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SLOVAKIA
WASTE MINIMIZATION IMPACT PROGRAM
EVALUATION OF THE WASTE MINIMIZATION PROGRAM
AT
POHRONSKE STRONJARNE
SLOVENSKE LODENICE SHIPYARD
ZTS TEES MARTIN

JUNE 9-14, 1997

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TABLE OF CONTENTS

Distribution List 3

Introduction 4

Visit to Pohronske Stronjarne 5

Visit to Slovenske Lodenice Shipyard 17

Visit to ZTS Martin 30

Professional Backgrounds of WEC Volunteer Experts 41

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INTRODUCTION

The World Environment Center (WEC) conducted a Waste Minimization Workshop in June 1996. The Workshop was sponsored by the Pollution Prevention Center (PPC) in Slovakia and focused on the concepts and practices of waste minimization to Slovakian industries. A model example was presented that could be used directly, or with appropriate modifications, allowing a plant or factory to develop their own waste minimization program. The participating companies were given assignments whereby they would design and implement a waste minimization program at their company.

During the week of June 9-14, 1997, a WEC team visited three companies in Slovakia to evaluate their progress in implementing their waste minimization program. The team consisted of WEC Volunteer Experts, Dr. Marvin Fleischman and Mr. William J. Seevers, Ms. Olga Hauskrechtova, WEC In-country Coordinator, and Dr. Pavol Rajniak, Executive Director, PPC.

The companies visited included: POHRONSKE STRONJARNE, SLOVENSKE LODENICE SHIPYARD and ZTS TEES MARTIN.

The WEC team focused on how the plants implemented their waste minimization programs including:

- The plants' establishment of a waste minimization program, including team structure at all their facilities;
- The plants identifying and initiating no/low cost waste minimization projects; and
- Recommendations to improve their program to save money and eliminate and/or minimize waste.

It is appropriate at this time for WEC to acknowledge the important contribution made by Volunteer Experts, Dr. Fleischman and Mr. Seevers, who gave freely of their time and energy in assisting us in our waste minimization efforts in Slovakia.

EVALUATION OF THE WASTE MINIMIZATION PROGRAM

POHRONSKE STRONJARNE

POHRONSKE STRONJARNE

William J. Seevers, President
Environmental Technology Group

Executive Summary

This report has been prepared as a summary of the key findings and recommendations of the waste minimization investigation that was carried out on behalf of the WEC by this author William J. Seevers, of the Environmental Technology Group, Inc. and Dr. Marvin Fleischman of the University of Louisville. The site visit was on June 9, 1997, and included a close inspection of the machine shop, tractor assembling and painting departments and the foundry. These departments were selected because they appear to provide solid opportunities for minimizing waste.

One of the major activities of this project was the application of the 10-Step Waste Minimization Program that has been developed by WEC for facilities of this type. This program is based on the idea that waste minimization is a team activity that can be carried out in selected segments of a plant by a project team that has been dedicated specifically to this effort. The objective of the entire project is to identify and mobilize teams that can plan and carry out comprehensive waste minimization programs for individual departments. During the initial trials, the waste minimization team will pay close attention to the project results and will report the accomplishments of the program to plant management.

This report has been prepared as a preliminary assessment of the waste minimization opportunities at the POHRONSKE STRONJARNE facility. We appreciate the helpful support from the POHRONSKE STRONJARNE staff and the support provided by Ms. Olga Hauskrechtova, WEC In-country Coordinator for Slovakia Technical Programs and Dr. Pavol Rajniak, the Director of the Pollution Prevention Center.

Project Hosts and Contacts

The WEC team which consisted of Mr. William J. Seevers, Dr. Marvin Fleischman, Ms. Olga Hauskrechtova, and Dr. Pavol Rajniak, visited the POHRONSKE STRONJARNE facility.

Our contact and hosts included: Jan Hazjuk, General Director; Ing. Anton Adamec, Basic Tools and Energy Manager; Ing. Stanislav Glezgo, Production-Technical Director; Ing. Ivan Pulis, Director of Marketing; Ing. Monika Majerova, a key environmental and health and safety engineer. The Environmental Director and Chief of each department report to Technical Director. Technical Director is responsible for Production, Environment, Warehousing and Shipping, and Purchasing.

The General Director, Mr. Hazjuk, spent several hours with us over the course of the day. We greatly appreciate their support.

Background

The products of plant are industrial vacuum cleaners, mining machinery, casting and machined parts. The worker population is now about 480 people. There are many operations in the plant that generate industrial and hazardous wastes. Priority areas that we looked at were the machine shop, and foundry. The plant reports that they are seeking ISO-9000 certified, meaning that they will meet international conventions for manufacturing quality control.

Methodology

The direct approach for implementing a waste minimization plan is through product inventory control and the reduction of production costs. Indirect savings also result in reducing/controlling the costs of waste disposal, wasted energy, excess water costs and the cost of environmental cleanup.

Waste minimization based only on production control represents a small part of the potential savings that can be accomplished through this process.

The waste minimization approach that has been recommended in this report includes the following steps.

1. Forming a multi-disciplined team to carry out the waste minimization activities in each of the departments that are selected for waste minimization. It is recommended that the team be composed of a representative of top management, engineers, production specialists, machine operators and other workers, trade union delegates, economists and safety experts. The General Director could be directly involved with this team.

2. It is suggested that adopting all available methods for reducing the consumption of lubricants and coolants in the machining departments and in the tractor painting and assembly departments should be one of the first priorities. These have been spelled out in detail in Dr. Fleischman's report.

3. Monitoring the results of waste minimization by measuring the reductions in production costs will be a key function of the waste minimization initiative. At a later time, the program can be expanded and allowed it to focus on reducing waste disposal costs, energy consumption, water usage and costs for environmental remediation.

4. Following this step, measuring the reductions in waste discharges to the surrounding environment such as oil leakage into the soil, chemical discharges to the river and emissions to the atmosphere.

Cost Saving Opportunities

At this point, data on cost savings are very preliminary. Some of the data are anecdotal and are therefore not useful for long-range planning purposes. The point here is that these examples illustrate methodologies that the waste minimization team may use in the future. All of these were reviewed and examined by Dr. Fleischman and myself during the site inspection and are in Dr. Fleischman's report.

1. The machine shop was the first stop on our inspection and there seem to be many opportunities for controlling the waste of cooling and lubricating oils. The floors and working surface are extremely slippery and the minimization of oil would also produce a safety bonus. Reducing and controlling the cooling and lubricating oils could make an excellent demonstration project. Dr. Fleischman has provided some cost estimates and payback schedules for this operation.

2. The disposal of oil contaminated shavings and machine shop cuttings. This is another candidate area for a waste minimization demonstration project. Dr. Fleischman recommends a chip wringer to separate the oil from the shavings and indicates that a capital investment of $21,000 will be needed. *An alternative would be the use of a bio-remediation process to eliminate the oil. This would increase the value of the scrap metal and eliminate the oil disposal costs.*

We also examined the paint shop and saw a number of opportunities for pollution prevention and waste minimization in this area.

Conclusions and Recommendations

1. The management of the plant is well positioned to organize and manage a waste minimization program for machine shop. The record keeping skills are fine for this activity.

2. The General Director indicates that the waste minimization/pollution prevention program has his full support.

3. The plant lends itself to the formation of waste minimization teams.

4. The composition of the waste minimization team for each division of the plant should include one member of upper management and members of the Environmental Department. It is recommended that the same people could serve on each of the individual waste minimization projects. The floating members of the team should include a department foreman, a health and safety specialist and an economist.

5. A formal training plan and schedule could be established and implemented and carried out over a suggested period of three months. The training could be provided by an outside group such as the Pollution Prevention Center. An outline of the training plan will be included in our final report.

6. Waste minimization objectives should be targeted and all potential projects, large and small should be considered. By and large, individual goals are going to be small and success will be a function of the total number of waste minimization opportunities and the persistence of the program over a substantial time period.

7. The program should begin with relatively small projects such as the machine shop and the disposal of machine cuttings. Other projects could be selected that are likely to yield measurable results within the first six months. The selected projects should be monitored on a monthly schedule and evaluated after six months and 12 months. The success of the program will be based on the quality of environmental records and reports and end results that are achieved at the end of the year.

8. The activities and results of the waste minimization program should be evaluated from the standpoint of benefits to the environment. The waste minimization program will result in reduction and ultimate elimination of subsurface oil leaks, contaminant discharges to groundwater and surface water and reductions in air emissions.

9. There are studies that indicate a direct correlation between waste minimization and health and safety performance. The assignment of a health and safety expert to each team will allow this relationship to be monitored and evaluated.

10. ISO 14000 would provide an environmental management plan for the entire plant that that is consistent with international conventions. An ISO 14000 plan would provide an excellent framework for the implementation of a waste minimization program.

11. Environmental regulations are likely to tighten in 1988 . Waste minimization will improve the prospects for meetings these stiffer requirements.

12. Dr. Fleischman has discussed the many information resources on waste minimization that are available over the Internet. He recommends that full use should be made of this resources. This is one of the areas that should be covered in the training of the waste minimization team. Access and day to day use of Internet resources can be coordinated with Dr. Pavol Rajniak.

13. The PPC has many other resources to offer including laboratory analysis of environmental samples and advisory services in a number of areas.

POHRONSKE STRONJARNE

Dr. Marvin Fleischman, Professor of Chemical Engineering
& Co-Director Waste Minimization
Industrial Assessment Center, University of Louisville

Executive Summary

Products: Industrial vacuum cleaners, Agricultural machinery, Mining machinery, Castings (grey cast iron foundry), Machined parts
Number of employees: 480 workers
Ownership: Partially management and employee owned
Certification: ISO 9000 certification expected by end of 1998
Production work shops (depts.): Foundry, Machine Shop
Schedule: 2 shifts/day, 5 days/week; Thermal treatment is done on a third shift because energy costs are lower at night.
Waste priorities:

- **Foundry:** Foundry modernization is being proposed and Japanese financing is being sought, ~$7-10 million. The plant wants technical assistance in selecting/evaluating new foundry technology. They do not consider waste sand to be a problem because they are in compliance for landfilling.
- **Coolants from machining:** Oil/water emulsions sent for off-site disposal
- **Metal shavings with cooling oil from machining:** Scrap metal dealer may in near future, not take shavings unless more oil is drained off.
- **High cost of waste management in general:** It was stated that some production might have to be curtailed because cost for implementing waste management is too high. For example, galvanizing is done at another company to avoid the waste management issues and costs.

Pollution Prevention/Waste Management Program

- Plant is guided by governmental regulatory rules, and waste management technology seems to have a higher priority than operating practices.

- Management seems to be top down, with a classical organization chart. Production is their top priority.

- Plant participates in Ministry of Environment country-wide waste minimization program to identify wastes. Three main program are waste segregation, substitution, and waste minimization. One accomplishment has been the substitution of calcium, sodium, and magnesium carbonates for barium carbonate throughout Slovakia, for the purpose of waste fixation so that wastes can be landfilled. Barium carbonate is cheaper than the alternative, but now waste management costs are less. They previously paid $500/ton for disposal in Czech Republic, plus cost of bags. Now they are able to dispose in Slovakia at cost of $10/ton. It is not clear what waste is being disposed.

- Initiative for waste minimization comes from the Environmental Department. Concern is more over what to do with waste rather than to prevent or minimize waste generation. No written or formal waste minimization policy/program was evident.

- Knowledge of process details and selection and use of raw materials by the Environmental Dept., and even the Technical Director, will further waste minimization. It is suggested that their role be expanded and their impact broadened by greater interaction with production and purchasing, through a waste minimization team.

- A waste segregation program has been started that includes workers and management, at all levels. Seminars are given each Friday for 1-1/2 to 2 hours for the chiefs of each workshop on various environmental topics. The chiefs must then explain to the workers. It is recommended that seminars be presented directly to workers, and workers should be trained. A worker incentive program could also be developed.

- To implement waste segregation, various containers for specific wastes such as dirty wool (for wipes) and empty paint containers, has been initiated. However, there is not yet a central collection system for segregated wastes. Thus the local containers get full and the workers have nowhere to put wastes. A central collection/sorting facility, with additional segregation of recyclables, is recommended. Alternatively, a waste disposal firm might take the wastes at a lower cost and recover the recyclables themselves, e.g., a Materials Recovery Facility.

- There is a precedent for five person teams to do bi-weekly safety inspections. The committee is appointed by the General Director and includes the Chief of the trade union, a member of top management, and the engineers responsible for worker safety from two different manufacturing divisions, not necessarily the unit being inspected. If a problem is observed, the team proposes a solution, and if the problem is not solved, the Chief of the particular divisions must explain to the boss. Workers can make proposals, and production meetings are held in each divisions. A worker will make a suggestion to his supervisor, and if the problem is not solved the worker can go around the boss to a higher level of management. The worker is protected in this through a strong union. It is recommended that the scope of this team should be broadened to include pollution prevention/waste minimization. In this capacity it could include a production supervisor, maintenance director, a design engineer, operators, and representatives from purchasing and accounting. The regular walk through audits could now also include waste generation.

- This waste minimization team should have a role in identifying and evaluating evaluating process as well as waste management technology. It is advisable that more attention be paid to the composition of the materials used in the plant, e.g., material safety data sheets need to be readily available and reviewed. For example, it appeared that there was confusion about what type of paints are being used among. The environmental and production people need to interact with purchasing in selecting more environmentally compatible chemicals to eliminate the generation of waste.

- Waste records are done by hand and not computer. A computer based waste and materials tracking system is recommended that will also maintain material balances, e.g., paints, water usage, and machining fluids.

- It is recommended to look at waste generation from raw materials receiving through processing, to products and waste out of the plant. Focus as much or more on causes and sources of wastes, as well as on what to do with the wastes and relying primarily on new technology. Investment in new

technology is not the only solution. Improving worker operating practices, housekeeping and overall plant cleanliness require much smaller investments, but can yield significant returns.

- Review the possibility of obtaining ISO 14000 in the near future. It is strongly encouraged to start the process now because it will force a pollution prevention/waste minimization, beyond compliance program to be initiated, developed, and implemented

Housekeeping and relations between workers and management appeared to be good. The plant has already developed a team approach for safety and health inspection, that includes indirect worker participation, and this can be expanded to include pollution prevention/waste minimization

Specific Waste Generating Operations

Waste oil
Five tons/year (not include waste cutting oil), ~$0.50/kilo or $500/ton.

Landfill Wastes
One thousand (1000) kg/year.

Machining
Emulsion coolants: Machines have individual sumps with screens and coolant (oil/water emulsion) is recirculated through the screens. There is a lot of coolant splatter onto the floor, and sumps and machines require better control of coolant losses. Sawdust is used as an oil leak/spill absorbent. The sawdust is free and is obtained from a wood working operation on the plant site. Two tons/year are incinerated at a cost of $0.30/kg. Machines are cleaned with cloth fibers purchased from a textile mill (One ton/year, 20,000 SK). Dirty fibers are incinerated off-site ($0.30/kg).

One kg of concentrate costs 40 SK or ~$1/kg, and 360 kg/month are used (Can not determine if this is the amount of concentrate used for makeup or the amount after mixing with water. Also, the coolant cost seems low). They would like to use longer life (synthetic) emulsions, but these cost 2.5 times as much. City water is used to make up emulsions, which are formulated according to recipe (4-5% concentrate) using pH and refractive index measurements. Coolant is not circulated or mixed when machines are not operating, and there is no aeration.. Coolant is changed once per year; otherwise odors would develop. Waste emulsion from a machine is placed in a drum which is emptied into a sump and then picked up by truck for off-site de-emulsification, 40 tons/year. at $50-$100/ton. Scrap metal is put into a dumpster and the drained coolant is placed into the above disposal truck.

Potential waste minimization opportunities:
- It is suggested to use deionized/reverse osmosis water to make up coolant emulsions, to prolong coolant life at least 2 times.

Cost of equipment:
- US$8500 (600 gpd, complete with salt brine storage tanks, carbon adsorber, filter)

Estimated Operating costs:
- Labor for resin regeneration and cleaning: 2 hours/week @ $5/hour (assumed)
  * 50 weeks/year = $500/year

- Cleaning solution: $100/year
- Filter replacement: $5 * 3 changes/year = $15
- Membrane replacement: $700/3 years = $230
- Total operating costs = $345/year

Estimated savings:

- Coolant purchases (assuming doubling of coolant life and using US prices): $700/dm * 2dms/month/2 = $700/year
- Waste disposal: $0.50/gallon * 1 gallon/9 pounds * 2000 pounds/ton * 40 tons/year /2 = $2200/year
- Labor (sump changes, transfer of waste coolant to sump, labor for makeup emulsions, etc.): 100 hours/year (assumed) * $5/hour = $500/year
- Total savings = $3400/year
- Net annual savings = $(3400- 345) = ~$3055/year

Payback:

- $8500/$3055/year = 2.8 years
- Break waste coolant emulsion with an ultrafilter, discharge resultant waste water to wastewater treatment plant, and send concentrated waste coolant oil off-site disposal. (Evaporation is another approach to reducing the volume of emulsion to be disposed).

Equipment purchase cost:

- $4500 (100 gpm drum top system with 100 micron prefilter, pump, tank, stand). A 200 gpd unit costs $10,500.

Estimated operating costs:

- Prefilter changeout: $6/filter * 4 filters/year = $24
- Additional labor for flushing unit after use, periodic cleaning, operating unit: $5/hour * 100 hours/year (assumed) = $500/year
- Membrane replacement: $395/2 = ~$200/year
- Contingency: $100/year
- Total operating costs: $824/year

Estimated savings:

- Savings would result from reduced waste volume going to off-site disposal:
  It is assumed that 90% concentration is achieved and no additional costs are incurred for sending wastewater to wastewater treatment plant.
- Total savings = 0.90 * $4400/year = $3960/year
- Net Annual Savings = $3960 - $824 = $3136/year

Payback:

- $4500/$3136/year = 1.4 years.
- Coolant management program to prolong coolant life: It is recommended to use deionized water to make up emulsions. Use biocides to prevent anerobic bacterial growth, and keeps sumps aerated or mixed during machine shut downs. Prevent dirt from getting into the sump and workers from throwing trash into the sump. Skimmer/aerator units are available to keep coolant systems fresh.

- Reusable, washable rags through an industrial laundry to clean machines: This would reduce waste disposal and eliminate cloth fiber purchases, but may be less economical than the present practice.

Oil Cooled Machines

Cutting oil costs ~ 20 SK/kilo (estimated US cost $2.60/gallon. in 55 gallon. drums) and 2000 kg/month. are used. Cutting oils are recirculated through screens. The oil does not drain well from the shavings. Metal shavings thus have a lot of oil on them and they cannot be disposed anymore in Austria. Shavings are placed in a container, the oil drains off and is incinerated off-site (not part of 5 tons of waste oil). Drained shavings from emulsion and oil cooled machines are sold as scrap metal. Scrap metal is segregated by the type of metal. One hundred tons/year, of dirty shavings are generated and they get paid 600 SK/ton. Transportation costs are $10/truck load. More revenue could be generated if the chips were cleaner. They are expecting new regulations which would require chips to be cleaner, and greater oil removal will be required in the future for scrap metal dealers to take the shavings. The oily shavings will be difficult to dispose of.

Potential waste minimization opportunities:

- Use a chip wringer to remove cutting oil from shavings and reuse oil.

Estimated Purchase Cost:

- Chip wringer, 2.1 cubic foot/load, 7.5 hp motor, 1 chip pan - $18,000 (not including sales tax and freight)
- Chip pan dolly to transport chips from machine to chip wringer - $95
- Chip pans to be placed on individual machines (5 each) - 5*$395/pan ~ $2000
- Total investment = $21,000

Estimated Operating Costs (800 pounds/day, 50 pounds/cubic foot, 15 cubic foot/day):

- Labor: 5 minutes/cycle for loading and unloading ~ 40 minutes./day*1hour/60 minutes*$5/hour*5 days/week*50 weeks/year = $833/year
- Electricity, Maintenance: $300/year assumed
- Total operating costs = $1130/year

Estimated savings:

- Additional scrap metal revenue: Assume 10 % premium for dry chips & 50% of shavings from oil cooled machines 500 tons shavings/year * 0.10 * 600 SK ($20)/ton = $1000
- Reduced cutting oil purchases (assume 50% reusability - reusability would have to be tested) 1000 kg/month * 12 months/year * $2.50/kilo = $30,000/year (Based on US costs, cutting fluid is estimated to cost ~ $2.60/kilo based on 55 gallon drums)
- Reduced oil disposal costs: Not accounted for
- Net annual savings = $30,000 + $1000 - $1130 ~ $30000/year
- Additional resulting benefits would be improved worker safety and housekeeping by less oil on shop floor

Payback:

- $21,000/$30,000 = 8.4 months
- If the recovered oil cannot be reused, the payback will be long. However, unless the oil is removed from the metal shavings, they may not be able to get rid of the shavings

Chip wringer to remove oil from shavings and a centrifuge to clean oil for reuse.

Investment cost:
- Incremental cost for centrifuge (3 hp for pumps and motor, automatic recirculation of cleaned oil to storage): $14,000
- Investment: $21,000 + $14,000 = $35,000

Incremental operating expenses: Negligible

Estimated savings:
- Scrap metal revenue (same as above)
- Reduced cutting oil purchases (manufacturer claims 75% reduction in cutting oil purchases): 2000 kg/month * 12 months/year * $2.50/kilo * 0.75= $45,000/year
- Savings on oil disposal costs would be greater than above because more oil will be kept out of the waste stream.

Payback:
- $35,000/$45,000 = 9.3 months

Blow oil off chips with compressed air.

Foundry

Black sand (containing lubricant) was scattered all around the floor of the Foundry. There were also open flames. A worker was observed to be brushing a fluid onto a piece (part or mold). The brush was dipped into a can of the fluid and then the fluid applied to the part, with fluid dripping all over the floor. It is highly recommended that to avoid waste the fluid application could be easily done over a container to catch the fluid drainage for reuse, or it could be brushed directly over the fluid container so that the drainage is returned. Sand is removed from the part and is landfilled, 10-12 tons/day (includes foundry sand), $30/day including transportation. It is cheaper to landfill than to give to a cement kiln (This should be checked out). Foundry parts are quenched and water goes to an oil/water separator.

Potential waste minimization opportunities:
- Recycling sand after crushing in a mill.
- Thermal sand reclamation system to recycle and reuse the sand immediately after iron is molded. This is expensive.
- Use of waste sand for fill at construction sites, pipe bedding, aggregated in roadway construction, as aggregate in production of asphalt or concrete, and in glass manufacture

Painting

A broad spectrum of paints is used according to customer specifications; some 2 part polyurethane. Spraying is done with conventional compressed air guns. The paint booth has positive air flow through air filters, and overspray is captured in below ground water sump. Water is coagulated and recirculated. Coagulated paint solids are disposed as hazardous waste. The paint balance is not known. Painting is not currently of environmental concern because a new conventional air filter spray booth will be installed during the second half of the year. The booth will exhaust through an activated carbon filter for emissions control.

The new booth can be an opportunity to incorporate pollution prevention/waste minimization into the painting process at the design/planning stage, e.g., standardization of paints, selection of high transfer efficiency paint sprayer (e.g., electrostatic, HVLP), type of air filters (e.g., polystyrene filters which dissolve in waste cleanup solvent), paint purchasing (e.g., returnable or recyclable containers), cleanup techniques, cleaning solvent recovery, solvent vapor recovery from the carbon filter (e.g., carbon reactivation with nitrogen and nitrogen reuse), etc. The waste minimization team can solicit continuous input from the appropriate regulatory agency to ensure compliance.

Boilers

Hot water heating system is one gas boiler and two coal fired boilers. Coal is 1-2% sulfur, and the plant would like to switch totally to gas to eliminate SO_x emissions. This will be expensive. A potential waste minimization opportunity is to burn waste oil and paint wastes in the boiler. This too will require converting one of the boilers.

EVALUATION OF THE WASTE MINIMIZATION PROGRAM

SLOVENSKE LODENICE SHIPYARD

SLOVENSKE LODENICE SHIPYARD

William J. Seevers, President
Environmental Technology Group

Executive Summary

This report has been prepared as a summary of the key findings and recommendations of the waste minimization investigation that was carried out on behalf of the WEC by William J. Seevers, of the Environmental Technology Group, Inc. and Dr. Marvin Fleischman of the University of Louisville. The site visit was on June 12-13, 1997, and included close inspection of the pre-priming shot blasting operation for steel plate, plant-wide waste separation, the centralized waste segregation and recycling center, ship board trimming, wiring, plumbing and finishing, final sand blasting and final painting. These departments were selected because they provide solid opportunities for minimizing waste.

One of the major activities of this project was the application of the 10-Step Waste Minimization Program that has been developed by WEC for facilities of this type. This program is based on the idea that waste minimization is a team activity that can be carried out in selected segments of a plant by a project team that has been dedicated specifically to this effort. The objective of the entire project is to identify and mobilize teams that can plan and carry out comprehensive waste minimization programs for individual departments. During the initial trials, the waste minimization team will pay close attention to the project results and will report the accomplishments of the program to plant management.

This report has been prepared as a preliminary assessment of the waste minimization opportunities at the SLOVENSKE LODENICE SHIPYARD. We appreciate the helpful support from the SLOVENSKE LODENICE SHIPYARD staff and the support provided by Ms. Olga Hauskrechtova, WEC In-country Coordinator for Slovakia Technical Programs and Dr. Pavol Rajniak, the Director of the Pollution Prevention Center (PPC) in Bratislava.

Project Hosts and Contacts

The WEC team which consisted of Mr. William J. Seevers, Dr. Marvin Fleischman, Ms. Olga Hauskrechtova, and Dr. Pavol Rajniak, visited the SLOVENSKE LODENICE SHIPYARD.

Our contact and hosts included: Ing. Lubomir Prekop, Environmental Department Manger, Ing. Peter Sipula, Chief of the Chemical Laboratory, Ing. Juraj Steiner, Principal Technical Manager, Ing. Kolomon Antal, Ship Production Manager, and Ing. Ivan Majer, Manager of Information Systems.

Background

Slovenske Lodenice builds passenger, cargo ships and dredges. The company also does ship repairs and maintenance and through an affiliate, it manufactures cargo shipping containers. The company employs 3000 people. There are many operations in the plant that generate industrial and hazardous wastes. The plant reports that they are ISO 9000 certified, meaning that they meet international conventions for manufacturing quality control. They are aware of the benefits of ISO 14000 certification which would bring them into compliance with international conventions and codes of conduct for environmental management.

Due diligence environmental audits of the plant were performed in 1994, as a step in qualifying for international financing to modernize the facility. The audit included the testing of underground water, soil and "mud in basins", (probably referring to waste materials on the river bed). The audit report addressed deficiencies in the waste sorting operation, the need to minimize hazardous waste and contaminants that are the by products of sand blasting. The Environmental Department provided a flow chart of the waste disposal program which we have attached as an exhibit for this section of the report. What it shows is that there are :

- 3600 tons/year* of solid garbage
- 10,000 tons of semi-liquid garbage
- 18,800 tons of hazardous semi solid/semi liquid waste
- 660 tons of carbide sludge from welding operations.

References were made by management staff to the near term tightening of environmental regulations and the difficulty that the shipyards will have in the future meeting air quality regulations.

(*Reported as SK/ton)

Methodology

The direct approach for implementing a waste minimization plan is through product inventory control and the reduction of production costs. Indirect savings also result from reducing/controlling the costs of waste disposal, wasted energy, excess water costs and the cost of environmental cleanup. Waste minimization based only on production control represent a small part of the potential savings that can be accomplished through this process.

The waste minimization approach that has been recommended in this report includes the following steps:

1. Recommend forming a multi-disciplined team to carry out the waste minimization activities in each of the departments that are selected for waste minimization. The team should be composed of a representative of top management, engineers, production specialists, machine operators and other workers, trade union delegates, economists and safety experts.

2. It is suggested to adopt all available methods for reducing the consumption of paints, blasting sands and shot, and for managing the disposal of solid and semi solid wastes. Also reducing the contamination of soil, underground water, river bed sediments and air. These have been spelled out in detail in Dr. Fleischman's report.

3. Monitoring the results of waste minimization by measuring the reductions in production costs. At a later time, the program could be expanded and allowed to focus on reductions in waste disposal costs, energy consumption, water usage and costs for environmental remediation.

4. Following this step, measuring the reductions in waste discharges to the surrounding environment such as oil leakage into the soil, accumulations of contaminated sediment on the river bed and emissions to the atmosphere.

Cost Saving Opportunities

At this point, data on cost savings are very preliminary. Some of the data are anecdotal and are therefore not useful for long-range planning purposes. The point here is that there examples point the way to methodologies that the waste minimization team may use in the future.

Plant personnel report that some of their customers have made note of excessive amounts of raw materials and unrecovered water products that are generated by the shipyard. One has reportedly offered to form a business partnership with the plant to recover and sell waste materials.

Central Waste Segregation Facility: This is a new facility that was set up under the direction of Ing. Lubomir Prekop and it handles approximately 30 tons/day of solid waste. Of this, approximately 80 tons/month are recycled (approximately 10 percent of the total). At the present time the waste separation is done by hand using five workers. By simply increasing the size of the work force and keeping track of the value of the recovered material waste, recovery operation could be increased substantially. This waste separation facility could serve as an incubator for a number of waste minimization programs at the ship yard which could be launched and paid for using the revenues from the waste separation program. Very roughly, the potential income from the 20,000 ton/year solid waste stream is probably $500,000 or more. The initial investment in labor, $250-300 per man month, and separating equipment to increase the capacity of this operation could be easily justified given the revenue generated by this operation. Also, there would be a reduction in the solid waste that would otherwise be landfilled.

Painting: This is probably the operating area where the greatest opportunities exist for cost savings. A quick calculation shows that the shipyard uses 100,000 liters/year of primer per year at $4/liter and 300,000 liters/year of finishing paint ranging from $3-$15/liter. Paint costs are several million dollars or more per year. Losses due to over spraying (40%) and wastage from spillage and inefficient usage bring the cost saving opportunities into the hundred thousand dollar range.
Dr. Fleischman regards this as an important area for waste minimization and points out changes that can be made in the application equipment, paint storage and distribution practices, and the methods of disposing of empty paint cans (which are by law handled as hazardous wastes).

Conclusions and Recommendations

1. The Environmental Department is well prepared to organize and manage a waste minimization program for the Central Waste Segregation Facility and the Plant Wide Painting Operations. .Ing. Lubomir Prekop is largely responsible for the formation and launching of the Central Waste Segregation facility. His operation could be increased substantially and could easily serve as the nucleus for a comprehensive waste minimization program that would generate significant savings immediately. Ing. Prekop's operation should be used as the nucleus of a 10-Step Waste Minimization Program. It is suggested that the budget for this operation should be free standing and generated out of current revenues from recycling.

2. Environmental audits will continue to be one of the tools used by lenders to evaluate the credit and investment value of the facility. Based on the 1994 audit that was done in support of a development loan for modernization, it is likely that there will be many more audits in the future (of increasing complexity and higher standards). The ability to manage solid and liquid waste and to control the formation of groundwater contamination plumes, areas of toxic soil, hazardous air emissions,

discharges of contaminated sediment to the river will become an ever more important management activity.

3. It is suggested that the Waste Minimization Team be built around the current operation managed by Ing. Lubomir Prekop, in addition, should include a representative of upper management, a trade union representative, a health and safety expert a member of the labor force and an economist.

4. A formal training plan and schedule should be established and implemented and carried out over a period of six months. The training should be provided by an outside group such as the PPC. An outline of the training plan will be included in our final report.

5. It is recommended that waste minimization objectives should be targeted and all potential projects, large and small should be considered. By and large, individual project goals are going to be small and the success of the project will be a function of the total number of projects and the persistence of the program over a substantial time period. Dr. Fleischman has recommended the adoption of formal incentives and I concur with this.

6. It is recommended that the most beneficial area to begin the program should begin with the waste segregation and the painting operation areas and should evolve from these two areas. Other projects should be selected that are reasonably likely to yield measurable results within the first six months. The selected projects should be monitored on a monthly schedule and evaluated after six months and 12 months. A report on the results should be completed at the end of the first year. The success of the program will be based on the quality of environmental records and the bottom line results that are achieved. The record keeping skills of the Environmental Department are more than adequate to meet the needs of this project.

7. The activities and results of the waste minimization program should be evaluated from the standpoint of benefits to the environment. The waste minimization program will result in reduction and ultimate elimination of subsurface oil leaks, contaminant discharges to groundwater and surface water and reductions in air emissions.

8. There are studies that indicate a direct correlation between waste minimization and health and safety performance. The assignment of a health and safety expert to each team will allow this relationship to be monitored and evaluated.

9. ISO 14000 would provide an environmental management plan for the entire plant that that is consistent with international conventions. It would also serve as an excellent framework for the implementation of a waste minimization program.

10. Environmental regulations are likely to tighten in 1998. Waste minimization will improve the prospects for meetings these stiffer requirements.

11. Dr. Fleischman has discussed the many information resources on waste minimization that are available over the Internet. He recommends that full use should be made of this resources. This is one of the areas that should be covered in the training of the waste minimization team. Access and day to day use of Internet resources can be coordinated with Dr. Rajniak of the PPC.

12. The PPC has many other resources to offer including laboratory analysis of environmental samples and advisory services in a number of areas.

SLOVENSKE LODENICE SHIPYARD

Dr. Marvin Fleischman, Professor of Chemical Engineering
& Co-Director Waste Minimization
Industrial Assessment Center, University of Louisville

Executive Summary

Products: Ships (passenger, dredges, cargo) and ship repair/renovation
Number of employees: 3000
Ownership: Recently privatized
Email address: majer_ivan@slk.sk
Certification: ISO 9000
Process (depts.): Surface preparation (shot blasting)---→ Cutting, Machining -----→ Priming --→ Assembly --→ Painting of assembled ship; Ship interior paneling, insulation, wiring, etc.
Schedule: 1.5 shifts/day (Some 3 shifts, mostly 1 shift), 5 days/week, 8 hours/shift
Overhead: 100% of employee wages
Waste priorities: Welding beads, paint consumption, materials segregation and greater degree of recycling, inexpensive alternatives to sand blasting for paint removal from ships undergoing renovation

Current Waste Management/Waste Minimization Program

- Waste management under Technical Director.
- Environmental Department writes regular reports twice per week to top management, who then delegates tasks to the factory.
- No regular meetings of technical management; meetings only as needed.
- No formal waste minimization program.
- Designers responsible for minimizing materials usage, e.g. machining/cutting operations - Material wastage from cutting < 20%.
- Incentive programs in place:
  - Bonuses given to designers (only designers?) for certain materials savings.
  - Bonuses are given for worker suggestions, e.g., a foreman who suggested cutting out smaller pieces from scrap steel plate, was rewarded.
- In past, a paint management team was established under the General Director's initiative. The team included research and development, design, purchasing, and production. The Environmental Department did not exist at the time. Foremen, but not operators, were included in the team. The team did not produce any significant results.

Accomplishments/Pluses

- Many wastes and their sources identified.
- Paint cleanup solvent recovery still in place.
- Waste sorting center established.
- Scrap metal recycling, including unchopped steel banding.
- Waste paper & cardboard baled and sold.
- Mr. Prekop is a "spark plug" for pollution prevention/waste minimization. He has already initiated a program, understands the problems, and previously worked in the plant in a production capacity.

He would need assistance or participation from production, purchasing, and workers (perhaps through a trade union representative).

- The managers all seem to know their specific jobs, but more frequent interaction is recommended for waste minimization.
- Mr. Sipula should definitely be included on the team when the priming and painting programs/processes are assessed.

Needs/Suggestions

- Facility seems to accept lack of worker discipline as reflected in poor housekeeping, trash on shop floor and not segregating various wastes as directed. There seems to be a communications/ relationship gap between workers and management. More worker training and incentives are highly recommended. For example, pick a particular work area for enhanced on-site waste segregation and recovery of recyclables, and return a portion of the recycling revenue or waste management savings to the involved workers in the form of a tee shirt or baseball cap.
- More proactive approach, e.g.,
  - Develop philosophy of preventing pollution rather than just responding to existing wastes.
  - Frequent process reviews.
- Could use more top management support, e.g.,
  - Incentives or penalties for workers regarding house keeping and waste segregation
  - More workers for materials separation.
- Environmental Protection Agency publications on shipyards, e.g., military facilities.

Specific Waste Generating Operations

Waste Segregation

Waste is produced throughout the plant, in work halls, pier, onboard ships. There are various boxes on shop floor for various wastes, including trash. Boxes are painted blue or yellow. However, workers do not segregate enough. Wastes are thrown into wrong containers, e.g. waste paper was observed in a parts container. Penalties for doing this are not allowed by top management. Recyclables are often thrown in the trash. Observed materials in the trash include: broken pallets, cardboard boxes, timber used to separate steel plates during transport, metal plates, metal and plastic welding wire spools (one spool had about 20 ft. of copper wire remaining), welding beads, other packaging waste.

<u>Potential waste minimization opportunities to recover more recyclables include</u>:

- Paint boxes different colors for different wastes, and put signs on boxes in both Slovakian & Hungarian.
- Keep boxes closed so that workers will have to open the top to put items in box. Maybe the extra effort will discourage the workers from throwing the wrong thing in the box, e.g., trash.
- Develop a segregation/recycling waste team - environmental coordinator, union representative, foreman, worker.

Central segregation facility

This is essentially a materials recovery facility that operates 5 days/week, 8 hours/day, 5 workers, 30 tons/day materials handling capacity, approximately 80 tons/month recycled. Waste carts are

transported by truck or forklift from work cells during the afternoon shift. Box contents are dumped onto a working pad with outlet chutes for specific wastes to specific collectors. Plastic, welding wires, electrical cable, and spent welding electrodes are not segregated. The trash was observed to contain pressure hoses, steel welding wire reels (should be recyclable), sawdust, gloves, springs (unused, tossed in on shop floor), metal clamps. Some of the reels that were thrown away had significant copper wire left, e.g., 10 meters or 8 pounds, scrap value of $2/kg and new copper wire costs 45-50 SK/kg A potential waste minimization opportunity is to run the trash through a conveyor with magnets to remove metals.

Eighty to 120 tons/month, 600 SK/ton excluding transportation cost, is landfilled. Currently about 5% of waste disposal costs are recovered by recycling. More workers are needed to optimize separation and segregation of recyclables (paper, steel, timber), and more recycling revenue could then be realized. However, they cannot get approval for more employees. (Labor ~$300/man-month). Segregation must start on shop floor, and greater segregation at work stations would then require fewer employees in the central sorting area.

Shot blasting

Shot blasting is used to prepare steel plates for priming. The grit (small particles and removed flash) are sent to a steel mill.

Priming and Ship Painting

Steel plates are primed prior to assembly into a ship, and the top coat is applied to the built ship. 100,000 liters of zinc silicate based primer are used at $4/liter. Numerous paints (400 types) paint are used, 300,000 liters/year Cost range is $3-$15/liter. Paint is 13-99% solids, and 2 part polyurethane and two part epoxies are used. At the time of the plant visit, the person directing the ship painting said that the two part paint being applied cost ~$100 SK/liter ($33/liter). Ten different thinners are used as cleaner, including xylene with vinyl benzene. Forty-thousand liters of thinner per year is purchased at $2/liter. Cleanup solvent from priming and ship painting are recovered in a still, and the still bottoms are combined with other hazardous paint wastes. The still bottoms are hazardous due to flammability of solvents being used, e.g., 135 flash point solvent (mineral spirits) used to clean ship paint guns. Ten to 15 tons/month of crushed and shredded empty paint cans with unused paint, still bottoms, cardboard baffles/protectors from ship painting and other paint wastes are landfilled as hazardous waste at a cost of six to eight SK/kg ($3000/month). Incineration would cost as much as $10/kg.

Priming is done with 40-50 automatic airless guns at (~300 bars). Overspray is caught in a recirculating water sump under floor grates. Forty percent of the purchased paint goes to waste as overspray, paint remaining in empty cans, equipment cleanup waste, coagulated paint solids from the water trap and solids that are scraped from the booth walls and floor grates.

For shipboard painting, the two parts are mixed in the pot and then applied using conventional compressed air spray guns (500 bars guns, pressure pot is 360 bars), roller, or brush. Painters are given training for 2 hours/day, 2 weeks/year. However, a lot of overspray was observed during painting (spray fan width was large). Painters use excess paint, e.g., will open a 20 liter can at the end of a shift and only use a small portion. The rest will go to waste. If the two parts of the paint have not been mixed, they can be closed and the paint used on the next shift. Also, paint cans are left open on the pier. Empty paint cans are not dried out, and usually contain about ½ liter paint residue which goes to waste. The paint supplier will not take back empty cans.

Potential waste minimization opportunities:

- It is recommended to purchase both primer and ship paint larger, returnable containers, e.g., 55 gallon drums, and have paint dispensed from a central location rather than having cans delivered to the work site on an as-needed basis. This can also serve as inventory control and reduce use of excess paint, e.g., like a paint distribution center. Their argument against this is that they use too many different kinds of paint to purchase in large containers, and large containers are not feasible for two component paints. It is suggested that if customer specifications allowed, they could standardize the paints used and reduce the number of different types. Another argument is that ships are in different locations, and materials transport would become difficult and be labor intensive.
- Provide incentives for painters to reduce excessive paint usage.
- Find a vendor that will take back empty paint cans or get paint in plastic lined cans. When the can is empty, the plastic can be removed and trashed, and the can will be clean and can be returned to the vendor or sold or given away as scrap metal. An alternative, if the paint can be purchased in plastic lined cardboard boxes, the boxes would take be easier to dispose of, i.e. , take up less volume
- Another suggestions is to wash cans with paint thinner and sell cans as scrap metal (as done by ZTS Tees MARTIN). The waste solvent can go to the solvent recovery still. In addition to possible revenue from selling scrap metal and reduced hazardous waste generation, savings will result from reduced operation of the crusher and shredder (labor and power). This can be done in a recirculating washer designed for washing out cans.
- Wash non-automatic spray guns in a recirculating gun washer. This will reduce solvent consumption and hazardous still bottom waste generation. It should be possible to wash both guns and empty paint cans in the washer.
- Blend paint waste, e.g., still bottoms, into primer, or have it done by a paint supplier
  - Assume that 10% of wastes can be blended and used as primer
  - Waste disposal savings = $3600/year
  - Savings in primer purchases = $5000/year
  - Net Savings = $8600/year
- Use High Volume Low Pressure (HVLP) spray guns for ship painting. This should reduce overspray because of higher transfer efficiency than current guns, thus reducing paint purchases and paint waste generation.
  - Cost of a turbine operated HVLP gun system - $16,000 (A 4 gun system is available for ~$19,000)
  - Assume that 2 systems would be needed at any given time
  - Total estimated cost (including training): US$ 35,000
  - Reduced paint purchases: $75,000/year (Assumed 5% reduction in paint consumption at cost of $5/liter)
  - Reduced waste disposal: $1800/year (Assumed 5% waste reduction)
  - Net Savings: $76,800/year

  (Electricity costs and possibly labor will be less than with current system. However, it is assumed that operating costs, including gun cleanup and maintenance will be the same for both current and HVLP guns)
  - Payback = $35,000/$76,800/year ~ 0.5 years. = 6 month
- For ship painting, use a pleural component (proportional) metering system for the two part polyurethane paints, i.e., components are pumped from their respective cans and mixed in spray gun nozzle as needed. This will eliminate the paint remaining in the pot that goes to

waste, and will thus also reduce paint consumption. Such a system should be useable with existing paint spray guns. Since the ships are in different locations, the unit could be put on a truck or otherwise made mobile to bring to various work sites.

- Assume a 2% reduction in paint consumption and paint waste, and average paint cost of $5/liter
- Savings ~ ~$31,000/year
- Investment = $36,000 (assumed that this includes training costs)
- Additional operating expenses = $1000/year
- Net Annual Savings = $30,000 year
- Payback = $36,000/$30,000/year = 1.2 years

Shipboard Insulation

Mineral rock wool, 40 to 130 mm thick, is delivered in sheets or rolls, 500 mm wide x 1000m estimated, long. The designer determines amount to be used, and worker obtains that quantity and no more, like a pharmacists. It is hard to estimate in advance exactly how much is needed and some trim cannot be avoided. Corrections are made the next time around as appropriate (feed back loop). Some waste insulation is used for smaller jobs. Trim (excess) waste is collected and sold to employees or elsewhere. The waste rate is about 20 cubic meters/year, and 10000 square meters, 5-7mm thick, is purchased annually. Insulation costs 3.5 SK/kg ($0.10/kg)

Shipboard Timber (used for interior decoration, utilities)

Wood, pressed wood, formica, and plywood is used. Excess is waste and is sold to employees at a low cost.

Shipboard Electric Cable, Plumbing

A computer system for piping layout and design has minimized waste. Waste metals are sold as scrap metal. Waste electric cable containing copper is trashed and landfilled. Workers are given one meter of cable longer than is needed because splicing is not allowed. Waste quantity is not known, but is believed to be about 10% of usage. No one is interested in purchasing this waste. Some copper is recovered on ship by workers, on their own.

<u>Potential waste minimization opportunities:</u>

- Strip or burn plastic off cable and recycle copper using worker idle time. (This could raise a trade union concern)
- Find an outside person who would take the cable and try to recover the copper, e.g., like pallets and cardboard are sometimes given away in U.S. plants.

Welding

Waste wire and electrodes are placed into trash box at the work site and landfilled. Electrodes come in plastic wrapped cardboard boxes, with wrapping around individual electrodes as well as the entire package. While the cardboard is recyclable ($0.10/kg estimate), too much labor is required to remove plastic. This seems to be a classical case of overpackaging.

<u>Potential pollution prevention opportunities include:</u>

- Worker separating plastic and cardboard from opened package at welding work site, and recycling plastic as well as cardboard.

- Work with supplier to reduce plastic overwrap and make it easier to separate plastic and cardboard, or find a supplier who will not overpackage.

Pallets

Broken pallets are given to employees, and good pallets are sent back to supplier. No pallet rebuilders are available.

Empty Drums

Not clear whether they can be returned to supplier. If not, possibly see if they can be crushed and sold for scrap metal value. Depending on the contents of the drum, e.g., paint cleanup solvent, empty drums might be considered as hazardous waste

Sandblasting

Old paint from ship cargo hatch is removed by blasting in the sand blasting building and by outdoor blasting from ships being repainted. In the building, dust is reused once with fresh sand. Waste sand given to a construction company who picks it up at their own cost. Primarily because of industrial hygiene issues, this is the last year in which local authorities will allow sand blasting prior to painting. They are considering using granite from India which is considerably more expensive than sand, but can be used six to seven times. They would like to find a cheaper alternative. "Black Beauty", used for blasting in the United States, might be a possibility.

EVALUATION OF THE WASTE MINIMIZATION PROGRAM

ZTS TEES MARTIN

ZTS TEES MARTIN

William J. Seevers, President
Environmental Technology Group

Executive Summary

This report has been prepared as a summary of the key findings and recommendations of the waste minimization investigation that was carried out on behalf of the WEC by this author William J. Seevers, of the Environmental Technology Group, Inc. and Dr. Marvin Fleischman of the University of Louisville. The site visit was on June 9th and 10th, 1997, and included a close inspection of the engine testing operation and the tractor assembling and painting department. These departments were selected because they appear to provide solid opportunities for minimizing waste.

One of the major activities of this project was the application of the 10-Step Waste Minimization Program that has been developed by WEC for facilities of this type. This program is based on the idea that waste minimization is a team activity that can be carried out in selected segments of a plant by a project team that has been dedicated specifically to this effort. The objective of the entire project is to identify and mobilize teams that can plan and carry out comprehensive waste minimization programs for individual departments. During the initial trials, the waste minimization team will pay close attention to the project results and will report the accomplishments of the program to plant management.

This report has been prepared as a preliminary assessment of the waste minimization opportunities at the ZTS TEES MARTIN facility. We appreciate the helpful support from the ZTS TEES staff and the support provided by Ms. Olga Hauskrechtova, WEC In-country Coordinator for Slovakia Technical Programs and Dr. Pavol Rajniak, the Director of the Pollution Prevention Center.

Project Hosts and Contacts

The WEC project team for the ZTS TEES visit included WEC consultants, William Seevers and Dr. Marvin Fleischman, and Dr. Pavol Rajniak, Director of the Pollution Prevention Center

Our contacts and hosts at the plant included Ing. L'ubomir Krsko, Strategy Director, Ing. Tatiana Jamriskova, Environmental Department Manager, .Mr. Ladislav Zvarik, Waste Department Manager, Ing. Milan Novotony, Manager for Diesel Engines Department C-06, Ing. Ondrej Bartos, Manager of Technical Office C-06, Ing. Jozef Valko, Manager of Technical Office C-04, Ing. Dusan Kubis, Manager for Maintenance C-04, Ing. Jozef Kurinec, Technologist C-04, Ing. Miroslav Zvarik Water Economy Manager, and Mr. Miroslav Mazanec, Manager for Tractors C-04. We were greeted with full cooperation by this group and they made every effort to provide the information that we needed for this investigation. We greatly appreciate their support.

Background

The products of the ZTS TEES plant include tractors, diesel engines, forestry machinery. The company was founded in 1949 and until recently employed 4500 people. The population is now about 3000 people. Two of the priority areas that we were asked to examine were the engine testing facilities and the waste from the tractor painting operations.

The plant reports that they are ISO-9000 certified, meaning that they meet international conventions for manufacturing quality control. They are seriously considering ISO-14001 certification which would bring them into compliance with international conventions and codes of conduct for environmental management.

Methodology

The direct approach for implementing a waste minimization plan is through product inventory control and the reduction of production costs. Indirect savings also result from reducing/controlling the costs of waste disposal, wasted energy, excess water costs and the cost of environmental cleanup.

Waste minimization, based only on production control, represent a small part of the potential savings that can be accomplished through this process.

The waste minimization approach that has been recommended in this report includes the following steps.

1. Forming a multi-disciplined team to carry out the waste minimization activities in each of the departments that are selected for waste minimization. The team should be composed of a representative of top management, engineers, production specialists, machine operators and other workers, trade union delegates, economists and safety experts.

2. Adopting all available methods for reducing the consumption of lubricants, transmission fluids and paints in the engine testing departments and in the tractor painting and assembly departments. These will be explained in detail in Dr. Fleischman's report.

3. Monitoring the results of waste minimization by measuring the reductions in production costs. At a later time, program can expand and focus on reductions in waste disposal costs, energy consumption, water usage and costs for environmental remediation.

4. Following this step, measuring the reductions in waste discharges to the surrounding environment such as oil leakage into the soil, chemical discharges to the river and emissions to the atmosphere.

Cost Saving Opportunities

At this point data on cost savings are very preliminary. Some of the data are anecdotal and are therefore not useful for long-range planning purposes. The point here is that these examples point the way to methodologies that the waste minimization team may use in the future.

1. There are some data from the tractor painting operation that indicate that approximately 4000 kilos of waste paint are collected for incineration each year and that the cost for incineration is 20 SK/kilo. This amounts to 80,000 SK/year or $2500

2. The annual consumption of paint is about 20,000 kilos or 20 kilos per tractor. The cost of red paint is 250 SK/kilo or $156,000.

   Reductions in paint wastage of 10%, 20% and 30% would result in savings of:
   $ 15,580, $31,160 and $46,740 respectively.

3. Lubricating oil used in engine testing amount to 18,000 kilos/year at a cost of 15 SK/kilo or 270,000 SK/year or $8437/year.

4. Engines are tested for 20 hours and lubricating oil is disposed of after six tests. Increasing the testing cycles to 12 would reduce oil usage to 9000 kilos/year and the annual cost to $4218/year.

5. All new and rebuilt engines test run for a period of 20 hours. The washing removes oils that leak through gaskets, seals and ports. With a clean surface the inspector is able to pinpoint the location of leakage points. Average water usage per 20 hour test cycle is 120,000 gallons. At a production rate of 2000 engines/year this amounts 24 million gallons/year. All of this water will require oil removal (with an oil water separator) and disposal.

6. Water use could probably be reduced by half. With water production costs ranging from $100 to $200 per million gallons and water treatment costs of $500 per million gallons, the engine washing operation may be one of the biggest cost savings opportunities for the engine testing department.

Through relatively small changes in production activities like painting and engine testing, the cost savings can be substanial.

Conclusions and Recommendations

1. The Environmental Department is well prepared to organize and manage a waste minimization program for the Engine Testing Department and the painting operation in the Tractor Department.

2. The plant lends itself to operating areas that can be approached with individual waste minimization projects.

3. It is suggested that the waste minimization team for each division of the plant should include one member of upper management and members of the Environmental Department. The same people could serve on each of the individual waste minimization projects. The floating members of the team could include a department foreman, a health and safety specialist and an economist.

4. A formal training plan and schedule could also be established and implemented and carried out over a period of six months. The training could be provided by an outside group such as the Pollution Prevention Center. An outline of the training plan will be included in our final report.

5. Waste minimization objectives should be targeted and all potential projects, large and small should be considered.

6. It is suggested that the program could begin with relatively small projects such as the tractor painting and engine testing operations. Projects can be selected that are reasonably likely to yield measurable results within the first 6 months. The selected projects should be monitored on a monthly schedule and evaluated after six months and 12 months. A report on the results should be completed at the end of the first year on the bottom line results that are achieved. The record keeping skills of the Environmental Department are more than adequate to meet the needs of this project.

7. The activities and results of the waste minimization program should be evaluated from the standpoint of benefits to the environment. The waste minimization program will result in reduction and ultimate elimination of subsurface oil leaks, contaminant discharges to groundwater and surface water and reductions in air emissions.

8. There are studies that indicate a direct correlation between waste minimization and health and safety performance. The assignment of a health and safety expert to each team will allow this relationship to be monitored and evaluated.

9. ISO 14001 will provide an environmental management plan for the entire plant that that is consistent with international conventions. A waste minimization program would provide an excellent framework for the implementation of an ISO 14001 program.

10. Environmental regulations are likely to tighten in 1998 . Waste minimization will improve the prospects for meetings these stronger requirements.

11. Dr. Fleischman discussed the many information resources on waste minimization that are available over the Internet. Access and day to day use of Internet resources can be coordinated with Dr.. Pavol Rajniak of the Pollution Control Center in Bratislava.

12. The PPC has many other resources to offer including laboratory analysis of environmental samples and advisory services in a number of areas.

13. Dr. Fleischman has made a number of observations and recommendations in the sections of his report. My report concurs with the recommendations, and the Pollution Prevention/Waste Management Program for ZTS TEES MARTIN in Dr. Fleischman report.

ZTS TEES MARTIN

Dr. Marvin Fleischman, Professor of Chemical Engineering
& Co-Director Waste Minimization
Industrial Assessment Center, University of Louisville

Executive Summary

Products: Forestry machinery, special vehicles, tractors, and diesel engines
Number of employees: 3000
Ownership: Recently privatized
Email address: tees@enelux.sk
Certification: ISO 9000
Production work shops (depts.): Mechanical, Machining, Welding, Assembly, Testing, Thermal Treatment, Surface Treatment (Painting, Chrome plating)
Schedule: 1 shift, 5 days/wk, sometimes 2 shifts
Waste priorities: Paint consumption and paint wastes; Engine and transmission oils from engine testing; High energy consumption for alkaline cleaning,

Pollution Prevention/Waste Management Program

- The personnel are aware of less waste generating and waste minimization technology, e.g., powder coatings, ultrafiltration for synthetic machining coolant emulsion breaking. They are also using what might be considered waste minimization technology, e.g., acid emulsion breaking of oily wastewaters. However, focus is primarily on "end-of-pipe" pollution control and waste management. In addition to trying to manage and solve problems, it is suggested to try to prevent the problems in the beginning.

- Teams are currently used to identify wastes. They consist of chiefs from major work cells or their representatives. Workers are not included, but team members solicit information from workers. For any comprehensive pollution prevention/waste minimization program to work, direct involvement of workers is necessary, and recognition and incentive programs are recommended.

- Teams need to expand to become waste minimization teams with representation not only from production and engineering, but also from purchasing, accounting, maintenance, and facilities management. Not only should the team include engineers and foremen from different production areas, but it should also include workers from these areas.

- Paint waste minimization is suggested as an initial pollution prevention/waste minimization demonstration project for the team because; this waste generating operation occurs in more than one production area, and it is one of the plant's waste priorities. The team would evaluate the entire painting process from: selection of paint type, packaging type and size, thinners and cleaning solvents, supplies, and vendors/suppliers; inventory control methods; paint spraying booth and equipment; paint spraying technique (to avoid overspray); paint cleanup methods; other operating and operator practices; scheduling; waste segregation; and waste management techniques. A paint team should include representatives (including operators) from all product lines that do painting.

- The WEC 10-step program should be followed, to include: identify wastes; track paint and solvent utilization and waste generation (also characterize wastes) at each step in the process; develop paint and solvent material balances; develop process flow sheets for painting that also show cleanup, develop and document operating procedures. Brainstorming sessions led by the team to identify sources/causes of specific waste streams and pollution prevention/waste minimization opportunities such as different types of paints, e.g., powder coatings, or higher transfer efficiency guns, e.g., High Pressure, Low Volume Spray (HVLP), should involve people at all levels from the specific production area(s). The team can then perform preliminary technical and economic evaluations of these proposals and rank them for further evaluation and implementation. The team should also identify and initiate/develop training programs for painting workers and other personnel.

- In general, develop material balances and process flowsheets for all significant waste generating operations, e.g., water balance for washing, coolant balance for machining operations.

- Initiate a machining fluid management program, preferably working with a supplier, to prolong coolant life, e.g., use deionized water to makeup coolant, provide aeration or mixing in sumps when machines are shut down overnight or on weekends.

- Find other waste disposal options, and check out hazardous waste regulations. It seems that a lot of paint waste goes to incineration which is expensive, when perhaps it could be landfilled, maybe as non-hazardous waste. Are fuels blending or off-site material recovery (e.g., solvents) options?

- Begin preparation for ISO 14001 certification to accelerate initiation, development, and implementation of a systematic waste minimization program and develop a policy of "going beyond compliance".

Specific Waste Generating Operations

Engine and Engine Parts Washing
Alkaline degreasing and technical benzene (aromatic petroleum based solvent, similar to gasoline) are both used. For alkaline degreasing, soft water at 60-70 degrees C^o is used and the cleaning solution is dumped after about two months

Since engines are in the warranty period, after testing they are disassembled and parts are washed in the petroleum based solvent. Waste organic cleaning solvent is incinerated off-site as hazardous waste. They indicated that they would like to switch to aliphatic based hydrocarbons. However, the waste solvent will probably still be hazardous. Two possible waste minimization opportunities* are on-site or off-site recovery of waste solvent by distillation, or a less hazardous solvent such as a terpene (testing would be required)

Engine testing
Engine and transmission oils are changed out after ~ 20 test hours. The same oil is run through six engines. The waste engine and transmission oils generated are one of the waste minimization priorities. Engine and transmissions oils are not segregated and the collective waste oil is sent to off-site incineration (18000 kilos/yr, 15 SK or $0.50/kilo or ~ $1.32/gal.), Average purchase price of virgin oil - 50 SK/liter). They would like to sell the waste oils, but there is chlorine of unknown origin in the waste oils. There is no chlorine in virgin oil, but there was in the past. One possibility is that waste

chlorinated solvents may be being mixed with the waste oils. If so, the source of the chlorinated solvents must be found.

**Many waste minimization opportunities could not be costed out because of insufficient data*

Potential waste minimization opportunities:

- Analyze waste engine oil and waste transmission oils, to determine whether they can still be used after the current testing period. If yes, run analyses at various intervals to get more accurate determination of oil life. It will be assumed for cost estimating purposes, that engine test time can be increased by 50%, or ten hours:
  Assumed cost of testing = US$2000/yr
  Waste reduction = 4500 kilos/yr
  Savings in waste disposal = US$2250/yr
  Savings in oil purchase costs = US$10,735/yr
  {*1.67/liter*1l/0.7kilos(assumed oil density)*4500 kilos}
  Net annual savings = $10,735 + $2250 - $2000 = $11,000/yr
- Segregate waste engine and transmission oils, send to oil reclaimers, and repurchase reconstituted oils at a lower price than virgin oils. This should be less expensive than incineration. So also should be a fuels program..

Engines are sprayed with water during testing to identify sites of oil leakage and to remove leaked oil. Water consumption is high and the quantity used is not known. Engine oil filters go to incineration after testing. Potential waste minimization opportunities for water & wastewater volume reduction include:

- Intermittent water spraying
- Don't spray if not leaking

Engine Painting

Engines are painted after testing. Black or green 2 component polyurethanes are used for small engines) and yellow nitrocellulose based paint for big engines. Gun nozzles are cleaned every day after painting by spraying solvent through the gun. Waste paint gun cleaning solvent is incinerated off-site.

Potential waste minimization opportunities:

- On-site or off-site solvent recovery by distillation and reuse
- Recirculating gun washer to use less solvent, coupled with solvent recovery

Waste water

The oily water from engine testing goes to settling, followed by oil skimming, residual oil adsorption on wood chips, and is sent to the on-site wastewater treatment plant via canal. Waste water from engine and tractor parts washing goes to acid emulsion breaking, oil/water separation (gravity settling, skimming), adsorption of residual oil on wood chips, then through canals to the on-site wastewater treatment plant, to the river. Recovered oil is incinerated off-site as are the wood chips.

Potential waste minimization opportunities:

- Treated wastewater reuse in engine testing
- Send waste oils and wood to a fuels program

- Burn oil and wood in on-site boilers. They generally purchase steam from the city. A gas fired boiler is used as an auxiliary, and would have to be converted to oil burning

Machining
Oily sludge from grinding contains coolant and abrasive particles from the wheel. Synthetic coolant (water emulsion) is disposed off-site.

Potential waste minimization opportunities:
- De-emulsification with an ultrafilter or other methods, so that the water can be discharged to the wastewater treatment plant and the reduced volume waste coolant (concentrate) disposed off-site.
- Establish a metal working fluids management program to prolong coolant life. Use deionized water to make up emulsions. Use biocides to prevent anerobic bacterial growth, and keeps sumps aerated or mixed during machine shut downs. Prevent dirt from getting into the sump and workers from throwing trash into the sump

Chrome Plating
Rinse waters are treated separately from other aqueous wastes. Cr(VI) in the rinse water is reduced to Cr(III); Cr(III) is precipitated as the hydroxide using caustic; A polymeric flocculant is added and the settled sludge is dewatered in a filter press. The filter cake is currently landfilled. They would like to sell the sludge cake for its chromium content to be used in making colored glass, but the quantity is too small.

Potential waste minimization opportunities:
- Metal recovery from plating rinsewater by ion-exchange, reverse osmosis, or electrodeposition, and reuse in plating bath.

Tractors
Tractors are sold filled with transmission oil taken from a large oil tank. The residual oil in the tank can not be pumped out and there is a sludge in the bottom of the tank which must be removed.

Potential waste minimization opportunities:
- Keep oil in tank mixed to avoid/minimize sludge formation
- Draw oil from bottom of tank
- Redesign tank so that all oil can be drained out, e.g., sloped bottom

Tractor Painting
Most parts come in already primed, and about 50% of the parts come in pre-painted. Alkaline degreasing spray prior to painting is necessary because of grease from workers hands on prior assembly line.

Mostly two part polyurethane paint is used. The two components for the paint are taken from their respective cans and mixed directly in the paint pot. The paint remaining in the pot at the end of the day goes to waste because the excess cannot be used the next day (because it has already been catalyzed). The amount of paint to be used is estimated manually. Ransberg electrostatic hand spray guns are used in one hall, and some conventional compressed air guns in another hall (50% conventional and 50% electrostatic in second hall). Small parts are sprayed with conventional guns. Spraying is done in a

booth with positive air flow into top of booth (through filters) to force paint overspray into the water sump at the bottom of booth. Paint solids are coagulated and removed from the recirculating water. About 20,000 kilos of paint are used annually (~20 kilos/tractor). Red paint costs 250 SK/kilo. Paint comes in 10 kilo cans.

Overspray was observed from the electrostatic spraying. The spray fan width was too wide and the operator was observed to be spraying directly into the atmosphere after coming to the end of the part.

Empty paint cans are first scraped, then cleaned with a xylene based solvent, and sold or given away as scrap steel. The waste xylene is part of the 4000 kilos. Guns are sprayed with an acetone based mixture or xylene into the water and are then cleaned overnight with hoses in a basket, using the same solvent, on a daily basis. The solvent and removed paint solids are then used in the paint for the next day. The paint waste rate is 20% (4000 kilos/yr) and cost is 20 SK/kilo for off-site incineration. Paint wastes include: waste xylene, coagulated paint solids, paint left in pots at end of work day or during a switch over, and paint solids from cleaning grates and the paint booth. Mechanical scraping is used to remove paint from grates is a general problem, and reduction of paint consumption is a priority. Used grates go out as scrap metal. Cardboard is used as dividers between small painted parts, for protection. Excess cardboard is incinerated.

<u>Potential waste minimization opportunities:</u>

- *Xylene recovery from paint can washing in a still and reuse:*
  Assume waste xylene is 1500 kilos/yr (3300 lbs/yr) or 450 gals/yr
  Assume 85% recovery in a still: 2805 lbs/yr or 383 gals/yr
  Savings in xylene purchases = $0.435/lb * 2805 lbs/yr = $1220yr
  Savings in waste disposal costs = 0.85 * 1500 kilos/yr * $0.67/kilo = $855/yr
  Cost of still (5 gal capacity): $5000
  Operating cost of still (electricity, condenser cooling water, supplies, labor for loading and unloading): $300/yr
  Estimated net annual savings = $(1220 + 855 - 300) = $1775/yr
  Payback = $5000/$1775/yr = 2.8 yrs

- *Reduce overspray by increasing/improving operator training and offer operator incentive.*
  The spray fan width was too wide and the operator was observed to be spraying directly to the atmosphere and completely missing the part. Assume a 10% reduction in paint consumption and paint waste:
  Savings = 0.10*(4000*$0.67/kilo of waste+20,000*$8.33/kilo of paint) = $19,930/yr
  Training cost = $5000/yr
  Annual Savings = $(19,930 - 5000) = $14,930
  Worker Incentives (15% of savings) = 0.15 * $14,930 = $2240/yr
  Net Annual Savings = $14,930 - $2240 = $12,690/yr

  Use a pleural component (proportional) metering system for the two part polyurethane paints, i.e., components are pumped from their respective cans and mixed in spray gun nozzle needed. This will eliminate the paint remaining in the pot that goes to waste, and will thus also reduce paint consumption. Such a system should be useable with existing paint spray systems. Assume a 10% reduction in paint consumption and paint waste:
  Savings = $19,930/yr

Investment = $36,000 (assumed that this includes training costs)
Additional operating expenses = $1000/yr
Net Annual Savings = $18,830/yr
Payback = $36,000/$18,930/yr = 1.9 years

- *Landfill paint wastes instead of incineration*
  Landfill disposal costs for paint wastes:
  7 SK/kilo or $0.23/kilo
  Savings = 4000 kilos/yr * $(0.67 - 0.23) = $1760/yr

Additional possible opportunities (not costed out):

- Switch to powder coatings for smaller parts, e.g., panel on tractors. These parts appear to be suitable for powder coatings; they are flat and not too large
- Extend pot life of 2 part coatings by cooling the pot
- Remove paints from grates by media blasting or in a burn-off oven
- Switch from conventional compressed air guns to HVLP guns to reduce overspray.

PROFESSIONAL BACKGROUND OF WEC VOLUNTEER EXPERTS

DR. MARVIN FLEISCHMAN, P.E.

POSITION

Professor of Chemical Engineering and Co-Director of Waste Minimization, Industrial Assessment Center; University of Louisville

EDUCATION

Ph.D. University of Cincinnati, Chemical Engineering
M.S. University of Cincinnati, Chemical Engineering
B.Ch.E. City College of New York

EXPERIENCE

Co-Director, Industrial Assessment Center
Direct and participate in combined energy and waste minimization audits at small to medium size manufacturers using students and faculty in U.S. Dept. of Energy funded program.

U.S. Air Force Summer Faculty Research Program
Experimental research on alternatives to ozone depleting substances for parts cleaning.

U.S. Army Summer Faculty Research and Engineering Program
Life cycle analysis of random chemical depainting alternatives.

3M McKnight Distinguished Visiting Professor in Pollution Prevention
Initiated interactions with industry and government agencies. Developed a pollution prevention course. Did preliminary pollution prevention assessments for manufacture of wood fiber board, photosensitive emulsions, steel castings, and wood furniture.

Director, Waste Minimization Assessment Center
Started and developed a U.S. Environmental Protection Agency funded program to do quantitative waste minimization assessments for small to medium size manufactures. Actively directed and participated in assessments, including site visits, literature searches, vendor contacts, cost estimating and report writing.

Consulting, Dow-Corning
Volunteer member of USAID team visiting Estonia regarding waste minimization in meat packing plants and dairies.

Professor of Chemical Engineering
Developed and currently teach the courses: "Industrial Waste Management", "Waste Reduction, Treatment, and Disposal", and "Safety and Health".

PROFESSIONAL ACHIEVEMENTS

Over forty published papers; numerous presentations and industrial, government, and contractor reports.

Listed in Who's Who in Engineering, Who's Who in America, American Men and Women of Science and other directories.

WILLIAM J. SEEVERS

POSITION

Environmental hydrologist/groundwater expert with over 36 years of experience in projects concerned with development and cleanup of groundwater.

EDUCATION

B.S. College of the City of New York, emphasis in geology, chemistry & physics
M.S. Geology and Groundwater Hydrology, University of Kansas
Water Resources Institute, University of Kansas

EXPERIENCE

Co-founder, Environmental Technology Group, Inc.
An environmental hydrologist in groundwater contamination, cleanup and supply. An expert on remediation of contaminated ground water and on regulations that guide monitoring and cleanup.

University of Kansas, State/USGS Cooperative Water Resources Program

Groundwater Hydrologist, Geraghty & Miller
Project Manger to Senior Vice President

Principal, Blasland & Bouck Engineers, PC
Organized and developed the Syosset, New York, and Leesburg, Virginia Offices.

Seevers Associates, Inc.
Technical and management consulting to industrial clients, lawyers and major engineering and planning firms.

Projects under the U.S. Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)
Projects involved cleanup, cost allocation amoung multiple parties and community participation. The work was carried out in accordance with the National Oil and

Hazardous Substances Pollution Contingency Plan. Projects were done entirely under federal direction while others were done with state, or state and federal involvement.

- Waste disposal site in Carmel, New York, involved environmental litigation;
- NEPARA and Maybrook lagoon Site in Harriaman, New York, quantities of mercury detected in calcium sludges from pharmaceutical manufacturing;
- South Albuquerque, New Mexico Superfund site cleanup;
- General Electric Plastics Division in Pittsfield, Massachusetts, remedial investigations and feasibility studies;
- LCP Chemicals, Linden, New Jersey, mercury contamination of solid and groundwater contaminates;
- East North port, New York, site assessment at landfill for the town of Hunington.

WILLIAM J. SEEVERS
CONTINUED

PROFESSIONAL ACHIEVEMENTS

Teacher at New York University, Academic Course on Hazardous Waste Management and Ground Water Remediation

Co-sponsor of New York Chapter of Inter-American Association of Sanitary Engineering and Environmental Sciences

Service Committee Chair, Environmental Business Association of New York State

New York academy of Sciences, Ground Water Environmental Issues in the New York Metropolitan Area