forth in Paragraph 13 shall be reduced by the amount of Two Thousand Five Hundred DOLLARS AND NO/100 ($2,500.00) to the sum of Six Thousand DOLLARS AND NO/100 ($6,000.00) pursuant to the terms of Paragraph 14. If Respondent does not satisfactorily meet the conditions specified in Paragraphs 14 and 15(a), (b) and (c) of this Consent Agreement and Final Order then the Two Thousand Five Hundred DOLLARS AND NO\100 ($2,500.00) amount shall, without further proceeding, immediately become due

and payable to EPA pursuant to the terms of Paragraph 18 herein, with interest as specified in Paragraph 20.

17. In full settlement of this matter, subject to Paragraphs 13, 14, 15, 16, 19 and 20 herein, Respondent shall pay Six Thousand DOLLARS AND NO/100 ($6,000.00) within thirty (30) calendar days of receipt, via certified mail/return receipt requested, of a fully executed copy of this Consent Agreement and Final Order.

18. Payment of civil penalty amounts required by this Consent Agreement and Final Order shall be made by forwarding a cashier's or certified check payable to "Treasurer, United States of America" and shall be sent to:

EPA - Region IV
Regional Hearing Clerk
P.O. Box 100142
Atlanta, Georgia 30384

Such check should reference the name and Docket Number of the Administrative Complaint. Respondent shall send a copy of the above check to:

Victoria A. George
Office of Regional Counsel
EPA - Region IV
345 Courtland Street, N.E.
Atlanta, Georgia 30365

along with written certification that payment has been made pursuant to the terms of this Consent Agreement and Final Order.

19. In the event that Respondent fails to meet any requirement of this Consent Agreement and Final Order, excluding those requirements of Paragraphs 14 and 15(a), (b) and (c), but specifically including all other requirements of this Consent

Agreement and Final Order (including, but not limited to, the timely payment of the amount stated in Paragraph 17 herein):

a. The Respondent agrees that the civil penalty amount due and payable pursuant to the terms of this Consent Agreement and Final Order shall be the full amount of the penalty originally proposed in the Complaint, that is Ten Thousand DOLLARS ($10,000.00); and

b. The Respondent agrees to pay the modified civil penalty amount described in subparagraph (a) immediately upon receipt of a Notice of Modification of Penalty. Payment of said modified civil penalty shall be made pursuant to the terms of Paragraph 18 herein.

20. The following notice concerns interest, late penalty and administrative cost charges that will accrue in the event any civil penalty (or the modified civil penalty if applicable) is not paid as directed.

NOTICE

Pursuant to 31 U.S.C. §3717, an executive agency is entitled to assess interest and penalties on debts owed to the United States and a charge to cover the cost of processing and handling a delinquent claim: 40 C.F.R. §13.11. Interest will begin to accrue on the civil penalty if it is not paid within thirty (30) calendar days of Respondent's receipt, via certified mail/return receipt requested, of a fully executed copy of this Consent Agreement and Final Order. Interest will be

assessed at the rate of the United States Treasury tax and loan rate: 40 C.F.R. §13.11(a)(1). In addition, a penalty charge of six (6%) percent per annum will be assessed on any portion of the debt which remains delinquent more than ninety (90) days after payment is due: 40 C.F.R. §13.11(c). However, should assessment of the interest and/or penalty charge on the debt be required, each will be assessed as of the first day payment is due: 40 C.F.R. §13.11(a)(1) and (c).

STIPULATED, CONSENTED, AND AGREED TO,
AND APPROVED FOR ENTRY, WAIVING NOTICE:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY, REGION IV,
COMPLAINANT

JUL 2 3 1991
Date

Winston A. Smith
Winston A. Smith, Director
Air, Pesticides, and Toxic Management Division
EPA - Region IV

BARNHARDT MANUFACTURING COMPANY, INC.
RESPONDENT

8-23-91
Date

George M. Hargrove Jr.
By: VP Manufacturing Co
Its: _____

[SIGNATURES CONTINUED ON NEXT PAGE]

[SIGNATURES CONTINUED FROM PREVIOUS PAGE]

IT IS SO APPROVED AND ORDERED

This 6th day of September, 1991.

Patrick M Tobin / Deputy for
GREER C. TIDWELL
Regional Administrator,
United States Environmental
Protection Agency - Region IV

EXHIBIT A

Outline of research and development program aimed at eliminating Barnhardt's usage of 1,1,1-Trichloroethane in its glues by finding by an alternative adhesive.

1. Research adhesive market to compare alternative water-based adhesives.

2. Select viable candidates for water-based adhesive tests.

3. Conduct plant trials of water-based adhesives and drying systems needed for water-based adhesives over three-month period by using the adhesives on representative products.

4. Evaluate products manufactured with water-based adhesives over three-month period.

5. Select alternative adhesive if a viable water-based adhesive is found to exist.

Exhibit A/PPAB3

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IV

IN THE MATTER OF:	)	
	)	
Stone Container Corporation	)	Resource Conservation and
Containerboard and Paper Division	)	Recovery Act
One Everitt Avenue	)	
Panama City, Florida 32402	)	Section 3008(a)(1)
EPA ID No.: FLD982080129	)	42 U.S.C. Section
	)	6928(a)(1)
Respondents	)	
	)	Docket No.: 91-09-R

CONSENT AGREEMENT AND FINAL ORDER

A Complaint and Compliance Order (Complaint) was issued against Respondent Stone Container Corporation on February 19, 1991. The Complaint was issued pursuant to Section 3008(a)(1) of the Resource Conservation and Recovery Act (RCRA), 42 U.S.C. § 6928(a)(1), as amended, and pursuant to the Consolidated Rules of Practice Governing Administrative Assessment of Penalties or the Revocation or Suspension of Permits, found at 40 C.F.R. Part 22. The Complainant is the Director, Waste Management Division, United States Environmental Protection Agency, Region IV (EPA).

The parties have conferred for the purpose of settlement pursuant to 40 C.F.R. § 22.18 and desire to settle this action. Accordingly, before any testimony has been taken, upon the pleadings and without any admission of violation or any adjudication of any issue of fact or law, Respondent Stone Container Corporation hereby agrees to comply with the terms of this Consent Agreement and Final Order (CAFO).

PRELIMINARY STATEMENTS

1. Respondent has been served with a copy of the Complaint together with a Notice of Opportunity for Hearing in this matter and has filed an Answer pursuant to 40 C.F.R. § 22.15.

2. For purposes of this Consent Agreement and Final Order only, Respondent admits that the Regional Administrator has jurisdiction over this matter pursuant to Section 3008 of RCRA, as amended, 42 U.S.C. § 6928.

3. Respondent is a corporation doing business in the State of Florida and is a person as defined in Section 1004(15) of RCRA, 42 U.S.C. § 6903(15).

4. Respondent owns a facility at One Everitt Avenue, Panama City, Florida.

5. At the facility, EPA alleges that Stone Container Corporation generates one liquid waste stream having a pH below two (2.0) and one liquid waste stream having a pH above twelve point five (12.5). These waste streams are generated in the facility's water purification process which utilizes cation/anion exchange demineralization units. Sulfuric acid and sodium hydroxide are used to regenerate the active ingredients in the cation/anion exchange units. Sulfuric acid use for the regeneration of the cation demineralization units currently averages between 240,000

and 300,000 pounds per month. EPA alleges that at the time of and prior to the inspection, each waste stream was disposed of into the facility's demineralization/backwash pond prior to discharge to the publicly owned treatment works. EPA alleges that this pond is a surface impoundment which is not in compliance with the requirements of 40 C.F.R. § 268.5.

6. Based on an inspection of the Stone Container Corporation facility conducted on January 30, 1990, by EPA, Complainant alleged in the Complaint that Respondent illegally disposed of hazardous waste at the facility, in violation of RCRA and regulations promulgated thereunder.

7. Respondent owns and operates a bark boiler wet scrubber at its facility. The scrubber uses caustic mixed with water as its scrubbing agent. Stone Container Corporation currently purchases and uses virgin caustic in the scrubber.

8. Respondent has fully complied with the technical requirements set forth in the Complaint.

9. Respondent neither admits nor denies liability in connection with the matters addressed by the Complaint.

10. Respondent consents to the payment of the civil penalty set forth in this CAFO and performance of the Pollution Reduction Project set forth in this CAFO.

11. The parties agree that settlement of this matter is in the public interest and fully complies with the applicable requirements of RCRA.

FINAL ORDER

Based upon the foregoing stipulations, the parties agree to the entry of the following Final Order in this matter:

A. Payment of Civil Penalty

1. Respondent consents to pay a civil penalty in the amount of $244,800.00 in this matter as stipulated in paragraphs A.2. and A.3. below.

2. Within thirty (30) business days of the receipt of a fully executed copy of this CAFO, Respondent shall make a penalty payment in the amount of $100,000.00. Payment shall be made as set forth in paragraph A.4. below.

3. In lieu of the remaining civil penalty of $144,800.00, Respondent agrees to perform the Pollution Reduction Project set forth in paragraphs B.2. and B.5. below. If Respondent fails to perform the Pollution Reduction Project in accordance with the dates contained in paragraphs B.2. and B.5. below, Respondent shall pay an additional penalty payment of $144,800.00 to EPA within thirty (30) business days of its failure to meet those deadlines. Payment shall be as set forth in paragraph A.4. below.

4. Payments shall be made by cashier's or certified check payable to the Treasurer, United States of America, and tendered to the United States Environmental Protection Agency, P.O. Box 100142, Atlanta, Georgia 30384. If any payment is not received within thirty (30) business days of being due, interest, handling charges and late-payment penalties will begin to accrue as set forth at 31 U.S.C. § 3717. Respondent shall provide a copy of the check to:

Regional Hearing Clerk
United States Environmental Protection Agency
Region IV
345 Courtland Street, N.E.
Atlanta, Georgia 30365

B. Pollution Reduction Project

1. Respondent shall install and operate two new cation demineralization units in the facility's water purification plant. The installation of the new cation demineralization units is designed to reduce the amount of sulfuric acid used in the regeneration of the cation demineralizers to between 25% and 50% of that currently used.

2. Respondent shall complete installation of the two new cation demineralization units no later than June 30, 1992. Respondent has estimated that this Pollution Reduction Project will cost approximately $578,000, as set forth in Attachment 1.

3. After completion of the installation activities referred to in Paragraph B.1., Respondent shall use caustic discharge

from the anionic regeneration units in partial replacement of the virgin caustic currently used in the bark boiler wet scrubber.

4. Respondent shall notify EPA in writing no later than ten (10) calendar days prior to final installation of the two new cation demineralization units.

5. Within thirty (30) business days of completion of the activities referred to in Paragraph B.2., Respondent shall submit to EPA proof of the purchase of the two new cation demineralization units and shall provide a summary of the final costs of the construction of the Pollution Reduction Project. The Respondent's facility plant manager shall certify that the receipts and costs are true and correct to the best of his/her knowledge and belief.

6. If Respondent does not or will not complete any of the obligations mandated by this CAFO within the time periods specified in this CAFO, Respondent shall have the burden of proving to EPA that the Respondent is or was rendered unable by Force Majeure to carry out the those obligations under this CAFO. Force Majeure is defined for purposes of this CAFO as an event arising from causes entirely beyond the control of Respondent and of any entity controlled by Respondent, including its contractors and subcontractors, which could not have been

overcome by due diligence and which delays or prevents the performance of any obligation under this CAFO. Examples of events which do not constitute Force Majeure include, but are not limited to, increased costs or expenses of performing the Pollution Reduction Project and the financial difficulty of Respondent to perform the Pollution Reduction Project. Within seven (7) business days of when Respondent first received actual knowledge of such event, Respondent shall advise EPA in writing of the anticipated duration and cause of the delay, all actions taken and/or to be taken to minimize the delay, and a schedule for completion of activities remaining to be performed under this CAFO. If EPA agrees that a delay is or was caused by a Force Majeure event, the time for performance hereunder shall be extended for a period not to exceed the actual delay resulting from such event. Respondent shall have the burden of proving that the delay was caused by a Force Majeure event, that the duration of the delay is warranted under the circumstances, and that best efforts were exercised to avoid and mitigate the effects of the delay. Failure to comply with the notification provisions of this Paragraph shall preclude the Respondent from asserting Force Majeure for an event.

7. Provided that Respondent complies with the provisions of this CAFO, this CAFO shall constitute a full and complete settlement of and shall release the Respondent from all liability, fines and penalties under Section 3008(a) of RCRA

relating to or arising out of all claims asserted or which could have been asserted in this matter.

8. The provisions of this CAFO shall be deemed satisfied upon the full implementation of the action set forth in Paragraphs A.2. and B.2., or alternatively, Paragraphs A.2. and A.3.

EFFECTIVE DATE

The effective date of this CAFO shall be the date it is approved by the Regional Administrator.

Agreed to this 21ST day of OCT., 1991.

Stone Container Corporation

Agreed to this 29TH day of Oct., 1991

Donald J. Guinyard
Director
Waste Management Division
United States Environmental Protection Agency
Region IV

It being agreed, it is so Ordered, this 30th day of Oct., 1991.

Greer C. Tidwell
Regional Administrator

ATTACHMENT A

Stone Container Corporation

Division Containerboard & Paper

Location Panama City Mill

Project No. 98111

BREAKDOWN OF ESTIMATED COSTS

DESCRIPTION DEMINERALIZED WASTE WATER TREATMENT

COST	
CATIONS (2 EA)	200,000
PUMP EXISTING WASTE TANK	8,000
FANS (H2S REMOVAL)	6,000
PIPING	51,000
INSTRUMENTATION	28,000
ELECTRICAL	46,000
LABOR (MECHANICAL & ELECTRICAL)	148,000
ENGINEERING	8,000
TAXES	31,000
FREIGHT	7,000
CONTINGENCIES	46,000
TOTAL COST	$578,000

CERTIFICATE OF SERVICE

I hereby certify that the original of the foregoing Consent Agreement and Final Order was hand delivered to the Regional Hearing Clerk for Region IV of the United States Environmental Protection Agency.

I further certify that I have caused one copy of the foregoing Consent Agreement and Final Order to be served upon each of the persons listed below, by causing said Consent Agreement and Final Order to be deposited in the U.S. Mail (First Class, Certified Mail, Return Receipt Requested and Postage Prepaid) at Atlanta, Georgia:

The Honorable Thomas W. Hoya
Administrative Law Judge
U.S. Environmental Protection Agency
Mail Code A-110
Washington, D.C. 20460

Charles A. Perry, Esq.
Robert Hogfoss, Esq.
Hunton & Williams
2500 One Atlanta Plaza
950 East Paces Ferry Road
Atlanta, Georgia 30326

Dated this 31th day of October, 1991.

Judy Greene

36816 a PDF

DOCUMENTS DISTRIBUTED BY THE US EPA POLLUTION PREVENTION CLEARINGHOUSE[1]

POLLUTION PREVENTION INFORMATION CLEARINGHOUSE/POLLUTION INFORMATION EXCHANGE SYSTEM (PPIC/PIES)

PPIC-1	PPIC General Information Package
PPIC-2	"PPIC: The Pollution Prevention Information Clearinghouse." US EPA Office of Environmental Engineering and Technology Demonstration and Office of Pollution Prevention. April 1990.
PPIC-3	"PIES: The Pollution Prevention Information Exchange System." US EPA Office of Environmental Engineering and Technology Demonstration and Office of Pollution Prevention. May 1989. Brochure.
PPIC-4	"Pollution Prevention Information Exchange System (PIES) User Guide, Version 1.1." US EPA Office of Environmental Engineering and Technology Demonstration and Office of Pollution Prevention (EPA/600/9-89/086). September 1989. 70 pp.

INTERNATIONAL CLEANER PRODUCTION INFORMATION CLEARINGHOUSE (ICPIC)

ICPIC-1	"Cleaner Production Newsletter." United National Environmental Programme (UNEP). Industry and Environment Office. Current Issue. 4 pp.
ICPIC-2	"ICPIC: The International Cleaner Production Information Clearinghouse." UNEP Industry and Environment Office and US EPA Office of Environmental Engineering and Technology Demonstration and Office of Pollution Prevention. April 1990. Brochure.

WASTE ASSESSMENT MANUALS

WAM-1	"Pollution Prevention Benefits Manual: Volume 1 (DRAFT)." US EPA, Office of Solid Waste and Office of Policy, Planning, and Evaluation. October 1989. 92 pp.
WAM-2	"Profiting From Waste Reduction In Your Small Business." Alaska Health Project. 1988. 46 pp.
WAM-3	"Waste Minimization Opportunity Assessment Manual." US EPA, Hazardous Waste Engineering Research Laboratory (EPA/625/7-88/003). July 1988. 100 pp.

INDUSTRY-SPECIFIC WASTE ASSESSMENT MANUALS

ISM-1	"Case Studies from the Minnesota Technical Assistance Program and the Oregon Hazardous Waste Reduction Program: Metal Finishing." Compiled from MnTAP and OHWRP fact sheets. November 1989. 50 pp.
ISM-2	"Case Studies from the Pollution Prevention Information Clearinghouse: Electroplating." US EPA Office of Environmental Engineering and Technology Demonstration and Office of Pollution Prevention. November 1989. 52 pp.
ISM-3	"Case Studies from the Pollution Prevention Information Clearinghouse: Printing." US EPA Office of Environmental Engineering and Technology Demonstration and Office of Pollution Prevention. November 1989. 20 pp.

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[1]**IT Environmental Programs. (September 1991).** ***Pollution Prevention Reporting for EPCRA Section 313--Draft.*** **Cincinnati: EPA, Office of Toxic Substances.**

ISM-4	"Case Studies from the Pollution Prevention Information Clearinghouse: Solvent Recovery." US EPA Office of Environmental Engineering and Technology Demonstration and Office of Pollution Prevention. November 1989. 32 pp.
ISM-5	"Guides to Pollution Prevention: The Commercial Printing Industry." US EPA. Office of Research and Development, Pollution Prevention Branch. 1990.
ISM-6	"Guides to Pollution Prevention: The Fabricated Metal Industry." US EPA Office of Research and Development, Pollution Prevention Branch. 1990.
ISM-7	"Guides to Pollution Prevention: The Paint Manufacturing Industry." US EPA Office of Research and Development, Pollution Prevention Branch. 1990.
ISM-8	"Guides to Pollution Prevention: The Pesticide Formulating Industry." US EPA Office of Research and Development, Pollution Prevention Branch. 1990.
ISM-9	"Guides to Pollution Prevention: The Printed Circuit Board Manufacturing Industry." US EPA Office of Research and Development, Pollution Prevention Branch. 1990.
ISM-10	"Guides to Pollution Prevention: Research and Education Institutions." US EPA Office of Research and Development, Pollution Prevention Branch. 1990.
ISM-11	"Guides to Pollution Prevention: Selected Hospital Waste Streams." US EPA Office of Research and Development, Pollution Prevention Branch. 1990.
ISM-12	"Guidelines for Waste Reduction and Recycling: Metal Finishing, Electroplating, Printed Circuit Board Manufacturing." Oregon Department of Environmental Quality, Hazardous Waste Reduction Program. July 1989. 35 pp.
ISM-13	"Guidelines for Wastes Reduction and Recycling: Solvents." Oregon Department of Environmental Quality, Hazardous Waste Reduction Program. August 1989. 45 pp.
ISM-14	"Pollution Prevention in Metal Manufacturing: Saving Money Through Pollution Prevention." US EPA, Office of Solid Wastes and Emergency Response (draft version 1.0). October 1989. 23 pp.
ISM-15	"Pollution Prevention in Printing and Allied Industries: Saving Money Through Pollution Prevention." US EPA, Office of Research and Development and Office of Pollution Prevention (draft version 1.0). October 1989. 16 pp.
ISM-16	"Waste Minimization in Metal Parts Cleaning." US EPA, Office of Solid Waste and Emergency Response (EPA/530-SW-89-049). August 1989. 50 pp.

FACT SHEETS

Alaska Health Project: Waste Reduction Tips

FAKH-1	All Businesses
FAKH-2	Dry Cleaners
FAKH-3	Photofinishers
FAKH-4	Print Shops
FAKH-5	Vehicle Repair Shops

California Department of Health Services: Waste Reduction Fact Sheets

FCAD-1	Aerospace Industry
FCAD-2	Asbestos Handling, Transport, and Disposal
FCAD-3	Automotive Repair Shops
FCAD-4	Commercial Printing Industry
FCAD-5	Metal Finishers
FCAD-6	Paint Formulators
FCAD-7	Pesticide Formulating Industry
FCAD-8	Printed Circuit Board Manufacturers
FCAD-9	Waste Reduction Can Work for You

City of Los Angeles: Fact Sheets

FCLA-1	Aerosol Containers
FCLA-2	For Users of Safety Kleen, Inc.
FCLA-3	Plating with Trivalent Chrome Instead of Cr+6
FCLA-4	What Should I Do With My Electroplating Sludge?

City of Santa Monica: Hazardous Waste Reduction Fact Sheets

FCSM-1	Automotive Painting
FCSM-2	Commercial Dry Cleaners
FCSM-3	General Commercial Printers
FCSM-4	General Guidelines
FSCM-5	Machine Toolers
FSCM-6	Metal Finishing
FSCM-7	Paint Formulating Industry
FSCM-8	Photographic Processors
FSCM-9	Printed Circuit Board Industry
FSCM-10	Vehicle and Equipment Repair and Maintenance Shops

County of San Diego: Hazardous Waste Fact Sheet

FCSD-1	Reduce Hazardous Waste

US EPA Headquarters, Office of Pollution Prevention: Pollution Prevention Fact Sheets

FPPO-1	EPA's 2% Set Aside Pollution Prevention Projects
FPPO-2	EPA's "List of Lists" Projects
FPPO-3	EPA's Pollution Prevention Incentives for States
FPPO-4	Guides to Pollution Prevention
FPPO-5	Local Governments and Pollution Prevention
FPPO-6	1991 Small Business Pollution Prevention Grants
FPPO-7	Pollution Prevention Act of 1990
FPPO-8	Pollution Prevention Training and Education
FPPO-9	Setting Up a Pollution Prevention Program

US EPA Headquarters, Office of Solid Wastes: Recycling Fact Sheets

FOSW-1	Municipal Solid Waste
FOSW-2	Plastics: The Facts about Production, Use, and Disposal
FOSW-3	Plastics: The Facts on Degradable Plastics
FOSW-4	Plastics: The Facts on Source Reduction
FOSW-5	The Facts on Recycling Plastics

US EPA Region III: Pollution Prevention Fact Sheets

FREG-1	Chemical Production
FREG-2	Coal Mining
FREG-3	Demolition
FREG-4	Electrical Power Generation
FREG-5	Getting More Use Out of What We Have
FREG-6	Metal Finishing

FREG-7	Oil Refining
FREG-8	Opportunities in Waste Water Treatment
FREG-9	Paper Manufacturing
FREG-10	Pollution Prevention (General)
FREG-11	Printing
FREG-12	Steel Manufacturing

Florida Department of Environmental Resources: Fact Sheet

FFLD-1	Pollution Prevention Through Waste Reduction

Michigan Department of Natural Resources: Waste Reduction Fact Sheets

FMID-1	Conservation Tips for Business
FMID-2	Glossary of Waste Reduction Terms
FMID-3	How Business Organization Can Help
FMID-4	Increase Your Corporate and Product Image
FMID-5	Michigan's Solid Waste Reduction Strategy
FMID-6	Procuring Recycled Products
FMID-7	Reducing Corrugated Cardboard Waste
FMID-8	Reducing Office Paper Wastes
FMID-9	Selecting a Supplier, Hauler, and Materials Broker
FMID-10	Waste Exchange: Everybody Wins
FMID-11	Waste Reduction Checklist
FMID-12	Waste Reduction: Getting Started
FMID-13	Waste Reduction Overview
FMID-14	Why Reduce Waste?

Michigan Office of Waste Reduction Services: Case Study

FMIO-1-1	Northern Fibre Operations, Sheller-Globe Corporation
FMIO-1-2	United Technologies Automotive Engineered Systems Division

Michigan Office of Waste Reduction Services: Fact Sheets

FMIO-2-1	Conservation Tips for Businesses
FMIO-2-2	Considerations in Selecting a Still for On-site Recycling
FMIO-2-3	Glossary of Waste Reduction Terms
FMIO-2-4	Increase Your Corporate and Product Image
FMIO-2-5	Managing Used Containers
FMIO-2-6	Procuring Recycled Products
FMIO-2-7	Reducing Corrugated Cardboard Waste
FMIO-2-8	Reducing Machine Coolant Waste
FMIO-2-9	Reducing Office Paper Waste
FMIO-2-11	Solvent Reduction in Metal Parts Cleaning
FMIO-2-12	Waste Exchanges: Everybody Wins!
FMIO-2-13	Waste Reduction Checklist
FMIO-2-14	Waste Reduction Overview
FMIO-2-15	Waste Reduction--Getting Started
FMIO-2-16	Why Reduce Waste?

Minnesota Office of Waste Management: Pollution Prevention Fact Sheet

FMNO-1 Minnesota's Toxic Pollution Prevention Act

Minnesota Pollution Control Agency: Waste Reduction Fact Sheet

FMNP-1 Waste Exchange Services

Minnesota Technical Assistance Program: Case History/Case Study/Success Story

FMNT-1-1 An Organizational Strategy for Pollution Prevention
FMNT-1-2 Metal Recovery: Ion Exchange/Electrolytic Recovery
FMNT-1-3 Metal Recovery: Ion Exchange
FMNT-1-4 Metal Recovery: Etchant Substitution
FMNT-1-5 Waste Minimization: Auto Salvage Yard
FMNT-1-6 Solvent Reuse: Technical Institute
FMNT-1-7 Hazardous Material Exchange: Concrete Panel Manufacturer
FMNT-1-8 Effluent Minimization: Metal Finishing Shop
FMNT-1-9 Solvent Management: Printing Press
FMNT-2-1 Refrigerant Reclamation Equipment/Services
FMNT-2-2 Reverse Osmosis
FMNT-2-3 On-site Solvent Reclamation
FMNT-2-4 Equipment Information for Printers
FMNT-2-5 Ultrafiltration

Minnesota Technical Assistance Program: Fact Sheets

FMNT-3-1 Managing Empty Containers
FMNT-3-2 Waste Management Guidance for Oil Clean-up
FMNT-3-3 Reducing Waste Usages with Cooling Towers
FMNT-3-4 Management Options for Old Paint and Pain Related Materials
FMNT-3-5 Considerations in Selecting a Still for On-site Recycling
FMNT-3-6 Properly Maintaining a Gunwasher to Minimize Waste
FMNT-3-7 Considerations in Metals Recycling
FMNT-3-8 Options for Shop Rags from Printers
FMNT-3-9 Reducing Solvent Emissions from Vapor Degreasers
FMNT-3-10 Prolonging Machine Coolant Life
FMNT-3-11 Reducing Volatile Emissions in the Fiberglass Fabrication Industry
FMNT-3-12 Hazardous Waste Fact Sheet for Minnesota Generators
FMNT-3-13 Waste Minimization Fact Sheet

Minnesota Technical Assistance Program: Intern Reports

FMNT-4-1 Process Water Reduction in a Wire Milling Operation (Summer 1989)
FMNT-4-2 Reduction of Solvent Emissions from Vapor Degreasing (Summer 1989)
FMNT-4-3 Trichloroethylene and Stoddard Solvent Reduction Alternatives in a Small Shop (Summer 1989)
FMNT-4-4 Alternatives to CFC-113 Used in the Cleaning of Electronic Circuit Boards (Summer 1991)
FMNT-4-5 Reducing Chlorinated Solvent Emissions from Three Vapor Degreasers (Summer 1991)
FMNT-4-6 Reducing Shingle Waste at a Manufacturing Facility (Summer 1991)

Minnesota Technical Assistance Program: Waste Reduction Checklists

FMNT-5-1	Cleaning
FMNT-5-2	Coating/Painting
FMNT-5-3	Formulating
FMNT-5-4	Machining
FMNT-5-5	Operating Procedures
FMNT-5-6	Plating/Metal Finishing

New Jersey Department of Environmental Protection: Technical Information Publications

FNJD-1-1	Fabricated Metal Manufacturing and Metal Finishing
FNJD-1-2	Vehicle Maintenance

New Jersey Department of Environmental Protection: General Information

FNJD-2-1	Hazardous Waste Minimization

North Carolina Agricultural Extension Service: Fact Sheets

FNCA-1-1	Chemigation Practices to Prevent Groundwater Contamination
FNCA-1-2	Design for In-Filled Sprayer Rinse System to Reduce Pesticide Wastes
FNCA-1-3	Disposal of Aircraft Rinsewater
FNCA-1-4	Disposal of Unused Pesticides, Tank Mixes, and Rinsewater
FNCA-1-5	Pesticide Container Disposal
FNCA-1-6	Preventing Pesticide Pollution of Surface and Groundwater
FNCA-1-7	Preventing Well Contamination by Pesticides
FNCA-1-8	Protecting Groundwater from Contamination by Pesticides
FNCA-1-9	Protecting Mountain Springs from Pesticide Contamination
FNCA-1-10	Reducing Pesticides and Saving Money Using Integrated Pest Management (IPM)

North Carolina Agricultural Extension Service: Pollution Prevention Pays in Food Processing

FNCA-2-1	Cut Waste and Reduce Surcharges for Your Dairy Plant
FNCA-2-2	Dairy CEOs: Do You Have a $500 Million Opportunity?
FNCA-2-3	Liquid Assets for Your Dairy Plant
FNCA-2-4	Liquid Assets for Your Poultry Plant
FNCA-2-5	Poultry CEOs: You May Have a $60 Million Opportunity
FNCA-2-6	Poultry Processors: You Can Reduce Waste Load and Cut Sewer Surcharges
FNCA-2-7	Survey Shows That Poultry Processors Can Save Money By Conserving Water
FNCA-2-8	Systems for Recycling Water in Poultry Processing
FNCA-2-9	Water and Wastewater Management in a Dairy Processing Plant

North Carolina Pollution Prevention Pays Program: Pollution Prevention Tips

FNCP-1	Developing and Implementing a Waste Reduction Program
FNCP-2	Drag-Out Management and Electroplaters
FNCP-3	Dye Bath and Bleach Bath Reconstitution for Textile Mills
FNCP-4	Pollution Prevention Publications Checklist
FNCP-5	Small Solvent Recovery Systems
FNCP-6	Solvent Loss Control--Things You Can Do Now
FNCP-7	Waste Reduction Options: Automobile Salvage Yards

FNCP-8	Waste Reduction Options: Radiator Service Firms
FNCP-9	Waste Reduction Techniques: An Overview
FNCP-10	Water and Chemicals Reduction for Cooling Towers
FNCP-11	Water Conservation for Electroplaters: Counter-Current Rinsing
FNCP-12	Water Conservation for Electroplaters: Rinse Tank Design
FNCP-13	Water Conservation for Electroplaters: Rinsewater Reuse
FNCP-14	Water Conservation for Textile Mills

Ohio Technology Transfer Organization: Waste Reduction Fact Sheet

FOTT-1	Waste Reduction Checklist

Oregon Department of Environmental Quality: Pollution Prevention Profiles

FORD-1	A Generator's Checklist
FORD-2	The Alexander Motor's Success Story
FORD-3	The Eastside Plating Success Story
FORD-4	The Tektronics Payoff
FORD-5	The Wacker Payoff

Virginia Waste Minimization Program: Waste Reduction Fact Sheets

FVAW-1	Acids/Bases
FVAW-2	Automotive Repair
FVAW-3	Lead Acid Batteries
FVAW-4	Managing Empty Containers
FVAW-5	Metal Recovery: Printed Circuit Board Manufacturer
FVAW-6	Paints, Inks, and Other Residuals
FVAW-7	Printed Circuit Board Manufacturer
FVAW-8	Reuse Strategies for Local Governments
FVAW-9	Rinsewater Reduction: Metal Finishing Shop
FVAW-10	Solvent Recovery: Fiber Production Plant
FVAW-11	Source Reduction Techniques for Local Government
FVAW-12	Video Tapes Available from the Virginia Waste Minimization Program
FVAW-13	Waste Exchanges
FVAW-14	Waste Minimization: Auto Salvage Yard
FVAW-15	Waste Minimization in Photographic Processing
FVAW-16	Waste Minimization in the Workplace
FVAW-17	Waste Reduction for the Aerospace Industry
FVAW-18	Waste Reduction for the Commercial Printing Industry
FVAW-19	Waste Reduction for Metal Finishers
FVAW-20	Waste Reduction Techniques: An Overview

Washington State Department of Ecology: Pollution Prevention Fact Sheets

FWAD-1	Auto Body Shops
FWAD-2	Automotive Repair Shops
FWAD-3	Drycleaners
FWAD-4	Photoprocessors
FWAD-5	Printing Shops

GENERAL POLLUTION PREVENTION INFORMATION

GEN-1 "Environmental Labeling in the United States--Background Research, Issues, anD Recommendations (Draft Report)." US EPA, Office of Pollution Prevention, December 1989. 69 pp.

GEN-2 "Federal Register Notice: Draft Guidance to Hazardous Waste Generators on the Elements of a Waste Minimization Program." US EPA (OSWER-FR-3421-1). June 12, 1989. 8 pp.

GEN-3 "PPIC User Bulletin" (Insert in Pollution Prevention News). US EPA Office of Environmental Engineering and Technology Demonstration and Office of Pollution Prevention. March 1990. 4 pp.

GEN-4 "Pollution Prevention in the Dye Industry." US EPA, Office of Pollution Prevention. June 1991. Brochure.

GEN-5 "Pollution Prevention." US EPA, Office of Pollution Prevention. Current Month's Issue. 6 pp.

GEN-6 "Pollution Prevention Research Branch: Current Projects." US EPA, Office of Research and Development (RREL). June 1990. 46 pp.

GEN-7 "Pollution Prevention Research Plan: Report to Congress." US EPA, Office of Research and Development (EPA/600/9-90-015). March 1990. 84 pp.

GEN-8 "Pollution Prevention Training Opportunities in 1991." US EPA, Office of Policy, Planning, and Evaluation and Office of Research and Development. March 1991. 85 pp.

GEN-9 "Preventing Pollution Through Efficient Water Use." Office of Policy, Planning, and Evaluation and the Office of Water (20W-0002). July 1990. Brochure.

GEN-10 "Report on the US Environmental Protection Agency's Pollution Prevention Program." US EPA, Office of Policy, Planning, and Evaluation. May 1991. 23 pp.

GEN-11 "Toxic Substances Control Act (TSCA) Consent Order: 3-V Chemical Corporation." US EPA, Office of Pesticides and Toxic Substances. August 7, 1990. 16 pp.

GEN-12 "Toxic Substances Control Act (TSCA) Consent Order: Sherex Polymers, Inc." US EPA, Office of Pesticides and Toxic Substances. January 30, 1990. 18 pp.

GEN-13 "Waste Exchange Information Package," (Contains current contact list for all North American exchanges, a background article, and a fact sheet). Compiled by the PPIC, June 1991. 10 pp.

GEN-14 "Waste Minimization: Environmental Quality with Economic Benefits." US EPA, Office of Solid Waste and Emergency Response (EPA/530-SW-87-026). April 1990. 27 pp.

GEN-15 "US EPA Pollution Prevention Strategy." US EPA, Office of Policy, Planning, and Evaluation. January 1991. 45 pp.

LOAN VIDEOS

A total of three video tapes may be loaned to an individual at the same time; requests should be limited to that number.

VID-1 "Beyond Business as Usual: Meeting the Challenge of Hazardous Waste." US EPA Region VIII. 28:30 min.

VID-2 "Less Is More: Pollution Prevention Is Good Business." US EPA, Office of Solid Waste. 23:13 min.

VID-3 "Introduction to the Pollution Prevention Information Clearinghouse." US EPA, PPIC. March 1990. 48 min.

VID-4 "3M's Pollution Prevention Pays Program and Challenge to Innovation." 3M Corporation. 1984, 1987. 9:00 min., 8:30 min.

VID-5 "Smart Moves." Chevron Corporation. 21:26 min.

VID-6 "Waste Not...Want Not." US EPA Region IV. 15 min.

VID-7 "The 1988 WRAP Awards." Dow Chemical. July 1989. 8:36 min.

POLLUTION PREVENTION INSTRUCTION MANUALS

Hazardous Waste Minimization Manual for the Small Quantity Generator

This manual provides information and guidance to small quantity generators on pollution prevention practices and suggested compliance requirements under the Resource Conservation and Recovery Act (RCRA) and other related State and Federal acts. The manual investigates the following subjects: the advantages of pollution prevention; the regulatory environment for waste reduction; pollution prevention approaches; how to conduct a waste audit; general, industry-specific, and waste-specific pollution prevention practices; and financing a waste reduction program. The manual includes a chapter of sources of pollution prevention information, as well as appendices covering regulatory issues relevant to the small quantity generator. An expanded edition of this manual is available with inserts pertaining to Pennsylvania generators.

Center for Hazardous Materials Research, October 1989
University of Pittsburgh Applied Research Center
320 William Pitt Way
Pittsburgh, PA 15238
(412)826-5320, (800)334-CHMR
Cost: $50

Industrial Waste Audit and Reduction Manual

The first step to effective waste reduction is a systematic audit of plant processes. The "Industrial Waste Audit and Reduction Manual" explains each step of the audit process, including determining the origin, characteristics, and volume of wastes being produced; evaluating waste disposal methods and costs; weighing costs and benefits of different waste reduction measures; and deciding on the best, most cost-effective methods for your operation. This manual is targeted at small- and medium-sized companies, and can be used by both technical and nontechnical staff. It includes example water audit case studies from printed circuit board manufacturing, steel pickling, and detergent manufacturing companies, and devotes one section to sources of pollution prevention information and assistance.

Ontario Waste Management Corporation, 1990
Attention: John Richmond
2 Bloor Street West, 11th Floor
Toronto, Ontario, Canada M4W3E2
(416)923-2918
Cost: $40

Industrial Waste Prevention

This practical guide provides step-by-step instructions to develop an effective waste minimization program. It includes forms, work sheets, and original waste prevention ideas that are relatively inexpensive and do not require major changes in your plant. The guide is designed for in-plant use for the prevention of hazardous and solid industrial waste and covers the following topics: the environmental manager's role, waste prevention planning, formation of a waste prevention committee, waste generation costs, and the development of waste prevention ideas.

Waste Advantage, Inc., 1988
17117 West Nine Mile Road
Southfield, MI 48075
(313)569-8150
Cost: $195 (includes access to technical assistance hotline)

Management and Minimization of Hazardous Waste Under RCRA

This manual was written as a teaching aid for workshops designed to meet the training requirements of the Resource Conservation and Recovery Act for North Carolina industries. Although its focus lies with educating generators about the Act's regulatory requirements, it promotes pollution prevention as the best means to avoid the legal and economic burdens of waste generation. The manual discusses how to plan a waste reduction program and conduct an audit, use operating practices conducive to preventing pollution, and motivate people to alter their behavior and adopt a waste reduction mentality.

North Carolina State University, September 1989
Industrial Extension Service, College of Engineering
PO Box 7909
Raleigh, NC 27695-7909
(919)737-2303
Cost: Contact the University for cost and availability information

New York State Waste Reduction Guidance Manual

This manual was prepared specifically for businesses located in New York and provides detailed descriptions of waste reduction techniques for major waste-generating processes used by State industries. Both in-state and out-of-state businesses can use this manual to learn more about waste reduction benefits, waste reduction techniques that may be applicable to their processes and waste streams, and ways to conduct a waste reduction audit. The NYS Waste Reduction Guidance Manual introduces the concepts necessary to undertake waste reduction, including starting and sustaining a waste reduction effort, investigating opportunities, identifying options, and performing feasibility analysis. Appendices provide additional sources of information, work sheets, a glossary, and applicable rules and regulations.

New York State Department of Environmental Conservation, March 1989
Division of Hazardous Substances Regulation
Bureau of Hazardous Waste Program Development
50 Wolf Road
Albany, NY 12233-7253
(518)485-8400
Cost: Contact the DEC for cost and availability information

Pollution Prevention Pays Instruction Manual

This manual was developed to introduce the concept of pollution prevention and cost savings to individuals entering the industrial work force. Pollution Prevention Pays, or PPP, is a management approach that results in a change from end-of-the-pipe measures for controlling pollution to preventative measures which 1) minimize or eliminate the production of pollution, and 2) result in savings to a company. The main concepts of the manual are 1) current legal and environmental issues which create the need for an industrial pollution-reduction program, and 2) an innovative systems approach to industrial-resource management that can reduce pollution and increase profits. The manual includes activity plans, materials, and information for instructors that focus on a basic problem-solving approach to waste reduction and management. The activities emphasize elimination of pollution at its source through process modification, product reformulation, recycling, and conservation of raw materials.

Western Carolina University, North Carolina Department of Natural Resources
North Carolina Pollution Prevention Pays Program, and the Gildea Foundation, June 1988
Dr. Susan Smith
Center for Improving Mountain Living
Bird Building
Western Carolina University
Cullowhee, NC 28723
(704)227-7492
Cost: $28

Profiting from Waste Reduction in Your Small Business

This publication helps small business managers and their employees work together to identify and implement methods to reduce industrial wastes. Moreover, it is designed to help managers and employees see their industrial waste as a financial resource rather than unavoidable byproducts of their business process. This manual shows how to organize a business to promote waste reduction, review business plans for waste reduction potential, conduct a waste reduction audit, evaluate a waste reduction program, and learn specific strategies for nine common business processes. It includes a section covering waste reduction resources for small businesses.

Alaska Health Project, 1988
431 West 7th Avenue, Suite 101
Anchorage, AK 99501
(907)276-2864
Cost: Free

Toxics Use Reduction Guide

This guide was developed to educate Colorado industry about the benefits of reducing the generation of toxic chemicals. It advocates a waste management strategy based on pollution prevention--not end-of-pipe treatment--which can lead to economic savings, reduced regulatory requirements, improved worker health, and protection of the environment. These claims are reinforced in a case study of Polaroid Corporation's pollution prevention success. The Toxics Use Reduction Guide includes a section that explains how any company can establish its own waste reduction program, from the planning stage to implementation. A list of pollution prevention contacts is also included.

Colorado Public Interest Research Group (CoPIRG), 1989
1724 Gilpin
Denver, CO 80218
(303)355-1861
Cost: $2

Waste Minimization: Manufacturers' Strategies for Success

The purpose of this guide is to inform both small and large manufacturers about ways to curtail waste generation and prevent the release of pollutants into the environment. It emphasizes the need for widespread voluntary initiatives to reduce hazardous waste generation. It answers such questions as "What is waste minimization?" and "Why should I establish and implement a waste reduction program?" before describing how manufacturers can establish their own pollution prevention programs. The guide briefly describes success stories from corporate and industry-specific programs and includes appendices on assistance resources, recommended reading, and terminology.

National Association of Manufacturers, 1989
1331 Pennsylvania Avenue, NW
Washington, DC 20004-1703
(202)637-3000
Cost: $19.95 (member); $29.95 (non-member)

Waste Minimization Opportunity Assessment Manual

This manual describes US EPA's recommended procedure for identifying hazardous waste pollution prevention opportunities. It was designed to promote EPA's preferred waste management strategy, which ranks source reduction and recycling first and second, respectively. The manual describes in detail how to conduct a waste assessment, from the planning/organization phase through the assessment and feasibility analysis, to final implementation of the pollution prevention options. The manual contains numerous appendices, including work sheets, an example waste assessment, causes and sources of waste, pollution prevention techniques, lists of government-sponsored assistance programs, and discussions of economic evaluation methods. The Waste Minimization Opportunity Assessment Manual is targeted at both those responsible for reducing waste streams and those interested in general information about pollution prevention. This manual is suitable for use as a primary text in a training course or as part of a technical assistance outreach effort.

US EPA Office of Research and Development, July 1988 (EPA/625/7-88-003)
Hazardous Waste Engineering Research Laboratory
Cincinnati, OH 45268
Cost: Free

Waste Minimization Resource Manual

This manual was designed for use by industry personnel at all levels who are involved with planning or implementing a pollution prevention program. The first section describes elements that constitute such a program: an overview of the pollution prevention concept; the statutory and regulatory framework; incentives; how to start, track, and evaluate a waste reduction program; and how to conduct a waste assessment. The remainder of the Waste Minimization Resource Manual is devoted to brief discussions of the various pollution prevention technologies.

Chemical Manufacturers' Association, June 1989
2501 M Street, NW
Washington, DC 20037
(202)887-1100
Cost: $40 (member); $60 (non-member)

Waste Minimization Training Modules

The California Department of Health Services' Alternative Technology Division is currently developing three pollution prevention training modules. Each module will consist of a workbook (which includes a text and self-testing exercise) and a supporting video. The topics of the modules are:

- Module 1--Waste Minimization for Hazardous Materials Inspectors (expected release: February 1991)
- Module 2--Conducting a Hazardous Waste Audit (expected release: March 1991)
- Module 3--Waste Minimization in the Metal Finishing Industry (expected release: April 1991)

California Department of Health Services, 1991
Attn: Robert Ludwig
Alternative Technology Division
714/744 P Street
PO Box 942732
Sacramento, CA 94234-7320
(916)324-1807
Cost: Contact the DHS for cost and availability information

Waste Reduction Assessment and Technology Transfer (WRATT) Training Manual (Second Edition)

This manual was originally developed by the University of North Carolina at Asheville's Environmental Quality Institute, with funding provided by EPA Region IV and the Tennessee Valley Authority. A second edition has been compiled and edited by the University of Tennessee's Center for Industrial Services. The manual was designed to train retired engineers, State employees, and affiliated university personnel to design or implement a waste reduction technical assistance program, but it is also suitable for businesses and waste assessment teams. The WRATT Training Manual concentrates on procedures that motivate people to search, screen, and put into practice measures involving administrative, material, or technology changes that result in decreased waste generation. It includes information on waste reduction awareness and incentives, Federal safety standards, State and Federal regulations, how to establish a waste reduction program and conduct a waste assessment, and waste reduction approaches for specific industries and waste types. The manual includes an industry preassessment checklist packet and appendices including sources of pollution prevention information, bibliographies, a directory of pollution prevention-related services, and a list of waste exchanges.

Tennessee Valley Authority, October 1989
Roosevelt Allen
Bicentennial Volunteers, Inc.
600 Summit Hill Drive
Knoxville, TN 37902
(615)632-8089
Cost: $40 (bulk quantity discounts available)

Waste Reduction in Your Business

This manual was prepared to assist Washington State businesses in reducing the amount of hazardous waste they produce. It is intended to be a tool that business managers and their employees can use to understand the benefit of waste reduction, learn how to start a waste reduction program, conduct a waste reduction audit, evaluate waste reduction options, and know who to call for assistance. The manual draws on both the EPA Waste Minimization Opportunity Assessment Manual and Profiting from Waste Reduction in Your Small Business.

Washington State Department of Ecology, November 1989
Office of Waste Reduction, Recycling and Litter Control
4407 Woodview Drive, SE
Lacey, WA 98503
(206)438-7541
Cost: Contact the DE for cost and availability information

STATE WASTE REDUCTION PROGRAMS

ALABAMA
Hazardous Material Management and Resource Recovery Program
University of Alabama
PO Box 6373
Tuscaloosa, AL 35487-6373
(205)348-8401

ALASKA
Alaska Health Project
Waste Reduction Assistance Program
431 West Seventh Avenue, Suite 101
Anchorage, AK 99501
(907)276-2864

ARKANSAS
Arkansas Industrial Development Commission
One State Capital Mall
Little Rock, AR 72201
(501)371-1370

CALIFORNIA
Alternative Technology Section
Toxic Substances Control Division
California State Department of Health Service
714/744 P Street
Sacramento, CA 95234-7320
(916)324-1807

CONNECTICUT
Connecticut Hazardous Waste Management Service
Suite 360
900 Asylum Avenue
Hartford, CT 06105-1094
(203)244-2007

Connecticut Department of Economic Development
210 Washington Street
Hartford, CT 06106
(203)522-7196

GEORGIA
Hazardous Waste Technical Assistance Program
Georgia Institute of Technology
Georgia Technical Research Institute
Environmental Health and Safety Division
O'Keefe Building, Room 027
Atlanta, GA 30332
(404)894-3806

Environmental Protection Division
Georgia Department of Natural Resources
Floyd Tower Easte, Suite 1154
205 Butler Street, SE
Atlanta, GA 30334
(404)656-2833

ILLINOIS
Hazardous Waste Research and Information Center
Illinois Department of Energy and Natural Resources
1808 Woodfield Drive
Savoy, IL 61874
(217)333-8940

Industrial Waste Elimination Research Center
Pritzker Department of Environmental Engineering
Alumni Building, Room 102
Illinois Institute of Technology
3300 South Federal Street
Chicago, Il 60616
(312)567-3535

INDIANA
Environmental Management and Education Program
Young Graduate House, Room 120
Purdue University
West Lafayette, IN 47907
(317)494-5036

Indiana Department of Environmental Management
Office of Technical Assistance
PO Box 6015
105 South Meridian Street
Indianapolis, IN 46206-6015
(317)232-8172

IOWA
Center for Industrial Research and Service
205 Engineering Annex
Iowa State University
Ames, IA 50011
(515)294-3420

Iowa Department of Natural Resources
Air Quality and Solid Waste Protection Bureau
Wallace State Office Building
900 East Grand Avenue
Des Moines, IA 50319-0034
(525)281-8690

KANSAS
Bureau of Waste Management
Department of Health and Environment
Forbes Field, Building 730
Topeka, KS 66620
(913)296-1607

KENTUCKY
Division of Waste Management
Natural Resources and Environmental Protection Cabinet
18 Reilly Road
Frankfort, KY 40601
(502)564-6716

LOUISIANA
Department of Environmental Quality
Office of Solid and Hazardous Waste
PO Box 44307
Baton Rouge, LA 70804
(504)342-1254

MARYLAND
Maryland Hazardous Waste Facilities Siting Board
60 West Street, Suite 200A
Annapolis, MD 21401
(301)974-3432

Maryland Environmental Service
2020 Industrial Drive
Annapolis, MD 21401
(301)269-3291
(800)492-9188 (in Maryland)

MASSACHUSETTS
Office of Safe Waste Management
Department of Environmental Management
100 Cambridge Street, Room 1094
Boston, MA 02202
(617)727-3260

Source Reduction Program
Massachusetts Department of Environmental Quality Engineering
1 Winter Street
Boston, MA 02108
(617)292-5982

MICHIGAN
Resource Recovery Section
Department of Natural Resources
PO Box 30028
Lansing, MI 48909
(517)373-0540

MINNESOTA
Minnesota Pollution Control Agency
Solid and Hazardous Waste Division
520 Lafayette Road
St. Paul, MN 55155
(612)296-6300

Minnesota Technical Assistance Program
University of Minnesota
1313 Fifth Street, SE, Suite 207
Minneapolis, MN 55414
(612)627-4555
(800)247-0015 (in Minnesota)

Minnesota Waste Management Board
123 Thorson Center
7323 Fifty Eighth Avenue North
Crystal, MN 55428
(612)536-0816

MISSOURI
Director, Environmental Improvement and Energy Resource Authority
225 Madison Street
PO Box 744
Jefferson City, MO 65102
(314)751-4919

NEW JERSEY
New Jersey Hazardous Waste Facilities Siting Commission
Room 614
28 West State Street
Trenton, NJ 08608
(609)292-1459
(609)292-1026

Hazardous Waste Advisement Program
Bureau of Regulation and Classification
New Jersey Department of Environmental Protection
401 East State Street
Trenton, NJ 08625

Risk Reduction Unit
Office of Science and Research
New Jersey Department of Environmental Protection
401 East State Street
Trenton, NJ 08625
(609)984-6070

NEW YORK
New York State Environmental Facilities Corporation
50 Wolf Road
Albany, NY 12205
(518)457-3273

NORTH CAROLINA
Pollution Prevention Pays Program
Department of Natural Resources and Community Development
Post Office Box 27687
512 North Salisbury Street
Raleigh, NC 27611
(919)733-7015

Governor's Waste Management Board
325 North Salisbury Street
Raleigh, NC 27611
(919)733-9020

Technical Assistance Unit
Solid and Hazardous Waste Management Branch
North Carolina Department of Human Resources
PO Box 2091
306 North Wilmington Street
Raleigh, NC 27602
(919)733-2178

OHIO
Division of Solid and Hazardous Waste Management
Ohio Environmental Protection Agency
PO Box 1049
1800 Watermark Drive
Columbus, OH 43266-0149
(614)481-7200

Ohio Technology Transfer Organization
Suite 200
65 East State Street
Columbus, OH 43266-0330
(614)466-4286

OKLAHOMA
Industrial Waste Elimination Program
Oklahoma State Department of Health
PO Box 53551
Oklahoma City, OK 73152
(405)271-7353

OREGON
Oregon Hazardous Waste Reduction Program
Department of Environmental Quality
811 Southwest Sixth Avenue
Portland, OR 97204-1390
(503)229-5913

PENNSYLVANIA
Pennsylvania Technical Assistance Program
501 F. Orvis Keller Building
University Park, PA 16802
(814)865-0427

Center for Hazardous Materials Research
University of Pittsburgh Applied Research Center
320 William Pitt Way
Pittsburgh, PA 15238
(412)826-5320

Bureau of Waste Management
Pennsylvania Department of Environmental Resources
PO Box 2063
Fulton Building
Third and Locust Streets
Harrisburg, PA 17120
(717)787-6239

RHODE ISLAND
Ocean State Cleanup and Recycling Program
Rhode Island Department of Environmental Management
9 Hayes Street
Providence, RI 02908-5003
(401)277-3434
(800)253-2674 (in Rhode Island)

Center for Environmental Studies
Brown University
PO Box 1943
135 Angell Street
Providence, RI 02912
(401)863-3449

TENNESSEE
Center for Industrial Services
105 Student Services Building
University of Tennessee
Knoxville, TN 37996
(615)974-2456

Center for Industrial Services
University of Tennessee
Suite 606
226 Capital Blvd. Building
Nashville, TN 37219-1804
(615)242-4816

VIRGINIA
Office of Policy and Planning
Virginia Department of Waste Management
Monroe Building, 11th Floor
101 North 14th Street
Richmond, VA 23219
(804)225-2667

WASHINGTON
Hazardous Waste Section
Mail Stop PV-11
Washington Department of Ecology
Olympia, WA 98504-8711
(206)459-6322

WISCONSIN
Bureau of Solid Waste Management
Wisconsin Department of Natural Resources
PO Box 7921
101 South Webster Street
Madison, WI 53707-7921
(608)267-3763

WYOMING
Solid Waste Management Program
Wyoming Department of Environmental Quality
Herschler Building, 4th Floor, West Wing
122 West 25th Street
Cheyenne, WY 82002
(307)777-7752