Case Histories of Cost Saving Through Waste Reduction by Tennessee Industries

A joint project of

The Tennessee Department of Environment and Conservation
Tennessee Valley Authority Industrial Waste Reduction
and
The University of Tennessee Center for Industrial Services

1997

Introduction

The Tennessee Valley Authority (TVA), the Environmental Protection Agency (EPA) and the eight states in EPA's Region IV pooled resources to fund a waste reduction assistance project using retirees. The first assessments were conducted in Tennessee beginning in 1989. That project consisted of assessments for 32 industries that volunteered to participate. The assessments identified opportunities for the annual reduction of 950 tons of hazardous waste, 600 tons of nonhazardous solid waste, and 680,000 gallons of wastewater.

Four years later, the industries involved in the pilot project were asked to provide information about their implementation of the assessment recommendations and about the results, in terms of both waste reduction and cost savings. Five of the 32 industries declined to participate or requested that their results remain completely confidential to protect proprietary interests or for other reasons. The remaining 27 industries agreed to allow publication of their results only as anonymous case studies.

In this pilot project, retirees conducted about 75% of the total assessment work; staff from The University of Tennessee Center for Industrial Services (UT CIS) provided the remaining 25 %.

The results were originally published in a 1994 report compiled by W. H. Uhtenwoldt, a retiree with the UT CIS Waste Reduction Assistance Program and Don Rucker, a technical report writer with TVA. The report was prepared for the UT CIS world wide web home page in 1997 by Tammy Hunt, student intern with UT CIS.

No information has been updated, but is reported as is, hoping to be the creative sparkplug needed to fire waste reduction efforts in similar industries throughout the world. Dollar savings reflect cost information available at the time of the report. Compliance and waste reduction recommendations were based upon the Tennessee environmental regulations in place at the time of the report. Technical and economic feasibility of waste reduction must be considered by each company. Consult local regulations as a part of any waste reduction effort.

More About Waste Reduction Assistance Programs

Efforts by various levels of government to promote sound waste management and environmental protection – typically through laws and regulations – have often been less effective than desired and more costly to enforce than expected. Understandably, industry has often been more concerned about reducing compliance costs and their effects on profits than about reducing wastes and their effects on the environment. The threat of penalties has produced suspicion of inspections and assessments, resistance to almost any prescribed changes, and at best, only grudging, minimal compliance with the letter of the law.

Many states have instituted waste reduction assistance (WRA) or pollution prevention programs to address these problems and the unserved need they represent. In contrast to regulation and enforcement, the WRA approach is based on voluntary cooperation among industries, university industrial extension programs, and state and federal agencies. Most of the state programs offer this assistance as free, nonregulatory, nonbinding, and confidential. It is no the threat of enforcement penalties but the opportunity for significant cost savings that motivates industries to make any changes that may be suggested.

In EPA Region IV state WRA programs, assessments are specifically made outside the context of regulatory and enforcement processes, and the results are held strictly confidential to protect proprietary interests.

Also, industries are under no obligation to implement any of the suggested changes. However, most industries are not only willing but even eager to implement some or all of the changes recommended because they want to take advantage of the associated cost savings.

The WRA approach does not compete with private enterprise. Such assessments are not commonly available from private consulting firms in the region. Also, many small companies would not make the speculative investment in contracting for such services even if they were available, because the extent of any potential saving cannot be identified until after the survey is completed.

On the other hand, the project may actually stimulate demand for commercial services. WRA assessments do not include designing or constructing any facilities or equipment that may be needed or modifying any processes or techniques as may be recommended. Industries must either implement the waste reduction suggestions on their own or contract with private consulting firms, construction contractors, or other commercial services.

Using Retirees

WRA costs are kept low because assessments are conducted by retired senior-level engineers specifically recruited and trained to identify and report opportunities for waste reduction. Although these retirees are reimbursed for travel expenses and are paid a modest hourly honorarium to supplement their retirement income, essentially, they volunteer their services as a means of passing on to the next generation the benefit of their specialized expertise and experience. Because the pool of available assessors contains specialists with many years of experience in almost every possible Standard Industrial Classification (SIC) Code it is usually possible to choose expertise that closely matches the needs of any particular industry. Frequently, it is possible to reduce travel costs by selecting well-qualified retirees who live in the vicinity of the assessment.

Financial Summary

The 27 companies that reported results docmented a combined annual savings of $2,380,626.

Total cost of retirees conducting the 32 audits was $59,000.

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Waste Reduction Case Study

Type of Industry: Carpet Yarn Spinning
SIC Code: 2281

Abstract:

This plant is part of a yarn-spinning mill, and its principal product is nylon carpet yarn for internal consumption only. The facility annually spins 233,000 bales of fiber.

There are no hazardous wastes generated from the spinning and dying operation. Drums of fiber treating chemicals such as lubricating agents and fugitive dyes are returned to the vendor for reuse. The chemicals are all water based so that no hazardous fumes are evolved by evaporation.

CIS did identify three non-hazardous waste streams:

1. Plastic wrap (Polyethylene) - This material covers the incoming bales of fiber.

2. Steel strapping which ties the bales into a unit.

3. Grease rags.

Currently these wastes are disposed of in an open dumpster. It was suggested that the plastic wrap, being a recyclable material, be sold. Information was provided relative to companies in this business.

The steel strapping, another recyclable, being disposed of to a landfill, should be chopped into small segments, stored in a drum and sold off, at the time of this visit, at $85/ton. Information of a company who purchases this type of steel scrap was provided. There was not any information available on weight or cubic yards of waste to landfill, but with an annual consumption of 14,000,000 pounds of yarn, the waste should be considerable.

Each incoming bale of fibers weighs 600 pounds, that is 233,000 bales annually. Lots of plastic, lots of steel strapping. Sell-off would relieve the local landfill considerably.

The recycling of grease rags was discussed and the conclusion was that because of the plant's location, recycling is more expensive than disposal.

Other wastes noted in small volume, such as cardboard paper. Due to insignificant quantity, no suggestions were offered.

Results

- A recycler hauls away, without charge or payment, 24 tons of plastic wrap annually, saving $432 in disposal costs.

- A recycler buys more than 72 tons of steel strapping annually ($1 per hundredweight) and hauls it offsite for recycling, without charge. Return of $1450 annually.

- A recycler hauls away, without charge, waste oils for recycling, eliminating disposal costs of $2500 annually.

- To reduce emissions from the use of coal, the company converted to natural gas and pays “pipeline rates”.

Waste Reduction Case Study

Type of Industry: Fabric Coating
SIC Code: 2295

Abstract:
This company is a manufacturer of vinyl and polyurethane coated fabrics for use in boot liners, shoe uppers and insulating jackets and cap material. In 1989 this company's use of 4,200 gallons of VOC solvents contributed to 30,000 pounds of VOC emissions, including wash solvents.

CIS suggested the replacement of solvent materials with a water-based material with the following production line potential percentages:

1. Vinyl Coating.....67%
2. Printed Top Coat.....50%
3. Vertical Cans.....50%

This would achieve a significant cut back in VOC emissions.

It was further suggested that they could replace the solvent type ink, where they can, without affecting the product, with water-based ink.

The above cost suggestion would generate cost savings of $35,000/year. The solvent changes alone would save $29,000 annually.

Results

A water-based coating was substituted for solvent coating, and "plastic sol," a material which is used to make vinyl and which can be recycled into the process, was substituted for solvent for cleaning pumps.

- VOC emissions were reduced by 206,000 pounds annually.
- Hazardous material disposal costs were reduced by $7000 annually.
- Solid waste was reduced by 31,000 pounds annually.
- Raw material costs savings totaled $13,000 annually.

Waste Reduction Case Study

Type of Industry: Wood Kitchen Cabinets
SIC Code: 2434

Abstract:
This company manufactures wood cabinets for domestic use. This facility has an established waste reduction program, which works well except for the large amounts of waste wood generated at the site.

Waste wood removal costs averaged $98,000/year. These dollars eat away the bottom line. Their scrap wood was estimated at 7,386 tons/year of which 1,056 tons was used as a supplemental fuel in Plant #1 boilers. This leaves 6,312 tons as excess, which is scrapped.

1. CIS suggested that they consider the purchase of the necessary augmentation of Plant #1 boiler with a second boiler to reduce natural gas usage to minimal amount. With the additional boiler plus the use of wood as fuel in Plant #2 an additional 1,208 tons of wood waste disposal cost would be eliminated at a savings of $19,000. Gas cost savings would be an estimated $77,000/year. Total savings would be $96,000.

The above suggestion requires a capital outlay of an estimated $229,000, with a four year pay back.

2. Solvent and paint wastes are minimized by reuse, internal recycle and distillation recovery in the plant.

Result

- Natural gas usage was eliminated in plant # 1 by installing a “hammerhead hog” to grind wood waste into chips for burning.
- Wood waste requiring landfilling was reduced 50% annually, for cost savings of $49,000.
- Wood waste hauling costs were reduced 20% annually.
- Natural gas costs savings were negated by increasing landfill costs for the remaining wood waste.

Waste Reduction Case Study

Type of Industry: Magazine Printing
SIC Code: 2721

Abstract:
This company's principal products are magazines and catalogs, along with newspaper inserts. Being a new plant, waste reduction programs were already in place for paper, ink, pallet recycling and solvent recovery. However, CIS noted the following suggestions after their plant assessment.

1. Substantial reduction of potable water can be realized by substituting well water for all process cooling water and lawn sprinkling. According to their records, they were using four times more water than normal for sanitary purposes.

2. When pre-press operations are complete in 1990, pre-treatment should be considered for aqueous discharge for reduction of bio-chemical oxygen demand (BOD). Chemical oxygen demand (COD) adjustment prior to discharge to the public owned treatment works (POTW). They currently exceed their permit limits for BOD and COD and are paying a monthly surcharge.

They rent "Safety-Kleen" stations for each printing press. They contain 25 gallons of Varsol, in the sump, used to clean metal parts. Varsol is petroleum naphtha. It is estimated that 15 gallons of Varsol per change out is vaporized in the work areas. CIS suggested that the substitution of an aqueous base detergent for surface cleaning would limit the use of Varsol to parts washing only.

3. Their solid waste was under control relative to pallets and cardboard, although more care should be taken as to what goes into the trash. CIS noted recyclables such as paper, cardboard and aluminum drink cans.

4. To avoid disposal cost for waste ink and to save money on ink purchases, CIS recommended they formulate a used ink blend from waste ink present on-site. By using information from a pilot project in California, CIS was able to help them with the technical details of ink blending. This would require an installation of an ink mill, which could salvage 28% of the waste ink.

Result:

- Sewer charges were reduced $10,000 annually.
- The number of Varsol stations were reduced from 43 to four and cleanout frequency was increased from two to three weeks, saving $5000 annually.

- Solid waste was reduced by more than 75% through employee involvement and improved separation techniques for paper and pallets.

- An ink-blending mill salvaged 90% of waste ink, saving and estimated $200,000 to $250,000 annually.

Waste Reduction Case Study

Type of Industry: Offset Printing
SIC Code: 2752

Abstract:
This company prints church related magazines, telephone company bill inserts and a magazine. They are advanced in waste management programs for streams such as paper, pallets, water, silver and aluminum waste. However, there appeared to be a need to replace solvents and to encourage proper disposal of ink kits.

1. CIS suggested that since they feed their presses with 40,000 pounds of ink annually @ $4.00/pound average in 5 and 25 pound kits, they should not send the used kits to a landfill, which contain an estimated residual total of 10-15 pounds/day. Arrangements should be made with their ink supplier to return kits containing usable ink for credit. The supplier can convert the various colors to black, which is the predominant industry color. This action will reduce landfill waste by 3,748 pounds/year, and glean back credit from the ink supplier.

2. CIS suggestions, relative to cleaning the presses with solvents was to select an aqueous cleaner as a replacement.

They could immediately contact a firm to set up the needed solvent cleaning stations and take away the spent solvents for recovery. With this accomplished they should do some R&D work searching out a suitable aqueous cleaner.

Results:

- The company is still testing various water-based cleaners, looking for a substitute for solvent, but each cleaner tested so far has caused production problems and resulted in finished products that do not meet company standards.

- The ink supplier did not welcome residual ink for blending.

- Landfilling of residual ink was reduced 2000 pounds annually through improved housekeeping in draining more ink from the kits before disposal and having this residue hauled offsite by a recycler. This resulted in saving $8000 annually.

Waste Reduction Case Study

Type of Industry: Greeting Cards
SIC Code: 2771

Abstract:
This corporation is a lithographic printer of greeting cards and internal printing forms. They requested an assessment of waste reduction potential.

The following wastes were found:

Hazardous	Non-Hazardous
Isopropanol	Paper
Blanket Wash	Paper Cores
Photo Scrap Film/Solutions	Aluminum Plates
	Waste Oil
	Waste Ink

Suggestions made by CIS were as follows:

1. Isopropanol: Atmospheric loss by evaporation is minimal since the solution is chilled. An accidental loss is severe in their continuous system, because this line by-passes the centralized mixer directly to the sewer. Suggestion was made to reduce risk of hazardous loss by installing a double block and bleed arrangement in the piping.

2. Blanket Wash: The hazardous waste resulting from this every four hour clean-up generates 2,640 pounds/month, which includes ink, the only contaminant. Suggestion was made to install a suitable cartridge filter to remove the waste ink and recycle the filtrates to eliminate hazardous waste disposal costs of $3,000/year.

3. Scrap Film: The plant uses an outside contractor to recover silver from waste solutions from proofing contractors and waste film, but any legal liability lies with the plant. Suggestion was made for them to purchase its own silver recovery unit This will afford them full control over the hazardous material and enjoy 100% of the recovered value.

4. Waste paper is segregated into mixed and white paper. They produced, and sold, 111,000 pounds/month of mixed paper at $70/ton and 11,000 pounds/month of white paper at $330/ton. No changes were suggested.

5. Paper cores, or rolls, are now discarded. It was suggested they be ground up and sold to a recycler for further processing.

6. Scrap aluminum plates are sold at $.80/pound. No suggestions were made.

7. Waste oil generated is 150 gallons/month and is given away to an outside contractor. This oil is not subject to contamination or thermal degradation, so it should be recycled and blended with fresh make-up oil to reduce costs and amount of oil sent off-site.

8. Waste Ink is generated at the rate of 2,600 pounds/month and is valued at $3.00/pound or $7,800/month. CIS suggested they reclaim the waste ink as black ink using virgin black ink as make-up. Black ink is the predominant color in the printing industry. Including drum removal, ink recovery costs in such a program could be $4,000/month additional savings.

Results:

- The use of isopropanol was eliminated.
- Volatile organic compound emissions were reduced 180,000 pounds annually.
- Improved segregation of white paper, printed paper, and solid waste saved $8000 annually by using the municipal solid waste system instead of a private disposal service.

Waste Reduction Case Study

Type of Industry: Printing Ink Manufacturer
SIC Code: 2893

Abstract:
This corporation manufactures printing ink in liquid form for both the gravure and flexographic processes. Their printing ink liquids are of 75% of solvent base and 25% of water base.

Their waste streams were identified as solvent wash and water wash.

Solvent wash is generated from the cleaning of batch drums and pigment mills when changing ink color. If this waste is not recycled into darker ink, it is stored in 55-gallon drums on a "diked" concrete pad outside the building. Their annual disposal costs are $8,840 per year.

CIS determined that at the present production levels, solvent waste generation is approximately 136 drums per year. The consideration of a solvent recovery system would significantly reduce disposal cost and increase raw material purchase savings. Assuming that 50% is non-recoverable sludge, 68 drums of solvent would be possible from the solvent recovery system. The estimated savings would be approximately $17,510 annually.

Water wash waste is mop-up water from the production area. It comprises cleaning water, which contains possible hazardous waste from the ink blending and wash water solvent clean up.

This material is stored on the same "diked" concrete pad as the solvent wash. Disposal costs is $6,630 per year. Although this water wash waste contains heavy metals form pigments, it has never been analyzed "hazardous".

CIS suggested that a large tank, possibly a plastic septic tank, stored on a pad outside the plant would provide a solids settling tank for the water wash waste. This tank could be cleaned out and the sludge disposed of once or twice a year. They should place the decant clear liquid into a drum sparged with air to remove VOCs, check pH and neutralize with lime, if necessary and empty gradually to sewer. This disposal method was estimated to save $5,967 per year in disposal costs with the assumption the sludge content would be reduced by 90%.

Non-contact cooling water, a non-hazardous waste, is used to cool the pigment grinding mills. After one pass through the cooling jackets water is dumped directly into the sanitary sewer. This constitutes 85% of the plant's water use at a cost of $11,138 annually. The water temperature is the same for entry to the grinding mill as it is when it exits to the sewer.

CIS suggested, as an option, the introduction of a water chilling unit into a closed loop water circulating system which would circulate the water until it has reached a given temperature. At this determined temperature, the system could be purged with the use of a heat sensitive valve. This rudimentary recirculating system was provided for their investigation and consideration.

Results:

- Disposal costs were reduced $1800 annually.
- Raw material costs were reduced $1200 annually.
- Wash water and mill flush water are reused in blended ink.
- Even though it does not clean batch drums and pigment mills as well, isopropyl acetate was substituted for N-propyl acetate because it allowed more compatible reuse of solvent waste in blended ink.
- Installation of an ink splitter and a waste water treatment system reduced wastewater sludge.
- Installation of a cooling water recirculation system is still under consideration.

Waste Reduction Case Study

Type of Industry: Trailer and Industrial Tires
SIC Code: 3011

Abstract:
This corporation is a manufacturer of industrial rubber tires, e.g., golf carts, riding lawn mowers etc. They requested a waste reduction assessment to be done at one of their plants focusing on scrap tire waste.

The assessment team learned that 71% of their waste volume came from scrap tires. They produced an average of 150 scrap tires per operating day. This reflects 2.08% of production. The company goal is 0.60%. Tires become scrap because they have quality defects, which are caused by product variability. Quality improvement is best defined as the minimization of process variability. This report relates primarily to tire scrap reduction.

The hazardous wastes identified were 250 pounds per month of cement solvent and a "special waste", 360 pounds per month; a mixture of paint, grease and oils. Licensed operators remove and dispose of these wastes. A recycling program is in place relative to solvents, oil, metal scrap and paper. Their hazardous waste totals only 600 pounds per month, classifying them as a small quantity generator.

The CIS waste assessment team summarized the processing waste generated in one month and note the following:

1. 71% of the total scrap value for the month ($58,000) resulted from scrap tires, $41,000.

2. Nylon scrap in the form of 2-sided coated fabric, was 23% of the total, or $13,000.

3. Scrap tires and nylon waste contributed to 93% of the total scrap dollars. This scrap reflects a part of the 60,000 pounds per month of solid waste to landfill.

The CIS team offered the following suggestions:

1. Control "sticher" pressure variations. It is believed that the variation in the sticher pressure allows air to "pocket" and is the cause of poor bonding. The use of accumulators, located close to the machine, would stabilize the pressure and would minimize this defect.

2. Install non-evasive measuring devices to gauge calendar products. This will eliminate waste due to "windows" for hand gauging by measuring gauge or mass at any point across the sheet. Corrective adjustments can be made on the calendar immediately. This should improve the quality of the interliner and reduce waste at the bias cutters and in the finished product, tires.

3. Keep calendar rolls free of rubber. Any rubber build-up on the rolls causes nylon yarn to be locally stretched when it passes over the built-up area and will 'heat-set'. The nylon memory will cause it to shrink and pucker.

4. Use of a tensiometer to measure nylon tension. The tension of the nylon appears to vary considerably. This measurement will establish a "norm" to control excessive tension stretch, which causes puckering.

5. Develop a better method for measuring the bias cutting angle. Control of the bias cutting angle must be kept within $\pm$ 1/2 degrees. The method currently used is not one of precision. One third of the measurements indicate the need for adjustments when no adjustment is required. CIS provided a suggested method for a more accurate level of measurement.

6. Reduce stock for "on-floor-inventory". Stock stored on the factory floor is subjected to contamination. There is no control of foreign substance invasion.

One last item noted by CIS was the many condensate leaks in the steam system that serves the curing molds. Lost condensate increases boiler load, boiler water treatment cost and wastewater discharge. It is always economically beneficial to fix steam and air leaks.

Results:

No results were reported.

Waste Reduction Case Study

Type of Industry: Hydraulic Industrial Hose
SIC Code: 3052

Abstract:
This corporation is a manufacturer of rubber and thermoplastic hydraulic and industrial hoses. The CIS waste assessment team concerned themselves with two waste streams, namely the water and trichloroethane. Their solid non-hazardous waste was disposed of in their own licensed landfill operation.

Flammable solids and liquids were disposed of off-site. Licensed haulers transport the lead oxide sludge, crushed drums and cans. This subject was not addressed.

Two recycling water systems are used throughout the plant. One is cooling water and the other is plant water, which includes condensed steam. The water picks up lead, oil and grease.

The lead is removed by passing the water through a clarifier where a flocculating agent precipitates the lead oxide to the bottom of the outlet pool of the clarifier. This lead sludge is pumped out by a chemical waste disposal company. Throughout this water treatment process system, oil and grease is floating on the water. Their present system of skimming off by a hand operation is not satisfactory.

CIS suggested an improved method of oil skimmers that use a floating tube system. The closed loop tube made of a flexible plastic attracts oil but not water. These units continuously drain the oil-covered tubes through scrapers and return the clean tubes to the water to attract more oil. It was estimated that the pay back for such a system would be less than one year.

The 1,1,1, trichloroethane in the amount of 120,000 pounds and at a cost of $55,000 evaporated into the plant atmosphere in 1988.

CIS suggested that the emissions be captured at the area of evaporation to reduce employee exposure and recovered to reduce emissions to the atmosphere. The best available technology is the use of carbon absorption beds. They would have to determine, along with the supplier, the volume of air to pass through the carbon beds. This would determine the size.

They could recover 85% of the 120,000 pounds valued at $55,000, or $47,000. An estimate of a solvent recovery system that could handle 1,000 cubic feet of air per minute is approximately $50,000.

Results:

The company controlled the mixture of hazardous and nonhazardous materials, improved the oil removal system in the water treatment plant, and changed to a water-based substitute for trichloroethane to dissolve lubricant.

- Hazardous waste was reduced 29,000 pounds annually, saving $15,000 per year.

- Disposal costs were reduced 25%.

Waste Reduction Case Study

Type of Industry: Rubber Molded Products (Car Floor Mats)
SIC Code: 3069

Abstract:
This company manufactures rubber floor mats by vacuum molding for the automotive industry. This type of manufacture generates a great deal of solid waste material amounting to six truck loads a day, four of scrap rubber, one of pallets and cardboard and one of paper bags. This type of scrap is generated by incoming raw materials. Butyl rubber comes in cardboard boxes. The mixing chemicals - clay, sulfur, and calcium carbonate - arrive in paper bags. All are on pallets.

Rubber scrap, which is cured rubber trim, is generated at 190,000 pounds per week, 50,000 pounds of this cured scrap is milled into powder. 25,000 pounds are used in compounding. This leaves 140,000 pounds going to the landfill and equivalent of 20-truck loads/week @ 3 1/2 tons per truckload.

1. CIS suggested that by reducing the sheet size of the uncured calendared rubber by 2% would reduce the cured rubber waste by 19,000 pounds to the landfill. Reducing the waste rubber by 140,000 pounds to 121,000 pounds would be a raw material saving of $0.25/pound or $4,750/week, or $247,000/year.

2. It was further noted that the 2% sheet size reduction should be furthered pre-trimmed to conform more to the molded shape, which should afford an additional 10,000 pounds of uncured trim for reuse. This 10,000 pounds is an additional saving of $2,500/week or $130,000/year and reduces the landfill cost.

3. A third suggestion relative to scrap rubber was to increase the use of cured hammermilled powder in-house by 5,000 pounds/week, and to increase sales of this powder by 5,000 pounds/week. The net results being a reduction of 10,000 pounds/week of scrap going to the landfill. The net cost of the hammermill process is $0.12/pound, cost saving would be $1,200/week, or $62,000/year.

If all three options were employed, it would result in savings of $439,000 with a scrap reduction to landfill of 2,000,000 pounds/year, or approximately 300 truckloads.

Installation of a new bulk storage system will eliminate paper bags from the wastestream. The use of returnable metal racks with their major customers is an ongoing program which to date has reduced pallets purchased from $600,000/year to $120,000/year. Unusable pallets are given to their employees.

Results:

Reduced-size sheets caused excessive loss of time in aligning molds. Internal use of powdered rubber scrap could not be increased and it was cheaper at the time to buy raw material than to make powdered rubber.

Waste Reduction Case Study

Type of Industry: Rubber Weather Strips
SIC Code: 3069

Abstract:
This corporation manufactures rubber and vinyl automotive weather strips and seals. They reported six wastestreams:

1. Solid waste, scrap rubber and vinyl extrusions, paper, cardboard and general trash: 1,296 cubic yards per day to landfill.

Waste generated at the extruder results from start-up, shutdown and defective material. Care should be taken initially with the incoming raw material to eliminate contamination during storage and handling which results in losses. Care should be taken at the extruder to control feed and speed throughout the long lines to minimize defective material. A program should be established quantifying this waste into categories by cause; e.g. set-up, tooling change, defective extrusions and end run pieces. This program would highlight the causes so that production alternatives can be established.

2. Wood pallets appear to be no problem. A local user hauls them away at no cost.

3. The plant generates contact and non-contact cooling water, which is discharged to the sewer system. This water is used for cooling and is recycled through an air-cooled heat exchanger. The amount used is nominal and creates no concern. A monthly fee of 414.00 for an unused water meter can be eliminated.

4. The solids collected by the water curtain in the spray booth are removed by skimming and filtering. This waste is air dried and landfilled and creates no concern at this time.

5. The Siluxes and glues are a hazardous waste containing solvents such as toluene and Methyl Ethyl Ketone (MEK). CIS suggested that since the “pot life” of Silux is limited, a master batch can be made, but the curing agent would be added at the point of use, providing only as much material as can be completely consumed before becoming unusable. Since the curing agent comprises only 4% of the total mixture, it can be added to a suitable quantity of the master batch by means of a burette or another type of volumetric device. This would reduce the hazardous waste caused by exceeding the “pot life” of the material. Savings should result in material cost, record keeping and disposal cost.

The company generates less than 50% of the quantity allowed a small quantity generator, but growth and change in product mix could result in a one-month generation rate over the 2,200-pound limit. Should this occur, they would become a large quantity generator for the entire year.

6. The 45 pounds of Naphtha used in the machine shop is disposed of as a hazardous waste by Safety-Kleen.

At the time of this waste reduction assessment, their automotive customers were on a "just in time" delivery release. This type of program, which is good for the automotive industry, causes havoc with manufacturers' production schedules. "Just in time" programs give you "windows" of firm ship dates and "windows" for planning purposes. It was suggested that they increase their production runs by combining their release dates. This will increase their in-process and finish goods inventory, but the reduction in waste costs would more than offset their inventory handling cost.

Results:

No results were reported for suggestions based on the assessment; however, other changes not addressed by the assessment emerged from the enhanced awareness of waste reduction opportunities:

- The company is installing a cardboard compactor and baler to reduce landfill waste.
- The company reduced by $1800 annually the cost of removing wood pallets.

Waste Reduction Case Study

Type of Industry: Fused Magnesite Ore
SIC Code: 3295

Abstract:
This corporation converts the raw material, magnesite ore into electric grade and refractory grade magnesium oxide by heating the mineral to a temperature greater than 5,000° F, in an electric furnace. They produce 7,200 tons annually of magnesia.

They requested assistance from CIS in locating an additive other than 20% hydrochloric acid solution that they use for external cooling of their furnaces and the cables leading to the carbon electrodes in these furnaces. They do recover and use these liquids, but have to replenish on a regular basis. They were reporting the amount added to the system to regulatory authorities and desired to identify an additive other than hydrochloric acid that would be free from regulatory concerns.

They are adding 650 kg per year of 20% hydrochloric to the recirculating cooling water and believed this was generating a hazardous waste. However, the hydrochloric acid is consumed in the process and does not generate a hazardous waste.

CIS noted that there was no recycling program in place relative to waste paper, aluminum and metal straps. It was suggested that they start such a program and return those segregated materials back into the recyclable main stream.

CIS noted that a part of the finishing process is the removal of metal fines that are present either from introduction with the ore or picked up along the way from the finishing equipment. These fines are removed magnetically and become a production waste stream designated as "special waste" and sent to the landfill. Some magnesia product is removed along with the metal fines during the magnetic removal process. It was suggested that if the company could find an easy and convenient method of separating the two, the magnesia could be returned to the process and the metal fine (iron) could be collected along with their other metal scrap, recycled and sold.

One other waste noted was the generation of magnesia carbonate, a by-product of their process, which was landfilled. This was not addressed in the assessment.

Results:

Use of a different magnet removed less magnesia during removal of metal fines:

- Solid waste was reduced 1,010,000 pounds annually, saving $2019 annually.
- Raw material needs were reduced, saving $177,000 annually.

Waste Reduction Case Study

Type of Industry: Automotive Locks
SIC Code: 3429

Abstract:
This company is a major manufacturer of ignition, door and trunk locks for the automotive industry. Their hazardous waste streams come from the plating department. Waste oils and solvents are generated throughout the plant.

1. In their large electro-plating operation, the largest waste stream cost saving could be in the area of drag-out. This can be done through counter current flow and by heating plating baths so that evaporation provides room for the drag-out to be returned. This would require extensive capital investment.

CIS suggested that the reduction of drag-out could be achieved by:

a) Increased part drainage time.
b) Racking parts to maximize drainage.
c) Using drain boards between tanks.
d) Minimizing the concentration of metal in plating baths.
e) Reducing surface tension (heat and/or surfactant).

While all of the above techniques should be considered, it was suggested that a) and c) be adopted and b), d) and e) be investigated further. Studies have shown that a drain of 10 seconds will reduce drag-out by 80%.

2. They had their dried sludge hauled away at a cost of $26,000/year to a TSDF.

CIS suggested they should chemically analyze samples to determine metal content with the thought of selling them through an industrial waste exchange.

3. There were three solvent waste streams in 1988 as follows:

a. 6,700 pounds of trichloroethane contaminated with chromium and other metals.
b. 2,660 pounds of used, but contaminated trichloroethane.
c. 1,400 pounds of used petroleum naphtha.

CIS suggested these solvents could be recovered through the use of a batch distillation system. Typically 90% of the liquid processed is obtained as a distillate for reuse while 10% must still be disposed of as a waste. At $90.00/drum for disposal, $2.95/gallon for virgin solvent, $0.70/gallon for operating the still, a 90% recovery level, annual savings can be estimated at $6,798. The initial investment is $3,700, while the payback period is 6.5 months.

4. They use 115 drums/year of hydraulic and cooling oil. Their current practice is to dispose of these oils as non-hazardous waste at a modest expense.

CIS suggested selling off this oil for its heating value as a fuel. They provided a list of potential buyers who reprocess, recover and resell.

Results:

Through process changes and improved housekeeping:

- Heavy metal wastes were reduced 80,000 pounds annually, savings $10,000 per year.
- Disposal costs were reduced 50%.

Waste Reduction Case Study

Type of Industry: Screw Machine Products
SIC Code: 3451

Abstract:
This company manufactures screw machine products for the automotive industry. Their principal products are needle valves and high compression hose fittings. They were concerned about their degreasing operation.

Kerosene and 1,1,1, trichloroethane are used for degreasing parts between operations and final cleaning. Kerosene is used as a pre-wash for components retaining large amounts of cutting oil and trimmings prior to final cleaning in trichloroethane. This waste kerosene is disposed of in waste cutting oil, which does not depress the flash point below 140 degrees F. Total waste oil is 900 gallons per year hauled off site to Indiana.

The only hazardous waste is trichloroethane still bottoms (1,600 gallons per year), which contains trichloroethane, kerosene, cutting oil and sludge. Still bottoms are hauled away for recycling in Kentucky. It was estimated that their trichloroethane emission losses were 31,000 pounds, 6,000 pounds point emissions and 25,000 pounds fugitive emissions

CIS suggested the following relative to trichloroethane vapor losses:

1. Limit the rate of lowering and removing the component basket to 11 feet per minute. Limiting the vertical travel rate will minimize the turbulence in the vapor layer and avoid drag-out of solvent when removing the basket.

2. Bring components up to temperature before removing them. Bringing the components up to temperature is suggested because the cleaning cycle is not complete if condensation is still forming, and the removal of components early will increase drag-out.

3. Operate their automatic degreaser as much as possible rather than their manual degreaser. The automatic degreaser is a closed system and has fewer fugitive losses than their open, manual system. If the manual degreaser must be used, incorporate a sliding cover to minimize solvent loss.

CIS suggested that to maximize the recovery of trichloroethane, the still bottom should reach an oil level of 60 to 70 percent; which is an optimum level for bottoms disposal. This can be accomplished by determining the boiling temperature of the still bottoms and should require no additional equipment.

Results:

The company reported that although some procedures were difficult to control, the suggested changes seemed to have reduced waste per unit volume of work; however, results were difficult to quantify due to increase in work volume.

Waste Reduction Case Study

Type of Industry: Automotive Suspension Systems
SIC Code: 3465

Abstract:
This plant produces 350 different automotive suspension systems components. They are stamped from steel, stainless steel, and aluminum; then spot-welded, where required, to form units. These units are painted for corrosion protection after pretreatment.

They requested a waste reduction assessment to identify opportunities to reduce or recycle waste. CIS identified the following:

1. Eliminate the paint stripping tanks. The paint-stripping tank is the major generator of hazardous waste on the site. It should be the primary target for elimination. Other industries have converted to burn off ovens for applications such as this, and enjoyed a cleaner, less labor-intensive operation without the hazards of handling hot caustic. CIS calculated, assuming four dumps of the stripper tank per year, that its operation costs $20,000 per year for material and disposal costs.

2. Reduction of improper coatings from poor electrical contact between the paint racks and the parts to be painted. Three suggestions were provided:

   a. Provide removable hooks that can be cleaned frequently by easily removing and sending to the stripper tank, or oven, in batches.

   b. A small sandblasting machine could also provide for more frequent cleaning of rack hooks.

   c. Provide more racks, with a larger number of hooks, changeovers could be made more frequently, allowing cleaning on a shorter time cycle.

3. Reduce labor involved in handling oils and hydraulic fluids. Returnable oil drums present a housekeeping problem and require labor for the draining and consolidating into drums. If the volume of individual oil types allow, the use of portable tanks should be evaluated along with bulk purchases.

4. Recycle of rinse water in paint pretreatment system. Currently rinse water from stage 11 is recycled into stage 10. In the same manner, it may be feasible to recycle other stages, such as stage 4 into stage 3, either continuously or on a batch basis, twice per week. This change would reduce water consumption by 1,200 gallons per week and still provide the same amount of clean water in stage 4. Recycling of rinses from the secondary rinse tank into the primary rinse tank is a common practice.

5. Rust prevention treatment. Rust preventative is sprayed on the part after the stamping operation. Since lubricating fluid is wiped on the metal prior to stamping, consideration

should be given to finding a source that produces a stamping lubricant with a rust preventative. This should provide more protection than the manual spray now used.

6. Industrial water consumption. Sewer costs for non-contact cooling water can be reduced by use of a cooling tower and recirculated water. A study of water consumption will highlight areas where additional savings can be made.

Results:

No results were reported.

Waste Reduction Case Study

Type of Industry: Electroplater
SIC Code: 3471

Abstract:
This company is a large job-shop operation that performs a service as opposed to manufacturing. As an example of their diversity, they plate lawn mower parts and hammer handles in chromium over nickel and automobile body parts in black chrome.

Their flow charts indicate a very sound operation. Joints between tanks are capped to eliminate dripping drag-out to the floor. Counter current water rinses are used after each plating tank. Water from the last concurrent tank over flows to waste treatment.

They use approximately 1,600,000 gallons of city water/month at an annual cost in excess of $70,000/year. The vast majority of this water is used for rinse water on the plating lines. Reduced water consumption is highly desirable because the cost savings would also result in the reduction of treatment chemicals and reduced sludge drying and disposal costs.

CIS suggested that the following be considered:
1. Increased drip-times on manual lines when excess capacity exists.
2. Install minimum drip timing lights on critical tanks to pace the operations control. The thought being that lights could be activated by a micro-switch as the rack is raised from the bath, remaining lit for a fixed period of time.
3. Greater use of flow control restriction orifices with low rates of 1- 2 GPM being the goal.

To monitor progress made in water reduction, it would be desirable to install flow meters in a few key locations. One meter per operating line would be adequate.

The most costly waste is the metal sludge generated when excess rinse waters and spent alkali and acidic solutions are neutralized and reduced in the treatment facility. Costs are over $100,000/year, to treat and dispose of this hazardous F006 waste. The total quantity of sludge generated is influenced by several factors identified by CIS:

1. Wastewater stream flow rate, dwell time.

2. Concentration of chemicals in the waste water stream. There are indications that the use of treatment chemicals (lime, sulfite) is more than required. The pH readings of effluent samples indicate high calcium and sodium and low chromium and nickel content of dried sludge. There are two cost penalties associated with excess treatment chemicals: initial cost of chemicals and disposal cost of precipitated sludge. Suggestions made were to improve the controls and have attractive paybacks. Instrumentation is available that would continuously monitor the pH and oxidation-reduction potential.

The above suggestions should help in selling the sludge to a recycler. Several of these recyclers were suggested to this company. Cost of metal is on the increase, particularly nickel. If moisture level or metal content, % and/or mix are a factor in the marketability of the sludge, they have the ability to dry the sludge to preferred moisture level.

Results:

- Water consumption was reduced by 2,000,000 gallons annually, which reduced the $70,000 water and sewer costs by 12%, or $8400 per year.

- Using two polymers instead of lime increased the cost for wastewater treatment chemicals, but that was offset by a 20% annual reduction in disposal costs and the elimination of 60,000 pounds of lime.

- Hazardous metal waste was reduced by 40,000 pounds annually, saving $6400 annually in disposal costs.

Waste Reduction Case Study

Type of Industry: Hot Dip Galvanizing Service
SIC Code: 3479

Abstract
This Company has six plants nationwide galvanizing 65,000 tons of steel annually. The request they made was their need to minimize waste from their pickling operation, and to reduce solid waste from their hot caustic dipping operation.

The hot dip galvanizing process is a three step process: surface cleaning (alkali wash, rinse and pickling), fluxing and hot dipping. The finished product consists of iron, coated with a series of zinc iron alloys with a coating of nearly pure zinc on the surface.

1. Alkali Wash:

   Surface cleaning of metal begins with dipping the iron in a hot caustic solution (alkali) to remove dirt, oils and grease. Air is sparged into the bottom of the tank to provide a washing action necessary for this removal. Approximately 8,000 pounds per year of caustic sodium hydroxide is added, as needed, to maintain a high pH.

   Every two years the sparging air is shut off allowing the suspended particles to settle to the bottom of the tank. The clean supernatant is pumped to a holding tank and the dried solids, 98% silica with some residual liquor, is shipped to Emelle, Alabama, and disposed of as hazardous waste (D002). Approximately 10 cubic yards are shipped at a cost of $1500.

   CIS suggested the continuous removal of solids through a dual filtering system containing an alkali resistant filter media. This would allow concentrating the solids into lesser volumes and save shipping costs. This would also extend their period of operation without having to shut down for solids removal. They should investigate the possibility of counter washing the solids with clean water or weak acid, getting the pH close to neutral so the solids would no longer be hazardous by characteristic of corrosivity. This wash could serve as alkaline make up.

2. Pickling

   After the iron is drained, it moves into the pickling tank for iron rust removal by soaking for 5 minutes in a 12 percent hydrochloric acid solution at ambient temperature. Around 43,000 pounds per year of hydrochloric acid is lost from the surface of the pickling solution by natural updraft through roof ventilators.

   Iron dissolved by the pickling solution contains both ferric (rust) and ferric iron (metal). When the dissolved iron content increases to the 15% range, the spent solution, containing 6% hydrochloric acid, is hauled off-site and neutralized with

waste alkali. A precipitate forms and is filtered out and disposed of in a sanitary landfill. The hauling and disposal costs are $40,000 per year.

CIS suggested they investigate the sale of the spent pickling solution as a feed material to a fertilizer manufacturer. The spent solution contains 3.6% zinc, 9.7% ferrous iron, 0.002% copper, all of which are valuable micro nutrients in fertilizer.

A further suggestion was the use of an inhibitor that would enhance rust removal (ferric iron) and reduce dissolving base metal resulting in ferrous iron in solution. If the dissolved iron, which is 99% ferrous iron, can be maintained below 10%, the life of the pickling solution can be extended almost indefinitely.

3. Galvanizing (Hot Dipping):
   Following the above cleaning and rinsing procedures, the cleaned iron is drained and immersed in a flux bath solution of 1 pound each of ammonium chloride and zinc chloride per pound of water. The passivated iron when drained and dried is ready for hot dipping. The finished product consists of iron, coated with a series of zinc alloys with a coating of nearly pure zinc on the surface.

CIS noted one other waste reduction opportunity. That is the recovery of waste heat from the flue gas resulting from firing the molten zinc. It was estimated that the stack gas now exhausted to the atmosphere is at a minimum temperature of 1,200° F. By installing an economizer (heat exchanger) in the stack, low pressure steam could be generated to replace up to 50% of the process steam now generated in the boiler. Approximate savings of $2,000 per month in natural gas costs.

Results:

No results were reported.

Waste Reduction Case Study

Type of Industry: Metal Cabinet Manufacturer
SIC Code: 3499

Abstract:
As a metal cabinet manufacturer, metal forming, welding and painting was the basis of their operation. They requested counsel with CIS relative to their hazardous waste.

CIS addressed the painting/coating operations, which appeared to be in need of attention from the standpoint of volatile organic compound (VOC) emissions. The highly volatile constituents used in formulating urethane paints include di-isocyanate polymers, which reportedly can have serious health impacts if prolonged worker exposure is involved.

CIS suggested the use of alternative paints that have less organic solvents than polane-T and acrylithane-C. One paint substitution is aqueous based paints. Very little or no organic solvents are contained in water base paint, and equipment cleanup would not require exotic solvents.

If water base could not be used, an option was to find paint with less solvent than the current coating. A high solid, low solvent paint would probably meet the corrosion resistance requirements. The third option was to use a powder coating. This would entirely remove solvents used during coating.

The spray techniques currently used in the spray booth, using compressed air spraying at 40-60 PSI, is among the lowest transfer efficiency at about 23%. Electrostatic spray applications and high volume-low pressure spray technology are the most efficient coating application techniques. Three reports relative to paint technology were provided.

CIS suggested fundamentals of good spray techniques, which consist of:

1. 50% overlap of the spray pattern
2. Gun speed of 250 feet/minute
3. Gun distance of six to eight inches
4. Holding the gun perpendicular to the surface
5. Triggering the gun at the beginning and end of each stroke

Good spray techniques should save 10% of the paint bill through the reduction of over spray. Annual costs for coating, labor, electricity, maintenance and solid waste disposal are all drastically reduced when transfer efficiency is improved.

The solvents used to clean equipment at the facility were carcinogenic. Safer solvents should be substituted if possible. Reducing solvent use and waste should be achieved through better cleaning techniques and solvent recovery. Since this facility uses only a few colors, consideration should be given to the use of multiple spray guns, for specific

colors. This should reduce wash/solvent consumption by avoiding additional cleanup operations during the day when switching paints.

Reduction of solvent use and waste could be further reduced through solvent recovery. It was suggested they investigate a small batch solvent distillation still capable of handling two to six gallons per day of used solvent with recovery efficiencies approaching 95 to 98% leaving a sludge almost free of solvents.

Results:

Most painting was contracted out to an outside service.

- Solid waste was reduced 720 pounds annually.
- Raw material costs were reduced $2400 annually.
- Labor costs were reduced $360 annually.

Waste Reduction Case Study

Type of Industry: Conveyor Systems
SIC Code: 3535

Abstract:
This corporation is a manufacturer of material handling systems using processes such as welding, forming, cleaning and painting.

CIS identified six waste streams:

1. Solid waste to local landfill
2. Wastewater to POTW
3. Scrap metal
4. Fumes from welding operation to atmosphere
5. Dried paint solids from spray booth
6. Over spray filters from paint operation

CIS suggested a recycling program for cardboard, paper and metal chips, which are currently landfilled.

Wastewater to POTW was assumed to have minimal pollutants from the present process operations.

All shapes of steel scrap metal are kept in three 10 cubic yard dumpsters provided by and sold to a metal reclaimer. The metal chips should be removed from the general trash and stored in the scrap area to be sold.

CIS advised that the fumes from the welding vents were exempt from air pollution control permits. They were cautioned that if they emit a hazardous vapor such as lead from a soldering operation, they would require a permit.

Relative to their paint waste, CIS advised them that their paint wastes are not hazardous as long as they are not flammable. The hazardous waste regulation applies to paint with chromium in a concentration above 5 parts per million. If there was any question relative to the chromate concentration, CIS can provide them with information on laboratories that can do the testing.

With their current conventional spray paint equipment in mind, CIS suggested the following waste reduction painting procedures:

1. Maintain 50% overlap between the spray pattern.
2. Maintain 6”-8” distance from the spray gun to the work.
3. Maintain a gun speed of 250 F.P.M.
4. Hold the gun perpendicular to the work surface. A spray gun angled at 45° can cause an over spray of 65%.

5. Adjusting air pressure to a minimum can reduce over spray by 40%.

Their current practice of separating dust from the paint filter should make them easier to dispose. They must guard against spontaneous combustion and devise a way to store them safely. If properly handled, they may be able to obtain a special waste approval for disposal in the sanitary landfilled.

CIS offered information on:

1. High-solid formulation paint
2. Powder coating
3. Water base formulation

Results:

Minimizing overspray and changing to a water-based paint where possible:

- Reduced paint purchase costs by $1200 annually.
- Reduced hazardous waste by 400 pounds annually and associated disposal costs were reduced by $2400 annually.
- Reduced dried paint solids from overspray and reduced associated disposal costs by $3960 annually.

Waste Reduction Case Study

Type of Industry: Bench Top Power Tools
SIC Code: 3546

Abstract:
This company prepares incoming material for finish products by stamping, machining, cleaning and painting.

Their hazardous wastes generated are:

1. Waste paint solvents resulting from spray gun cleaning. The paint thinner used to clean the spray painting equipment is a non-halogenated solvent, esters and ketones, classified as F003 and F005 and can be totally eliminated by substituting a water base paint. CIS indicated savings of thirty-six 55-gallon drums/year.

2. Petroleum Solvents (Varsol) from parts cleaning tubs, D001. CIS suggested they eliminate the solvent by cleaning the parts in an existing water-based cleaning system. This reduction would be 100% of solvent and twenty 55-gallon drums/year.

3. Sludge from black oxide coating process, D007, D008. CIS suggested they investigate their process to isolate and eliminate the sources of lead. Change to a coating bath, which does not contain chromates to reduce or eliminate heavy metal, which cause the sludge to show toxicity. The reduction would be eight 55-gallon drums/year.

Non-hazardous waste streams were identified as:

1. Dried paint waste from spray booth. CIS suggested automatic spraying as opposed to manual to reduce overspray. The saving potential is 50% or ten 55-gallon drums/year.

2. Phosphate sludge from baths. CIS suggested the use of deionized water only in their phosphate baths to reduce sludge quantity by 30% or nine 55-gallon drums/year.

3. Used oils generated in their process. CIS suggested they investigate the reclaiming of cutting oil for re-use with a potential 80% reduction or 24,000 gallons annually.

The potential disposal cost saving for hazardous waste was $7,050/year and for non-hazardous waste was $10,050/year.

Results:

- Hazardous waste decreased 35,000 pounds, saving $22,000 annually.
- Nonhazardous solid waste decreased 20,000 pounds, saving $500 annually.

- Disposal costs decreased $23,000 annually.
- Raw material costs decreased $7000 annually.
- Labor costs decreased $10,000 annually.
- Material recovery savings increased $6000 annually.

Waste Reduction Case Study

Type of Industry: Speaker Enclosures
SIC Code: 3651

Abstract:
This company manufactures small speaker enclosures of the type used in commercial establishments, at ceiling level, for background music and in-house public address systems. Their key process is woodworking and assembling. Their raw material is a medium density particleboard with a 6-mil vinyl overlay. The sheets of particleboard are cut, drilled and routed. Hot glue is used to reinforce corners and a water base paint is applied to exposed edges. None of the materials used were found to be hazardous.

The principal waste generated from operations at one of their plants is sawdust from the woodworking operation. The principal waste from the other plant was cardboard. The CIS team visited both plants.

Although this company did not consider sawdust disposal a serious problem, it is environmentally desirable to reduce landfill use as much as possible.

CIS noted that 40% of the sawdust generated is captured by a centralized vacuum system with intakes at various workstations. The other 60% becomes airborne and eventually settles to the floor and is collected by normal sweeping operations. Sawdust, removed by the vacuum system, is collected in a metal bin located outside the plant. Local farmers, gardeners, and landowners remove this at no charge. A private landfill contractor removes the "sweepings" and other trash at a disposal cost of $80 per month. The cardboard waste is picked up by the city and goes to the city landfill.

The possibility exists that the local municipality may require that all waste generated in the city limits be disposed of in the city's disposal facility. The city may require special waste containers for the sawdust. If this happens, their cost could increase.

CIS suggested that as opposed to sweeping up the 60% on the floor, the company install "plug-in hose ports" in the existing system and vacuum surface dust as opposed to sweeping. Another consideration was a pelletizing process, which prepares sawdust to use as fuel.

This company has been unable to find a recycler willing to pick up their cardboard. CIS informed them of a non-profit group opening a recycling facility in Tennessee. This facility is employing handicapped persons and is providing recycling services on a regional basis for cardboard. Information and phone numbers were provided.

Results:

- All sawdust is being collected and given t a local farmer to reduce soil erosion, eliminating the $960 disposal cost.

- The company still has not been able to arrange for cardboard recycling.

Waste Reduction Case Study

Type of Industry: Aircraft Parts and Auxillary Equipment
SIC Code: 3728

Abstract:
This manufacturing operation consists of machining, sheet metal fabrication and metal finishing.

Their opportunities for waste reduction appear to be in their metal finishing lines.

Although timers and conductivity cells are utilized for control of rinse water lines, a great deal of control was manual. CIS suggested additional instrument control. Particular attention should be given to tanks using timer controls to optimize the time vs. concentration.

Rinse water flows were measured at three tanks. In two lines the flows were each 6.4 GPM and in the third tank the flow was 14.6 GPM. Reduction of rinse water flow will not significantly reduce the amount of sludge from the wastewater treatment plant. Reducing the flow will reduce the cost of water and sewer charges, and also reduces the hydraulic loading on the wastewater treatment plant. The treatment plant will increase its efficiency and reduce the operating time since it is on a batch basis.

CIS suggested drag-out pans be used between tanks to conserve on rinse water concentrations and chemical usage. The operations should use the racks over each tank to provide more dwell time for solution and rinse drainage.

This company should consider a plastic abrasive media for paint stripping. This could eliminate the need for the highly hazardous chromic and nitric acid chemical stripper.

Results:

- Hazardous waste was reduced 12,000 pounds annually, with a cost savings of $34,000 per year.

- Air emissions were reduced 9300 pounds annually by reduced use of raw materials, with a cost savings of $31,000 per year.

Waste Reduction Case Study

Type of Industry: Aircraft Assemblies and Sub-Assemblies
SIC Code: 3728

Abstract:
This company is a major manufacturer of aircraft components, primarily aircraft wing sections, to private industry and the government. Their request of CIS was to suggest a method of substituting for solvent in their degreasing activities.

One of CIS' principal suggestions in an earlier report was that they should replace the trichloroethane vapor degreaser with an aqueous degreaser. This would eliminate hazardous waste disposal costs of $42,000/year and avoid future regulatory problems. Since the earlier report, the Clean Air amendments have been signed into law on November 15, 1990. They specifically mandate the phasing out of TCA (100% by 2005) and impose increasingly higher excise taxes on this product beginning in 1991.

Based on CIS' previous suggestions, the company's engineering laboratory has been able to identify cleaning compounds that do an effective job and are easily disposed of in an environmentally safe manner. These products are thoroughly tested for biodegradability and the lab personnel are enthusiastic about the likelihood of achieving high quality operational results in the degreasing process. They anticipate reduced maintenance costs in downstream operations as well.

An alkaline cleaner has been tested in manual wipe down activities as a substitute for TCA with promising results.

It was suggested by CIS and confirmed by the company's engineering staff that three TCA vapor-degreasing tanks could be converted to aqueous cleaning. Their environmental and engineering staffs are proceeding with an overall plan for the conversion to aqueous degreasing. A cautious approach was envisaged due to concern for customer quality requirements and a desire to minimize conversion expenditures.

Results:

- Over four years (1988 – 1991), hazardous waste was reduced 4,000,000 pounds, saving $350,000.
- Over two years (1990 – 1991), solid waste was reduced 9,500,000 pounds, saving $41,000.
- Over the same two years, wastewater was reduced by 10,925,000 gallons, saving $138,200. Water consumption was also reduced by 7,675,000 gallons, saving an additional $95,200.

- Over four years (1988 – 1991), air emissions were reduced 211,800 pounds, saving $95,300.
- Disposal costs were reduced $500,000 annually.
- Raw material costs were reduced $200,000 annually.
- Utility costs were reduced $300,000 annually.
- Material recovery costs were reduced $50,000 annually.

Waste Reduction Case Study

Type of Industry: Boat, Bus and Truck Seats
SIC Code: 3732 and 2531

Abstract:
This company, in the processing of their products, generates the following hazardous waste:

1. Trichloroethylene (for degreasing) 12,700 pounds to the atmosphere/year. CIS suggested they consider an aqueous cleaning system, which would eliminate the trichloroethylene emissions.

2. Toluene (paint thinner) 8,300 pounds to the atmosphere/year. CIS suggested a water base paint system to eliminate the toluene emissions. This process substitution is pertinent because of the trichloroethylene and the health hazards associated with toluene emissions. Capital outlay was estimated at $300,000 with a two-year pay back. Other plant improvements could be made at the same time making the economics more attractive.

Non-hazardous waste streams of 16,000 cubic yards of corrugated wood pallets and 1,750 cubic yards of mixed metal stampings were identified. Their cost in this area was $53,000 annually.

CIS suggested that all corrugated be compacted and sold. Many wood pallets, which were damaged, but not beyond repair, should be reclaimed and put back into their system. Pallets beyond repair should be shredded in a chipper and given to local governments, landscapers, schools, hospitals, etc. They would possibly realize a profit of $11,000 instead of an outlay of $53,000. The recycling of salable products could cut their annual hauling fee by 50% or $26,000. They currently glean $47,000/year on the sale of metal scrap, but better waste management can yield an additional 1,750 cubic yards of mixed metal scrap to this saving.

Results:

- Installation of a water-based wash system and powder paint system eliminated use of trichloroethylene as a degreaser and toluene as a paint thinner.

- Hazardous waste was reduced 147,000 pounds annually, providing a cost savings of $50,000 annually.

- Solid waste disposal costs were reduced 75%, saving $45,000 annually.

- Raw material costs were reduced 10% annually.

Waste Reduction Case Study

Type of Industry: Bicycle Seats
SIC Code: 3751

Abstract:
This company is a privately owned and managed corporation recognized as a leader in the manufacturing of bicycle seats and infant seats. In-process activities include wet and dry electrostatic spray painting, metal cleaning and stripping operations.

Five waste streams were identified in their plant:

1. 100,000 gallons per day of process water is discharged into three settling ponds, which overflow into a tributary of a river. 60,000 gallons per day of non-contact cooling water flows directly into the tributary. This source discharge is authorized under a NPDES permit, and the stipulated pH, BOD, DO and chemical limits are rarely exceeded in the bi-monthly grab samples.

CIS agrees that the daily cost of the water system is minimal, but the cost of maintaining the lagoon system (settling ponds) can be significant. The cost to empty, dredge and dispose of accumulations in the first stage industrial lagoon was $300,000 in the prior year. At the plant's present flow rates, the residence times are reduced resulting in BOD and dissolved oxygen levels near the allowable limits.

A reduction in the amount of water used would be advantageous both from cost and problem avoidance perspectives. The least expensive way to mitigate water usage problems would be to reduce the amount of water usage and thereby increasing residence time in the lagoons. It was suggested that this reduction first be approved through improved measurement and control, install flow measurement gauges on individual process streams, monitor them bi-weekly. This will help determine where the greater potential for water conservation exists. If water usage can be reduced without affecting production rates or quality, the installation of flow control valves will provide positive control overflow rates.

2. Volatile organic compounds (VOC) are emitted into the atmosphere from the painting operation. Current levels are pressing the NESHAP permit level of 100 tons per year of VOC.

CIS suggested that the levels could be considerably reduced by shifting more of their production to the powder spraying line, or by changing from a solvent-based paint to a water-based paint. This change would reduce the solvent waste (D001 and F003) and drop this company into the RCRA category of small quantity generator.

3. Steel scrap generated from their metal forming operations amounted to 1,660 tons in 1989. This reflects a scrap rate of 8.5 percent.

CIS suggested an improved scrap reporting system, indicating the cause, the machine and the department. It was also suggested that they improve their raw material (steel) purchase orders by specifically detailing material specifications such as hardness, metal chemistry, and width and thickness tolerances. All of the above will control and eventually reduce scrap. Reducing the scrap rate from 8.5% to 7.5% will provide an annual saving of $90,000.

4. A paint thinner solvent is used to clean out paint lines at color change over. In 1989, 6,063 gallons of this solvent (Exxon Aromatic 150) were recycled off-site and must be treated as a hazardous waste D001.

CIS suggested that they should consider recycling the paint thinner on site as long as they continue to use solvent based wet painting systems. The two hazardous wastes generated from their manufacturing process have their origin from the wet paint operation. The larger volume is the ignitable solvent/paint mixture, 6,063 gallons.

Several manufacturers make units in the 15-30 gallon per day size they would require. The current cost for solvents and disposal is $15,000 per year. On site recycling, with a solvent recovery of 95%, would cost $4,000 per year.

5. The final waste stream addressed was 35,000 gallons of oil/water emulsion generated annually and disposed of as a non-hazardous waste, at a cost of $13,000 per year.

CIS determined that it should be possible to reduce the size of this waste stream, and the costs. But, there appeared to be no clear-cut criteria for deciding when to dispose of the emulsion in use and to prepare a fresh batch. It was all arbitrary and based on appearance and/or odor. It was suggested that the vendor be contacted and asked to provide definitive criteria relative to replacement, perhaps chemical testing as opposed to physical appearance.

Finally, an effort should be made to increase the general level of waste reduction consciousness throughout the plant by a waste reduction policy statement.

Results:

- Recirculating cooling water saved 20,000 gallons daily.
- Using only powder paint reduced VOC emissions 75,000 tons annually and saved $15,000 per year.
- Hazardous waste was reduced 30,000 pounds annually.
- Disposal cost savings totaled $4000 annually.

Waste Reduction Case Study

Type of Industry: Electrical Power Generator
SIC Code: 3823

Abstract:
A waste reduction engineer in a company that constructs nuclear power plants requested a waste reduction assessment. A total of 52 waste streams were identified, but only three were included in the scope of this assessment. They were paints and coatings, chemical laboratory wastes, and oil waste.

1. Paint and coating use: Their problem has been excess material, which was the outgrowth of a protracted construction period, and little coordination between the many organizations operating at the site. This accounted for the volume, mixture and hazardous nature of materials purchased for coatings.

CIS suggested the following:

a. Environmental engineers at the site should establish common coating applications techniques. Emphasis should be placed on coatings that are water based, non-hazardous, non-toxic, or have minimum solvent content.

b. Application equipment should be those that provide maximum transfer efficiency, such as high-volume, low-pressure, high-solid guns, electrostatic systems.

c. Painting should be scheduled to maximize the consumption of any NRC minimum mixture volume coating.

d. Surface cleaning should be done with non-chlorinated, non-hazardous, and non-toxic materials where possible.

e. Purchasing and storage should be centralized to maintain a controlled manageable inventory.

f. Suppliers should be required to store pre-purchased coatings at their facility until required. All of the aforementioned are the steps necessary to reduce waste, which was the result of over buying.

2. Chemical laboratory waste: CIS suggested that the way to reduce both hazardous and non-hazardous waste in the chemical control laboratory was to devise a controlled inventory to prevent surplus chemical accumulation. It was estimated that the existing surplus chemical waste amounts to $1000 per year and through a controlled inventory system could be reduced to $100 per year or less.

CIS suggested that the non-hazardous and hazardous waste not be mixed together. Misuse of non-toxic materials simply dilutes the toxic waste and increases the cost of

removal. Infrequent and special analysis should be reviewed for actual need. They should be minimized or eliminated.

3. Oil waste streams: CIS noted three waste oil waste streams and a sludge resulting from the deionization of water.

a. Diesel crankcase oil: Emergency electrical power is available from five sets of generating units each powered by two diesel engines with a crankcase oil capacity of 350 gallons each. The oil contains a chlorinated paraffin. Chlorine in the oil creates a disposal problem. Their present oil recycler will not accept the oil as non-hazardous claiming it will chlorinate all oils with which it is to be mixed during processing and storage. Disposal cost for each oil change is $6258. By including the new oil cost, the total expense becomes $8129 per change for one unit.

CIS suggested the use of newer multi-grade oils, without the additive of chlorine. Information was provided, relative to oil source information, and the need for a viability study was suggested.

b. Turbine lubrication: Steam turbine generators are lubricated by means of a closed pressurized system. Used contaminated oil is processed and cleaned using metal contamination removal techniques, reconstituted and reused. The oily residue from processing is sold. The $100-300 return is not significant but the absence of disposal charges is noteworthy.

c. Hydraulic systems: Their closed system design permits contamination monitoring, reconditioning and reuse without a resultant waste discharge.

d. Deionization: The chemically basic materials used in association with water deionization results in a grey-white sludge requiring disposal. The mixture of carbonates, oxides, sulfates and alumina accumulates at the rate of 40 cubic yards per year. It is stored in a retention pond on site. It was suggested that when disposal becomes necessary, fertilizer or cement manufacturers might be interested.

Results:

No results reported.

Waste Reduction Case Study

Type of Industry: Electric Power Distribution – Urban (Transport and Service Centers)
SIC Code: 4911

Abstract:
This company is the eighth largest utility company in America based on kilowatt hours sold. They do not generate electric power. They buy their power from TVA and distribute it to 228,000 residential customers and 290,000 commercial customers over 4,482 miles of power lines. They maintain a transport center and two service center where vehicles are serviced and meters and transformers are repaired. The purpose of the assessment was to help identify further opportunities for waste reduction and to provide information for developing an ongoing waste reduction program. CIS reviewed current practices in the transport center and service center and made suggestions for improvement where necessary.

Used motor oil is stored in a 1,000-gallon tank and is sold to an oil contractor. Quantity is estimated at 3,600 gallons/year. A regulatory change will classify used motor oil as a hazardous waste if not disposed of properly. They should satisfy themselves that the contractor is disposing of their waste oil properly.

Used anti-freeze is poured into a sanitary sewer, about 200 gallons/year. It was suggested that recycling using the Glyclean system of filtering and replenishing additives be considered from an economic standpoint.

An industrial cleaning company maintains three solvent parts-cleaning stations on a four week fixed schedule. It was suggested this frequency level was too high and it should be examined in order to reduce cleaning fees.

It was suggested by CIS that the two service centers send all their obsolete meters to the reclamation center, located at the transport center, in order to maximize negotiating leverage and assure that all meters are disposed of in accordance with company policy.

In the tool repair shop a strong alkali, used as a degreaser, is washed off with water on the asphalt driveway. It was suggested the tools be washed in a sink, which drains into a sanitary sewer.

This company has many good programs in place for managing the waste it generates, such as segregating cardboard, computer paper, clean white paper and aluminum cans. Prior to this program 678,000 pounds of trash were landfilled at a cost of $4,000 annually. They expect significant savings from this program and from the sale of scrap.

Results:

Recommendations were not implemented

Waste Reduction Case Study

Type of Industry: Electric Power Distributions – Rural (Vehicle Maintenance and Service Centers
SIC Code: 4911

Abstract:
This corporation provides electric power in five counties to 52,000 customers over 5,700 miles of power lines. They purchase its power from TVA at 18 substations located throughout its five county distribution system.

The assessment was performed at their vehicle maintenance shop and service shops, in two cities.

All used vehicle fluids, except anti-freeze, are stored, co-mingled in a 55 gallon drum and given away to a recyler, about one drum/month. In one location, used motor oil is given to an individual and the ultimate use in unknown. It was suggested that the used oil be routinely moved to the other location to avoid future liabilities.

It was suggested that antifreeze be disposed of in a sanitary sewer. It was suggested that they should investigate the Glyclean method of recycling if the volume warrants it.

Used batteries are sold to a junk yard for $0.25 each. It was suggested, to avoid any future liabilities, they should insure that their batteries are properly reclaimed.

Transformer painting is done in the filed. It was suggested that they should investigate using water base paint.

They currently dispose of 500 meters annually in a landfill. It was suggested they look for potential customers.

Office waste, white paper and corrugated, is not segregated. It was suggested that this be done and the waste be sold in order to reduce landfill costs and earn recovery dollars.

It was suggested that they establish a waste reduction policy statement from the general manager to all employees making them more conscious of waste reduction goals and to obtain their full cooperation in specific programs.

Results:

Results were not reported

Waste Reduction Case Study

Type of Industry: Aircraft Repair
SIC Code: 7699

Abstract:
This company services and repairs helicopters, from a simple oil change to a complete engine tear down. Their service also includes stripping and repainting.

The following waste stream materials are used in their process:

1. Degreasing (DG-66)

    a. Perchloroethylene (40%)
    b. Aliphatic hydrocarbon (45%)
    c. Dichloromethane (15%)

2. Part Stripping (Turco 5873)

    a. Methylene chloride (75%)
    b. Methyl alcohol (10%)
    c. Ammonium hydroxide
    d. Sodium chromate (0.6%)

3. Frame Stripping (Turco 5469)

    a. Methylene chloride (55%)
    b. Phenol (20%)
    c. Sodium chromate (1.0%)

4. Aluminum Parts Stripping (Turco W. O. #1)

    a. Phosphoric acid (55%)
    b. Butoxyethanol (12%)
    c. Nonylphenoxpoly ethanol (5%)

5. Solvent base paints, motor oil and water

CIS identified available management options relative to their waste stream. The annual usage of degreasing solvent DG-66 is 330 gallons at a cost of $5,470, which includes disposal. The installation of a filtering system to remove dirt, grease and carbon will prolong the life of DG-66. The filter can be installed between the degreasing solution pump and the goose neck outlet just above the catch basin. Doubling the life cycle, which filtering would do, will save $2,735 annually.

In order for this company to become a small quantity generator they must reduce their contaminated rinse water volume by more than 65%. In their engine part cleaning area, rinse water for paint stripping amounts to 175 gallons per month. On-off spray nozzles should be used as opposed to the practice of letting the hose run continuously.

At their airframe stripper facility, a system of filters and storage tank should be provided in the wastewater system. Water can be taken from this rinse water storage tank, filtered and used for initial rinses. The only additional water to be added would be the final fresh water rinse. The filter should be disposed of as hazardous waste, unless testing proves they are not. The return water should be tested on a scheduled time frame to verify its acceptability. Their tanks would require only semi-annual pump out. Gross annual savings could be as high as $16,000, and qualify them as a small quantity generator.

The long-term option: they are encouraged to start a program of evaluating alkaline and biodegradable cleaners as a replacement for their phenol and methylene chloride based cleaners. This could ultimately eliminate their waste disposal problems and costs.

Information relative to alkaline cleaners was provided along with information on filters.

Results:

The recommended solvent filtering system was installed:

- Hazardous waste was reduced 7000 pounds annually.
- Disposal costs were reduced $3000 annually.
- Raw material purchase costs were reduced $1500 annually.

Waste Reduction Case Study

Type of Industry: General Medical and Mental Hospital
SIC Code: 8062

Abstract:
This medical center consists of two general hospitals and a mental health facility. All three facilities have a total of 814 beds. The director of safety requested counsel with CIS relating to their waste management program. They reported three waste streams:

1. Routine General Trash: aluminum cans, paper, plastic, cardboard, etc.

2. Dietary Waste: food scraps, broken glass and grease.

3. Hazardous Waste: x-ray film and processing solutions, mercury, xylene, alcohol and formaldehyde.

Radioactive waste and infectious waste was excluded from this assessment.

CIS assessment team made the following observations and suggestions:

1. "Recycling Center" rooms are used to collect aluminum cans and paper to be picked up by a recycling company. These pick-ups have not been made in a timely manner, which results in an untidy area. This causes discouragement on the part of the employees. It was suggested that management take a more active to insure scheduled pick-ups.

An off-site warehouse does some cardboard recycling. The amount of cardboard CIS noted being generated in the hospital complex would justify baling and selling to a recycler. This would reduce the load on the 40 cubic yard trash compactor, along with hauling and tipping fees. This compactor is hauled daily.

2. The dietary waste goes into the trash compactor and then to a landfill. CIS determined that the 40 cubic yard compactor being pulled daily was not full. They suggested that visual determination when loading materials into the compactor shortens the stroke of the ram. The significant increased hydraulic pressure of the ram can be used as an automatic indicator of when the compactor is full.

Every day hauling could be reduced with noticeable dollar savings along with landfill space.

3. Hazardous waste, or "medical redbag" waste, is gathered daily in special holding room labeled "infectious waste storage pool". A qualified contractor hauls this waste away to a medical waste disposal facility.

X-ray film developing solution is replenished indefinitely. Fixing solution is processed for silver recovery, then discharged to the sewer with rinse water. Waste film is sold for silver recovery.

Mercury recovery, from broken instruments, is collected in "mercury spill kits" by trained personnel and accumulated in a secured area for sale to a reclaimer.

The xylene, alcohol and formaldehyde wastes are generated in the histology laboratory preparing tissue specimens for pathological examinations.

Although they have a waste management plan in effect, additional support is necessary from management to establish timetables for the support people.

Results:

Aluminum cans are now being collected at the various sites where the waste is generated rather than in central "Recycling Center" rooms. Schedules for timely pickup and recycling are being met. Collection areas are neat. Personnel are participating in keeping the program active.

Hauling the compactor only when it is full eliminated one pickup per week and saved 5% of the disposal cost, or $15,600 annually.

Waste Reduction Case Study

Type of Industry: Airbase Support Service
SIC Code: 8744

Abstract:
This service is a mission support group for an Air Force Base. Their services include environmental protection, industrial health, chemical, metallurgical and photographic laboratories, machine ship and model shop. Also included is janitorial services and refuse collection. Their environmental engineer requested a waste reduction survey. It was determined that four areas were to be surveyed: model shop and general trash, paint and photo lab, test gun projectile lab, and Freon refrigerants.

Model shop and general trash: The electro-deposit anodizing tanks and the chrome plating tanks were seldom used. The anodizing line was cleaned every three years and the chrome tank on a 5-year interval.

CIS suggested that the chrome tank, 50 gallons, be treated at clean out time with a chemical that will reduce the chromium from hexavalent to trivalent.

The perchloroethylene degreaser, housed in its own building, was determined to be too large for the small parts being cleaned. They added one 50-gallon drum of perchloroethylene every two weeks. The loss was due to the vat not being covered and to drag out.

CIS suggested that a smaller degreaser or a small ultrasonic energy unit be used. The large degreaser should be shut down, and started only when required.

Outside of the degreaser building is their "open air" pickling vats for mild steel and stainless steel. CIS suggested that they use the structural steel frame work, which accommodates handling equipment, to install a metal or plastic panel roof to avoid dilution of their vat mixture by the weather and to shelter the workers.

The only known recycling was done at the commissary where they had a corrugated baling machine. A food service company managed the cafeteria and no recycling was done in this area. CIS suggested that a recycling program start in the area where the military personnel and their families reside. The 130 families generated 83 cubic yards of trash per week, along with an additional 8 cubic yards from their recreational facilities. The total of 91 cubic yards could be reduced considerably.

Paint and photo lab: Their painting operation was well run. The hazardous waste generated from the spray booth water curtain is a sludge mixture of paint, solids, and water. One 55-gallon drum was generated every three months and transferred to a hazardous waste contractor for disposal.

The paint stripping was done with a slag product. It operated on a "once through basis" only and is non-hazardous. 192,000 pounds were landfilled. CIS suggested that this grit could possible be reusable. An evaluation should be made to make this determination. The impact on savings, raw materials and landfill cost could be considerable.

The photo lab is phasing out of their one hazardous waste stream by replacing their sulfuric acid sodium bichromate rack cleaning solution with a substitute, which is non-hazardous and could be discharged to the sewer.

Test gun projectile lab: Three of the four cleaning stations have been changed from trichloroethane to a Citra solution. The fourth station should also be converted.

The cutting oil used for internal machining was a petroleum fatty additive with a metal deactivator. CIS suggested an emulsifiable mineral oil, which is completely soluble in water.

Hydrogen, used as a transmitter, was trapped, after use, in a large container. It was then allowed to slowly escape to the atmosphere. CIS suggested that consideration be given to the use of a storage tank and compressor for the recovery and reuse of the hydrogen.

50,000 pounds of Freon were annually lost at a cost of $160,000. The loss to the atmosphere was excessive. CIS suggested a preventative maintenance schedule of monitoring for leaks at the flanges, pump seals, valves and condenser using a Halogen or similar leak detection device. It was suggested that they investigate the replacing of refrigerant R-12. Industry is looking at HFC-134 as a possibility.

Freon refrigerant waste: The wind tunnels at the base are extremely large and can generate up to 1,000,000 CFM at temperatures of -150° F. The refrigeration units for this area were 8,600 tons each at full capacity and 30 years old. CIS concluded that 110,000 pounds of Freon leaked to the atmosphere at annual cost of $432,000. They will, by 1995 change over to HFC-134A. The new refrigerant does not appreciably affect oxygen depletion in the ozone layer and does not deteriorate rubber seals. Until that time controls should be established through an improved preventive maintenance procedure.

CIS suggested the following:

1. Improving leak testing with better instrumentation.

2. Improving pump and compressor seals.

3. Reducing of equipment vibration which causes leak in solder joints on cooling coils.

4. Repairing or replacing cooling coils which were judged to contribute more than 40% or 44,000 pounds of Freon loss annually.

Results:

A waste reduction program was recently initiated, concentrating first on recycling solid waste. To date, recycling of metals, cardboard, and high grade white office paper has reduced solid waste 2,972,000 pounds annually and saved $250,000 annually.