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Pollution Prevention and Business Management: Curricula for Schools of Business and Public Health, Volume 3: Supplemental Readings

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Profiting From Pollution Prevention

If it's good for the environment, it's good for business, or so these four companies implementing pollution prevention programs will tell you.

By Matthew P. Weinstock

In 1989, Diceon Electronics Inc., a 150-employee manufacturer of high-tech circuit boards, was using chemical compound called dithiocar-bonate (DTC) in its manufacturing pro-ess. The Nashua, N.H., company was enerating nearly 11 tons of waste a onth, and spending close to $4,700 a onth on treatment.

Al Karg, Diceon's environmental anager, discovered a chemical process eing used by European power plants hich, he thought, might work at iceon. The process generated a more ncentrated sludge containing a higher rcentage of reclaimable metals.

"I found out what the chemical was n organic chemical called trimer-apto, triazine, trisodium salt (TMT)) nd had some samples sent up," he ex-lains. "We thought it might be to our dvantage to give it a real world run. e decided to run some tests on it for a eek. Before that week was up, we told he chemical manufacturer we wanted o run it for a month, just to make sure, nd we've been running it ever since."

With the use of TMT, says Karg, iceon sends only 6 tons of waste off ite for treatment and recycling. Addi-ionally, the reclaimer that Diceon orks with is able to handle the TMT-ased sludge at a lower price. The facil-ty has cut its water treatment costs by ver two-thirds and saves close to 0,000 a year in waste handling fees by educing its use of toxic chemicals and ecycling more sludge.

"What we have done in waste treat-ent/pollution prevention, is to hange chemistries which has led to a ecrease in the amount of sludge we re generating," explains Karg. "It has otten to the point where it is cost-ad-antageous for us to recycle. That gives s a competitive advantage and re-duces our liabilities."

Diceon is one of a growing number of companies finding that when it comes to pollution, prevention is far less costly than treatment or cleanup. A host of federal laws and regulations have attempted to eliminate pollutants at the point where they enter the environment — the so-called "end-of-pipe" approach. Though showing some success in curbing pollution over the last 20 years, con-

David Galway/Tony Stone Worldwide

trol and treatment technologies are expensive to implement and operate.

According to the National Assn. of Manufacturers (NAM), the U.S. spends about $70 billion a year on pollution control. Industry expenditures make up nearly two-thirds of that amount. Moreover, attempts to clean up the nation's past environmental mistakes are proving extremely expensive. Federal, state, and local governments, together with industry, spend an estimated $22 billion a year on Superfund activities. That number is projected to reach $54 billion by 2002.

EPA View

EPA defines pollution prevention as "the use of materials, processes, or practices that reduce or eliminate the creation of pollutants or wastes at the source." This includes practices that reduce the use of hazardous materials, energy, water, or other resources. A pollution prevention program can include recycling, product reformation, changes in the manufacturing process, chemical use reduction, or a host of other innovative ideas.

It makes more sense for a facility not to produce waste than to develop or pay for expensive treatment technologies, points out Harry Freeman, Pollution Prevention Research Branch, Risk Reduction Engineering Laboratory, EPA. Both the environment and the company benefit from such an approach, he says.

"It is easy to see how pollution prevention makes for a cleaner environment -- you are not generating any waste," says Freeman, "but it also improves a company's bottom line, makes compliance with regulations easier, and demonstrates a real sense of caring for the environment. Also, it will create a safer work environment for workers. Pollution prevention reduces the amount of hazardous chemicals workers come in contact with. It is a win-win strategy."

EPA, which has been criticized for focusing too much on pollution controls for individual media, has been giving pollution prevention a higher profile in recent years. In 1989, EPA established a pollution prevention program to further promote the concept. It has initiated voluntary programs like 33/50 to encourage industries to reduce their use of toxic chemicals.

EPA also created the Source Reduction Review Project (SRRP) to help the agency better assess regulations and pollution prevention opportunities therein. SRRP allows the agency to weigh the benefits of source reduction alternatives vs. end-of-pipe controls during rulemaking. Such analysis is guiding EPA's writing of more performance-based standards. Indeed, a number of Clean Air Act regulations currently being worked on will seek to encourage industry to institute pollution prevention programs.

3M's Pollution Prevention Track Record

	U.S.	International
Air Pollutants	140,000 tons	14,000 tons
Water Pollutants	16,300 tons	1,400 tons
Wastewater	1 billion gallons	700 million gallons
Sludge/Solid Waste	416,000 tons	16,600 tons

Source: 3M

Freeman predicts that more and more industries will see the benefits in reducing pollution at the source, rather than waiting to treat it at the end of the pipe.

For Diceon, the benefits have been dramatic. The company's monthly waste treatment bill has dropped from $4,700 to $2,700.

In addition, says Karg, they are saving nearly $83,000 a year on water treatment costs. When using DTC, Karg explains, there were certain conditions which required the use of additional chemicals. Treating this water cost $5.80 per 1,000 gallons. TMT eliminated the need for many of those additional chemicals and the cost of treating the water dropped. Now, although the facility generates about 20,000 more gallons of wastewater, treatment costs are only $2.00 per 1,000 gallons.

Karg gives his management credit for giving him the freedom to test new processes which may be more efficient and better for the environment.

"Waste treatment, for any business, is a cost-setter. It is not generating revenue so we are always trying to find ways to run as efficiently as we can and reduce waste," Karg says. "We made sure we stayed within the regulations and did things in a cost-effective manner without interrupting the manufacturing process."

Pollution Prevention Pays

While pollution prevention efforts are in their infancy at many companies, 3M has been doing it for almost 20 years. The St. Paul-headquartered company made pollution prevention a priority in 1975 when it began the "3P" or "Pollution Prevention Pays" program.

"3M has always responded to negative business situations with some kind of positive program," says Robert Bringer, staff vice president, Environmental Engineering and Pollution Control, 3M. "In the early 1970s, some of our plant managers were beginning to see the effect of early environmental regulations which were requiring them to install pollution controls. They viewed these expenditures as pretty negative. They asked how we could turn this around. 3P was the answer. It was a positive response to the whole problem. Get people's minds off pollution control and get them on pollution prevention."

A voluntary program, 3P encourages 3M employees to develop innovations which will prevent pollution at the source through product reformulation, process modification, equipment redesign, and resource recovery.

Projects are submitted to a 3P Coordinating Committee made up of representatives from the engineering, manufacturing, industrial hygiene, and laboratory divisions as well as the environmental engineering and pollution control department. Projects must meet four criteria to be approved:

- Eliminate or reduce a pollutant.
- Benefit the environment through reduced energy use or more efficien use of resources.
- Demonstrate technical innovation
- Save money.

If a project is approved, imple mented, and shown to be successfu the employees responsible for it receiv an award.

Bringer admits that it took a while fo 3P to catch on. Most of the projects ac cepted in the early years were basicall cost-saving programs that had a pollu tion prevention side to them.

"Over time, there was a subtl change in the way people looked at th program," Bringer says. "As we kep collecting information and results o these projects and fed them back to th employees, people began to see th benefits. They began to look for pollu tion prevention opportunities that ha cost savings associated with them."

At 3M's Cottage Grove, Minn., facil ity, a group of employees has not onl saved money through a pollution pre vention project, but actually created a new revenue source for 3M.

The facility produces magnetic oxides for recording products. A by-product, ammonium sulfate, was being discharged to a wastewater treatmen facility, but essentially passed through the system untreated. Because the treatment facility served a large industria complex, a number of wastewater streams were mixed and the ammonium sulfate was diluted to the point where it could not be removed or recovered. State regulations, however, required the facility to reduce the ammonia content in treated water.

A group of employees decided to remove the ammonium sulfate before it could mix with the other waste streams and be diluted. To do so, the facility invested in a vapor compression evaporator. Essentially, the evaporator strips the ammonia from the waste stream and produces a solution that can be used as a fertilizer. 3M generates $150,000 annually by selling this fertilizer. At the same time, 677 tons of water pollution is being prevented annually.

The facility also saved about $1 million by installing the evaporator, at a cost of $1.5 million, instead of purchasing more expensive end-of-pipe pollution control equipment.

Worldwide, 3P has made considerable contributions to curbing 3M's pollution problems, says Bringer. Since

Demarest (with William Reilly): By eliminating CFCs, Kryptonics saved money, sold the technology, helped the environment, and won an award.

1975, more than 3,400 projects have been implemented saving the company close to $573 million ($470 million from U.S. operations and $103 million from international operations).

"I Breathe the Air Too"

Kryptonics Inc., a manufacturer of polyurethane products in Boulder, Colo., used 40,000 lb. of CFCs in 1990. That usage would have been close to 100,000 lb in 1992. Instead, it was zero.

Chuck Demarest, president and director of technology, Kryptonics, says the company had seven uses for CFCs in its products. He set a goal to reduce that to zero. With relative ease, he says, six of the uses were eliminated, but the seventh, a silicone mold release, proved more difficult.

"It took about a year and a half to eliminate that use," he says. "There really wasn't any available alternative that was acceptable so we had to go back to ground zero." That meant the company had to develop its own technology to solve the problem.

"We got lucky with some engineering effort," Demarest explains. "We were actually able to bypass solvents completely. Instead of replacing CFC 113 with an alternative solvent, we were able to produce a mold release spray — a very fine mist — without using any solvent. By changing the method of spraying, using different pressures and nozzles on the spray system, we were able to get the silicone to

A HELPING HAND FOR TOXICS REDUCTION

Large corporations like 3M and Chrysler have the resources to undertake long-range research programs and investigate innovative pollution prevention technologies. For many small and mid-sized companies, however, just staying afloat and meeting EPA regulations is a major challenge. How can they take advantage of pollution prevention opportunities?

The Massachusetts legislature tried to answer that question when it passed the Massachusetts Toxic Use Reduction Act of 1989. As part of that act, the Toxic Use Reduction Institute was formed at the University of Massachusetts at Lowell. Some 600 facilities covered by the act pay a fee which funds the institute.

"We are basically doing research into alternatives to the use of toxic chemicals. We are also doing training," says Michael Ellenbecker, the institute's associate director. "Under the Massachusetts law, companies have to prepare a toxic use reduction [TUR] plan which says they are going to reduce the use of toxic chemicals. We're doing research to help companies find alternative chemicals and are also training people to be use reduction planners."

According to the law, any TUR plan submitted to the state needs to be signed by a "planner." The institute, Ellenbecker says, has developed a curriculum for people who want to be certified as planners. The curriculum provides future planners with both general information on how to develop a TUR program and also provides some industry-specific examples. Ellenbecker says the course provides mid- to small-sized companies with the opportunity to have their own employees certified instead of hiring an outside consultant (who has to be certified as well).

Research Initiatives

While the institute has been in existence for only about a year and a half, it is undertaking some ambitious research projects.

"In research," Ellenbecker explains, "we are trying to focus our efforts on projects that are useful to the widest audience in industry. A lot of our research is focusing on solvent substitution and cleaning-related activities."

The institute funds research fellows at the university who are conducting research into chemical substitution. Additionally, says Ellenbecker, it has initiated a matching grants program with industry to investigate ideas that may be "on the far reaches of technology."

The institute currently is funding six matching grant projects. For example, Texas Instruments has received matching funds to look at an application in supercritical fluids and how they can be used in some processes. On another project, the institute is funding a manufacturing consortium called Bay States Skills to study how nontoxic lubricants can be substituted for toxics in metal-forming processes.

Ellenbecker says this program is a direct return for the companies since they pay a fee to support the institute.

"We are sort of giving them money back to look at toxic use reduction projects," he says.

Helping Small Business

While assisting large corporations like Texas Instruments in research projects, the institute is continually looking for ways to help smaller companies. Next month, the institute expects to open a surface cleaning lab at the university. The lab will help companies find nontoxic alternative solvents to clean machine parts.

Several different cleaning systems will be made available for testing at the lab. Companies can bring in machine parts and find the best alternative to the system they use now. And, says Ellenbecker, the lab will offer the service free of charge.

"Small- and medium-sized industries will be able to come to us with their parts and we can tell them what works and what doesn't," he says.

split up into micro-size droplets."

Along with eliminating the use and subsequent emission of CFCs, Kryptonics is now able to recycle the mold release. The CFC-based solvent had to be vented out of the facility. Now, because there is no solvent that is evaporating, the mist created is pure mold release that can be captured and reused.

Demarest says Kryptonics invested close to $50,000 in developing the new spray technology, but has "saved thousands" already by eliminating the use of CFCs. Moreover, the company is selling this technology to other industries. They have 10 orders to date for the new spray system. Each system costs approximately $40,000. Yet, as Demarest points out, it eliminates the need for expensive solvents and will help reduce compliance costs associated with EPA regulations.

"There was really no economic advantage to cutting the use of CFCs when we first started this process," he says. "There is today. There is a high tax on CFCs. They are becoming very expensive to use. Also, there are a lot of reporting requirements and regulations and other peripheral issues. My main objective, though, was to eliminate them for environmental reasons. I breathe the air, too."

In reward for its efforts, Kryptonics was named a winner of the EPA Administrator's Awards program in May of this year.

Benchmark for the Future

Unlike end-of-pipe controls, successful pollution prevention programs require considerable foresight. Environmental managers have to try and predict what the regulatory agenda in the future will be and, at the same time, envision how their product may change over time. It is proactive thinking, the type of thinking environmental managers at Chrysler Corp. try to use.

"There is a certain philosophy at Chrysler," says Peter Gilezan, director, Environmental and Energy Affairs, for the automaker, "which takes a proactive rather than reactive approach to the environment. In the automobile industry, with the short lead time we are working on — 35 to 40 months to bring a product from concept to production — we need to try to anticipate what the regulatory agenda is going to be. Our overall umbrella is that we integrate environmental requirements into the process, the product, and the facility."

Chrysler did just that when it designed the new Jefferson North Assembly Plant on Detroit's lower east side. The $1 billion plant, which opened in January, has already eliminated more than 30,000 tons of scrap by using returnable containers.

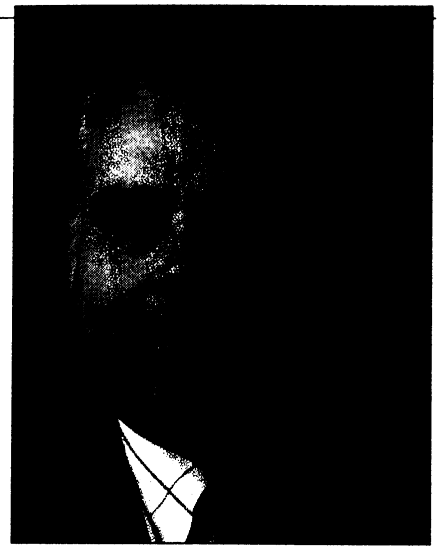
An on-site water treatment facility, which can treat up to 500,000 gallons of water per day, helps the plant meet, and in some cases, exceed state and federal regulations. In addition, says Gilezan, a number of recycling and product substitution technologies were built into the plant's design.

"Pollution prevention was the goal from the start," he says. "The plant itself was constructed on 270 acres that had been cleaned up for development. Instead of going to a green area, we recycled the land. Prior to us being there, there were manufacturing plants, service stations, etc...."

Realizing that air regulations will be the focal point of regulatory action for the next several years, Chrysler equipped the Jefferson plant with three innovative volatile organic compound (VOC) control systems:

• A three-stage system purifies air from the paint and solvent spray booth. In the first stage, air is directed toward a dry filter house where paint particles are removed from the air stream. The second stage removes solvents by passing the air over activated carbon. Finally, in the third stage, air is directed to incinerators and heated to 1350 F to

Chrysler's Peter Gilezan: "...we integrate environmental requirements into the process, the product, and the facility."



3M's Robert Bringer: "Get people's minds off pollution control and get them on pollution prevention."

destroy any remaining solvents.

• A second VOC system dries and recycles wet paint sludge. In most assembly plants, nearly 40 percent of paint ends up as waste. Typically, it is captured in water and hauled to landfills for disposal. At the Jefferson plant, paint overspray is converted into a nonhazardous powder and reused as paint for the underbody of Chrysler cars.

• The third technology uses an antichip powder instead of liquid materials that contain VOCs to prevent stones from chipping the lower portions of a car's body panels.

The Jefferson plant also has aboveground storage tanks for gasoline, oil, and solvents. This helps to prevent ground water contamination. These tanks are surrounded by containment barriers. There are also leak detection devices for all underground equipment.

Like Kryptonics, Chrysler won an EPA Administrator's Award for the design and construction of the Jefferson North plant.

"We were driven by a number of agendas, not all environmental," Gilezan points out. "Reduction of materials and recycling of materials mean cost savings. Material reformulation means improved quality, more customer satisfaction.

"We will use Jefferson as our benchmark. Every Chrysler plant from here out will be based on what we did in Detroit. Pollution prevention is an ever growing concept. It is not enough to say we worked on it at the lab and it works. That technology has to be put into production. That's what we've done and are doing."

Designing a Corporate Environmental Program: The Colgate-Palmolive Approach

Douglas R. Wright
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New York, New York

Protecting the environment is an integral part of Colgate-Palmolive's corporate mission — to become the best, truly global consumer products company. Colgate's 29,000 people are dedicated to behave in a socially responsible manner and to keep our business operations environmentally sound. Environmental issues are addressed in each of our key business categories: oral care, personal care, household surface care, fabric care, and pet dietary care.

Preserving Value and Creating Value

The keys to our environmental program focus on two critical concepts — preserving value and creating value.

When we speak of preserving value, we focus on compliance — making sure that Colgate-Palmolive meets or exceeds all local regulatory requirements. For Colgate, compliance is not an option — it is a requirement, and often our corporate standards are higher than those established by the regulatory community.

The second key to our environmental program is creating value, which addresses our whoie conversion process. Colgate cannot achieve success or transform its business thinking to meet environmental challenges without winning over the hearts and minds of its business partners. Colgate and its global partners must share a common commitment to protect and preserve the environment with the basic understanding that it's not simply the right thing to do; it also makes good business sense.

It is not always easy to understand the business challenges presented by the environment. A typical first reaction is to see nothing beyond problems, risk, and costs. These are tough perceptions to overcome. However, we were confident that with the right program we could change the thinking of our worldwide management organization. In essence, our employees had to have the tools to see opportunities rather than problems, benefits instead of risks, and savings opportunities beyond the costs. Only then could they be motivated about the environment and start to drive environmental initiatives on their own.

Creating a Program

Colgate's environmental program began with a set of fundamental requirements. As a company, we agreed that the program had to be broad-based, inclusive, and designed to engage and motivate people at all levels of the organization. It should cut across all functions and extend to every region of the world. Our environmental initiatives must be relevant to Colgate's business objectives and adaptable to our business and manufacturing processes. We knew that to be successful, everything we do has to be achievable, and if possible, measurable. Finally, our program must build collective leadership: Colgate's environmental program has to empower people throughout the organization. Everyone must want to take responsibility for the environment.

Understanding our Constituents

We assembled a cross-functional, pan-regional team to define our goals. We identified our internal constituents as senior management, research and development (R&D), packaging, the manufacturing and engineering groups, and our marketing, sales, and financial organizations around the world. Our external constituents are our consumers and suppliers, government entities, the trade, the financial community, environmentalists, and our shareholders. We took time to understand each group's unique set of concerns and sensitivities, and to agree how best to communicate our environmental initiatives to each group. Only then did we begin to define the mission and values that now form the foundation for Colgate's environmental program.

Defining the Mission

Our team worked long and hard to define the various ways that the company could demonstrably contribute to win-win situations for all constituencies. We needed a road map or a mission statement to get there. We are committed to

- make continuous improvement in the environmental performance of our products, services, and facilities,
- communicate responsibly to all our constituencies about our environmental activities, and to
- add measurably to Colgate's reputation and growth as a result of our environmental commitment.

Starting with this foundation, we made considerable progress and had the basic tools to begin communicating effectively. But we had to go one step further. We needed to bring these conceptual terms down to Earth for our Colgate global organization. Our people had to understand, in a basic sense, what it meant for them day-to-day.

Introducing ENVIROPRIDE

We launched our ENVIROPRIDE™ program with the simple, yet powerful, premise that "making a difference in the world makes a world of business sense." The program's intent is to make a difference to the world we live in, in the products we make, and to the constituents we serve. These practices will make good business sense to our customers, our consumers, our communities, our business managers, and, of course, to our shareholders.

The strategy that drives the program borrows from existing environmental vocabulary. Again, we wanted to keep our message as simple and as easy to remember as possible. We call our strategy "The 7Rs" — Reduce, Reuse, Recycle, Reformulate, Redesign, Reward, and Renew.

The First "R" — Reduce

Colgate has made significant advances in reducing raw and packaging materials and the energy required to manufacture, store, and transport our products. In France, where we dominate the bleach market, we have successfully capitalized on the common consumer practice of using refills. For our La Croix bleach, for example, we use a proprietary technology to create sachets that weigh only 10 grams. The consumer pours the sachet's contents into a 50-gram bottle and reconstitutes the product with water. This technology significantly reduces our consumption of plastic, and it has been successfully transferred to other parts of the world.

Colgate has also developed lighter weight bottles. Again in Europe, where we are the market leader in household surface care, we reduced the gram weight of an Ajax bottle by over 20 percent. In the United States, we made our Ajax and Dynamo laundry detergent bottles 30 percent lighter, which also makes them more efficient for our trade partners to warehouse and display.

In the United States in the summer of 1992, Colgate introduced the Stand Up Tube for toothpaste, and it is now available in Europe. The Stand Up Tube eliminates the outer carton, thus reducing the amount of packaging the consumer must dispose of by 70 percent when compared to the competitive pump products against which it is targeted. As the number one toothpaste manufacturer in the world, Colgate created a packaging innovation that truly symbolizes Colgate's commitment to address consumer demands for package reduction.

Waste minimization is another part of our reduction program. Around the world, Colgate has undertaken programs to reduce the quantity and the toxicity of air, water, solid, and chemical waste emissions from our manufacturing facilities.

The Second "R" — Reuse

Across the globe, Colgate encourages the reuse of packaging through refills. In Australia, where we have a strong fabric softener business, Colgate's refills have reduced the volume of packaging by 80 percent. Much of the cost savings associated with this reduction are then passed along to the consumer. We have also been able to transfer our refill packaging technology from developed to developing markets, where the focus on lower unit cost is most attractive because of the low levels of disposable income in those countries. Suavitel fabric softener in Mexico and Fabuloso all-purpose cleaner in Colombia are two such examples. We have taken refills from the traditional household products category to the personal care arena, with refills for our Softsoap liquid soaps in the United States, and deodorants in Germany.

The Third "R" — Recycle

ENVIROPRIDE's third R reflects on the use of recycled raw materials in our manufacturing processes, our commitment to postconsumer recycling, and the increased recycled content in our packages.

From a consumer standpoint, recyclability is our first concern. As curbside programs expand our packages must be compatible with them or our products will not be competitive. Colgate is quickly adapting to the rapidly evolving recycling infrastructure growing up in the world. We imprint recycling code systems on the bottom of each bottle and use these codes to educate consumers. At present, we focus primarily on polyethylene terephthalate (PET) and high density polyethylene, because that's what current systems can handle.

Total Quality Environmental Management: The Procter & Gamble Approach

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Procter & Gamble is a $30 billion, worldwide consumer products company. It sells products in five major categories, including laundry and cleaning products, paper products, food and beverage products, health care products, and beauty care products. Currently, slightly over half of the company's sales come from its U.S. operations that include 60 manufacturing sites. The balance of Procter & Gamble's sales comes from four major geographic regions — Canada, Europe and the Middle East, Latin America, and the Far East — that include 90 manufacturing sites and many distribution operations in 52 countries.

Following a long-term commitment to sound environmental performance, Procter & Gamble initiated Total Quality Environmental Management (TQEM) in the mid-1980s. This approach has significantly improved two well-established areas: environmental science, which supports product development; and environmental engineering, which supports product manufacturing. TQEM has also led Procter & Gamble to develop a new initiative called product stewardship, which recognizes environmental quality as a new consumer need. Product stewardship incorporates environmental attributes into the development of Procter & Gamble products and packages. It has fostered the adoption of a companywide environmental quality policy and a network of resources to coordinate global environmental improvement strategies.

Procter & Gamble's Strategic Approach

During the past year, a process was initiated to move Procter & Gamble's TQEM from a "tactical" approach, in which environmental experts alone do their best to achieve excellent results, to a "strategic" approach that involves everyone. By strategically deploying current TQEM efforts in alignment with business needs, Procter & Gamble institutionalizes its environmental programs and obtains support for needed resources. This approach can be best described by the following key elements of TQEM:

1. **Vision:** Excellent environmental performance will contribute to sustained business success.
2. **Design:** Establish integral links between business needs and environmental performance.
3. **Action:** Institutionalize global approaches to continuous improvement systems.
4. **Communication:** Share learnings and capitalize on successes both internally and externally.

Vision

Procter & Gamble's TQEM vision encompasses three primary program areas: product development, product manufacturing, and product stewardship. In turn, each of these areas developed a vision that directly aligns with their support of the business objective. Thus,

- product development will ensure the application of sound science, and the safety of products and ingredients;
- product manufacturing will establish Procter & Gamble facilities as local industry environmental leaders; and
- product stewardship will use environmental leadership initiatives to build the business and avoid business interruptions.

Design

Having established its long-term vision, each program area designed an objectives, goals, strategies, and measures (OGSM) plan for realizing its vision.

Specifically, an OGSM strategic deployment tool is used to deliver results tied to business needs:

- "objectives" state the expected outcome in broadly defined, qualitative terms;
- "goals" enumerate specific, tangible, quantitative results used to track progress toward the expected outcome;
- "strategies" determine how the objectives and goals will be met; and
- "measures" contain specific, tangible results that can be reported frequently to evaluate strategies and progress toward the objectives.

For example, Procter & Gamble's product manufacturing program uses its OGSM (Fig. 1) to keep Procter & Gamble's 150 operating sites aligned on a strategic leadership objective that ensures maximum flexibility, that is, lower costs and more timely permits.

In this case, three quantitative goals — 100 percent compliance, flat environmental costs, and positive public perception — support the leadership objective. The strategies that describe how the goals will be met include using superior management systems to maintain long-term compliance, pollution prevention to reduce wastes and costs, and the Superfund Amendments and Reauthorization Act of 1986 (SARA) Toxics Release Inventory (TRI) to improve public perception. Measures include annual management system ratings, annual waste and cost comparisons, and SARA 313 data.

Action

Each of Procter & Gamble's three primary program areas has developed specific action plans focused on continuous improvement. Among the most important continuous improvement tools for each program are the following:

PRODUCT DEVELOPMENT

- "Cutting-edge" safety assessments are routinely used by environmental scientists to evaluate new product ingredients and new products: for example, scientists can use artificial streams to evaluate the fate and impact of new materials on rivers and streams.
- Life cycle assessments are routinely applied to new developments as a holistic method to quantify resource use and waste throughout a project's or a product's life.

PRODUCT MANUFACTURING

- Annual system audits and ratings are used to evaluate and improve long-term site environmental management system capability, not just compliance.
- Site environmental leader certifications ensure that each site has a person capable of handling the day-to-day environmental tasks; new sites must meet this requirement before they can be incorporated into the TQEM approach.
- Pollution prevention is used as a systemic method to reduce site wastes, maintain costs, and promote the concept of designing waste and risk out.

PRODUCT STEWARDSHIP

- Consumer research is Procter & Gamble's number one "secret to success." It is routinely used to identify new consumer needs and wants in the environmental area. The company's "800" numbers and targeted market surveys are the main continuous improvement tools for this research.
- Procter & Gamble uses the U.S. Environmental Protection Agency's integrated waste management hierarchy as a strategic guide to decisions that result in waste reduction. Source reduction options are considered first, then recycling and composting, followed by waste-to-energy burning and landfilling. In many product categories, the concept of getting better performance from less material is a major driving force.
- Product and packaging initiatives aligned with companywide waste reduction goals are expected from each business are

Objective	Goals		Strategies		Measures
Local Industry Leader	* Meet/Exceed Law	⇨	Management Systems	⇨	Audits/Ratings
	* Flat Costs	⇨	Industry Pollution Prevention	⇨	Wastes/Costs
	* Positive Perception	⇨	Reduce SARA TRI	⇨	SARA 313 Data

Figure 1.—An OGSM strategic deployment tool.

throughout the world. Today, over 500 such initiatives operate under the umbrella of continuous improvement.

Communication

The last major element of Procter & Gamble's TQEM approach uses effective communication to share learnings and capitalize on successes. Communication involves three major activities within the company and three more in the larger community.

INTERNAL COMMUNICATION

- Sharing performance expectations is a critical step to ensure clear consistency of purpose throughout the organization. Typical examples of such expectations include operational standards and alignment on specific performance targets.
- Sharing results and future plans is an ongoing step in the TQEM process. In this case, formal reports are generated annually for management review; some measures may even be reviewed quarterly.
- Learnings and successes are routinely applied or reapplied through an extensive staff network. Information sharing is a continuous process involving a corporate Environmental Quality Team and networks of Site Environmental Leaders.

EXTERNAL COMMUNICATION

- Being good neighbors and maintaining a positive public perception are important aspects of Procter & Gamble's TQEM. Site managers are encouraged to maintain an open dialog with their local communities.
- Talking about products and their environmental attributes helps consumers understand what Procter & Gamble is doing to address their environmental wants and needs.
- Talking to others about the value of TQEM is a way for the company to share its learnings while helping advance the art of environmental systems management.

Significant Achievements

This continuous improvement approach has allowed Procter & Gamble to make significant environmental and business achievements, especially in the areas of product manufacturing and product stewardship. For example:

Worldwide Product Manufacturing

- Site environmental management system ratings have improved 25 percent over the past two years.
- The percentage of sites conducting annual environmental audits has improved from 65 to 85 percent over the past two years.
- The percentage of sites with a certified environmental leader has increased from 45 to 75 percent over the past two years.
- The amount of waste from the Lima, Ohio, plant has been reduced by 77 percent in four years, and the amount of waste from the Mehoopany, Pennsylvania, plant has been reduced by 63 percent in three years. These plants were demonstration sites for the President's Commission on Environment Quality pollution prevention studies.
- The amount of waste from its 40 European manufacturing sites has been reduced by 47 percent in three years.

Product Stewardship

- The elimination of unnecessary cartons for several health and beauty care products, such as Sure™ and Secret™ deodorants, saved 3.4 million pounds per year of solid waste.
- A 90 percent source reduction through less packaging was achieved with the introduction of refill pouches to replace liquid detergent and fabric softener bottles in Europe and Canada.
- The introduction of the vacuum coffee brick to replace cans eliminated about 85 percent of the packaging material.
- The three-layer bottle technology for liquid detergents allows us to use as much as 50 percent recycled plastic.
- Recycled fiber is now used in 90 percent of paperboard packaging.

It should also be noted that whenever Procter & Gamble makes a product or packaging improvement, the competition often follows. That's okay because measurable progress toward our nation's environmental goals cannot be met by a company or industry alone.

Looking to the Future

Total Quality Environmental Management h lowed Procter & Gamble to move toward in which solid environmental performance helps deliver sustainable business success. Procter & Gamble people believe that TQEM is more than a fad. They expect that consumers will continue to demand advances in the environmental quality of their products and packages, and that local communities with Procter & Gamble manufacturing sites will continue to look to them for leadership. As a result, there is much more to be done, and Procter & Gamble believes that TQEM, which is a never ending journey of continous improvement, is the right approach to environmental and business success.

Case Study: Roll the Presses But Hold the Wastes: P2 and the Printing Industry

Wayne P. Pferdehirt

Few people immediately think of the printing industry as a major source of air emissions and, to a lesser degree, hazardous wastes and wastewater contaminants. However, inks, cleanup solvents, and platemaking processes are among the many materials used by printers that can have major environmental impacts, as well as drain company profits. Many printers have found that changing materials and processes improve print quality and reduce pollution. This article addresses pollution prevention opportunities and how technical assistance programs can help printers reap these benefits.

WHEN CONSIDERING SOURCES of air emissions, hazardous wastes and wastewater contaminants, few people immediately think of the printing industry. But inks, cleanup solvents, and platemaking are among the many materials and processes used in printing that can have significant environmental impacts, especially in light of the size and diversity of the printing industry.

Environmental pressures faced by printers are intensifying as the 1990 Clean Air Act Amendments are implemented, hazardous waste disposal costs increase, and wastewater agencies place tighter restrictions on allowable discharges. For example, many large printers situated in air quality nonattainment areas are finding it increasingly difficult to expand or raise production, as they bump up against their air permit limits. Owners of some smaller shops, who sometimes are just trying to keep their heads above water in the highly competitive quick-print business, often do not even recognize the hazardous wastes that they generate, much less focus on management and reduction programs.

The technologies and materials used by printers have definitely changed and will continue to change in response to environmental concerns. Despite these advances, made for the most part by the larger corporations in the industry, plenty of opportunities remain for smaller firms. Facilitating the transfer of these technologies, as well as helping printers to see the sound, lasting merits of front-end reduction strategies, are needs that pollution prevention technical assistance programs should fill. This article addresses waste reduction opportunities in printing and how technical assistance personnel can work effectively with industry members to reduce pollution at the source in this vitally important industry.[1]

Background on the Printing Industry

The great variety and depth of this industry make it difficult to make generalizations about printers, the industry, and the pollution prevention issues and opportunities its members face. This diversity

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Table 1. Printing Industry Profile: Shipments by Industry Sector, in Billions of Dollars

Industry Sector	*Amount*
Commercial Printing	$61.6
Business Forms	7.2
Book Printing	4.9
Blankbooks/Binders	3.7
Engraving/Platemaking	3.1
Trade Services	2.0
Book Binding	1.6

Source: Printing Industries of America, *Facts & Figures on the Printing Industry*, 1993 Estimates.

is also essential to consider when developing outreach and technical assistance strategies.

Printed products include newspapers, magazines, plastic and paper packaging, beverage cans, soda cans, T-shirts, promotional novelties, printed labels, and control panels for various equipment, just to name a few. These operations can occur at many types of locations, including a large commercial printing plant, a small corner printing shop, or an in-house printing department of a consumer products manufacturer.

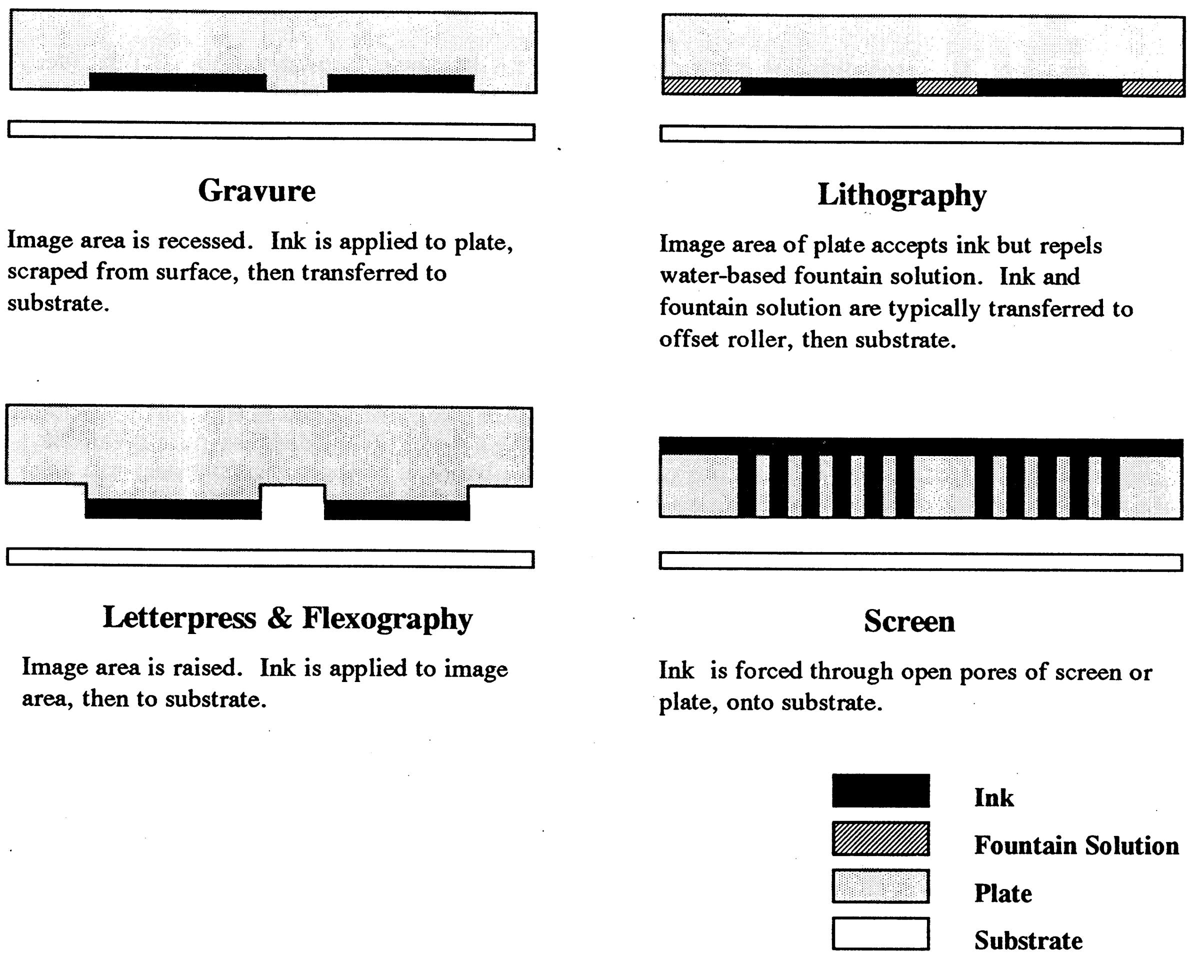
Interestingly, the printing industry is dominated by small businesses. Only 20 percent of the firms in the industry have more than twenty employees, and only 4 percent have more than one hundred. As a whole it is estimated that the U.S. printing industry employs nearly 820,000 persons at 72,000 establishments and will have gross sales of over $160 billion in 1993.[2] **Table 1** reflects the relative size of the various principal elements of the industry.

The printing industry may be defined by several Standard Industrial Classifications (SIC) depending on whether the focus is on users of particular printing technologies or manufacturers of specific products. Often the industry is interpreted to mean firms in SIC 27—Printing, Publishing, and Allied Industries. This definition, however, misses manufacturers of paper, cardboard, and plastic packaging (SIC 26), as well as quick-print copy shops (SIC 59), and in-house copy shops for businesses spread across all SIC groupings. (This article uses the word "industry" to refer to businesses of all types that use printing as part of their production process.)

Basics of printing

The printing process includes three fundamental steps. First, a printing plate is prepared. Platemaking typically employs any of

Figure 1. Conceptual Illustration of Basic Printing Processes



Adapted from California Dept. of Health Services, *Waste Audit Study - Commercial Printing*, 1989.

several photochemical processes particular to the type of printing technology used. Second, the plate is inked and the image is transferred either directly, or indirectly through an intermediate medium, onto the surface to be printed. Third, after the ink is dried, the printed material may receive any one of numerous finishes, depending on the intended final product. Related activities that may be part of a printing operation include binding, finishing, printing plate imaging and development, film processing, image setting, typesetting, composition, and graphic design.

Different processes can be used to print an image onto various materials, or substrates. The most common printing technologies are lithography, gravure, flexography, screen printing, letterpress, and plateless or nonimpact technologies. A brief description of each of these technologies is provided in the box on page 440. **Figure 1**

Explanation of Basic Printing Processes

Lithography

Off set lithography is the predominant printing process. The lithographic process relies on the fact that oil and water do not mix. Metal printing plates with a light-sensitive coating are used; the image area of the plate is hardened and coated. A water-based fountain solution is applied by dampening rollers to enable non-image areas of the plate to repel ink. Ink, applied by inking rollers, adheres only to image areas of the plate. The image is transferred to a rubber blanket, which in turn transfers the image to the substrate being printed. Fountain solutions usually contain 5 to 10 percent isopropyl alcohol (IPA). Inks are usually solvent-borne or ultra-violet cured. Web offset lithography is commonly used to print newspapers, magazines, and catalogs. Applications for sheet-fed lithography include books, posters, brochures, and artwork.

Gravure

In gravure printing, the image area is etched or engraved into the surface of the printing plate. The printing plates are commonly made of copper with a light-sensitive coating. Ink is applied to a plate, then wiped from the surface with a tight-fitting blade, leaving ink only in the depressed image areas. The image is transferred from the printing plate to the substrate. Rotogravure presses use the gravure process to print continuously on long rolls rather than sheets of paper. Gravure printing, unlike processes such as lithography and flexography, does not break solid, colored areas into minute dots to print the areas, and therefore is capable of reproducing high-quality, continuous tone pictures, especially when using glossy inks. Gravure printing is most commonly used for such applications as art books, greeting cards, advertising, currency, stamps, and some packaging. Typically, solvent-borne inks are used in gravure printing, although water-borne inks are sometimes used.

Flexography

In "flexo" printing, a printing plate made of plastic, rubber or some other flexible material is used. Ink is applied to a raised image on the plate, which transfers the image to the printing substrate. The fast-drying inks used in flexographic printing make it ideal for printing on such impervious materials as plastic and foils, making flexography the predominant method of printing flexible bags, wrappers, and similar forms of packaging. Also, the soft rubber plates are well-suited to printing on thick, compressible surfaces such as cardboard packaging. Inks used in flexography are usually either water-borne or alcohol-borne.

Screen Printing

Unlike the impervious plates used in other printing processes, silkscreening forces ink through unblocked portions of a porous screen or plate onto the desired substrate. Inks used include solvent-borne inks and some UV curables. Screen printing is usually used for art books, greeting cards, advertising, packaging, and even for printing circuit patterns on printed circuit boards.

Letterpress

Letterpress was once the predominant printing method, but its use is declining. Letterpress printing uses either type forms containing metal type and carved blocks or photoengravings, or photographically developed relief plates. Ink is applied to the printing plate or type form, and the image is transferred from the raised image to the substrate. Solvent-based inks are usually used in letterpress. Web letterpress, traditionally used to print newspapers and magazines, is being replaced for these applications by lithography. Sheet-fed letterpress is often used for stationery, business cards and announcements.

Plateless Technologies

This group of technologies includes electrostatic and laser printing, and other printing methods which print without the use of separately developed or prepared plate or screen. Although currently used primarily for low-volume applications, these methods are likely to see increased use as the technologies continue to develop.

Table 2. Potential Sources of Wastes in the Printing Industry[a]

Hazardous Wastes[b]

- Photographic Wastes (photo developer, photo fixer, intensifiers, reducers, systems cleaner, scrap litho film)
- Spent Solvents (carbon tetrachloride, ethanol, isopropanol, ethyl benzene, 1,1,1-trichloroethane, methylene chloride, trichloroethylene)
- Waste Inks with Solvents or Heavy Metals (inks and empty containers)
- Cleaning Rags Soaked with Solvent or Containing Residues of Heavy Metals
- Strong Acid or Alkaline Wastes (ammonium hydroxide, hydrochloric acid, nitric acid, phosphoric acid, sodium hydroxide, sulfuric acid, chromic acid)
- Spent Plating Wastes (spent etch baths, spent plating solutions and sludges, and cleaning baths)
- Ink Sludge Containing Heavy Metals (ink sludges with chromium, lead or cadmium)
- Containers with Hazardous Residues of Solvents, Inks or Adhesives
- Miscellaneous (refrigeration tank filters, used oil from vehicles or compressors)

VOCs

- Inks (xylenes, ketones, alcohols, aliphatics)
- Fountain Solutions (isopropyl alcohol, VOC substitutes for IPA)
- Adhesives (binding, labels)
- Cleanup (toluene, naphtha, kerosene, methanol, chlorinated solvents)

Toxic Wastewater Emissions

- Rinse from Photo Developing Processes
- Any Liquid Hazardous Waste Dumped down Drain

Nonhazardous Solid Wastes

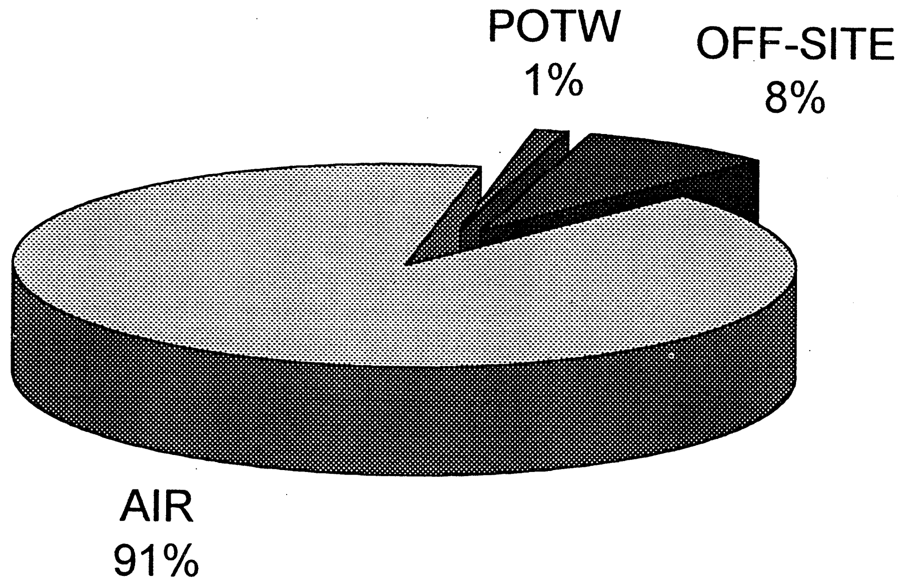
- Waste Substrate (paper, plastic, foil, textiles and metals from trimmings, rejects, and excess quantities)
- Nonhazardous Waste Inks (inks and empty containers)
- Rags and Wipes without Solvents or Hazardous Residues
- Empty Cartons, Wrappers and Roll Cores

[a] This list indicates the types of wastes that may be generated by a printing process. Actual wastes generated by a printer will depend on the technologies and material used, and waste reduction measures employed.

[b] Classification as hazardous will depend on state regulations and, for some materials such as rags, the management methods used.

illustrates the relationship between the plate image area, ink, and substrate for each of the traditional printing technologies. The most appropriate technology for a given application will depend on the substrate, the type of image being printed, the required quality of the printed image, and relative costs of the various methods. Trade associations for printers often are segregated according to

Figure 2. Distribution of TRI Reported Releases for Printing Industry (1989 U.S. total, all media)



the printing technology used by their members.

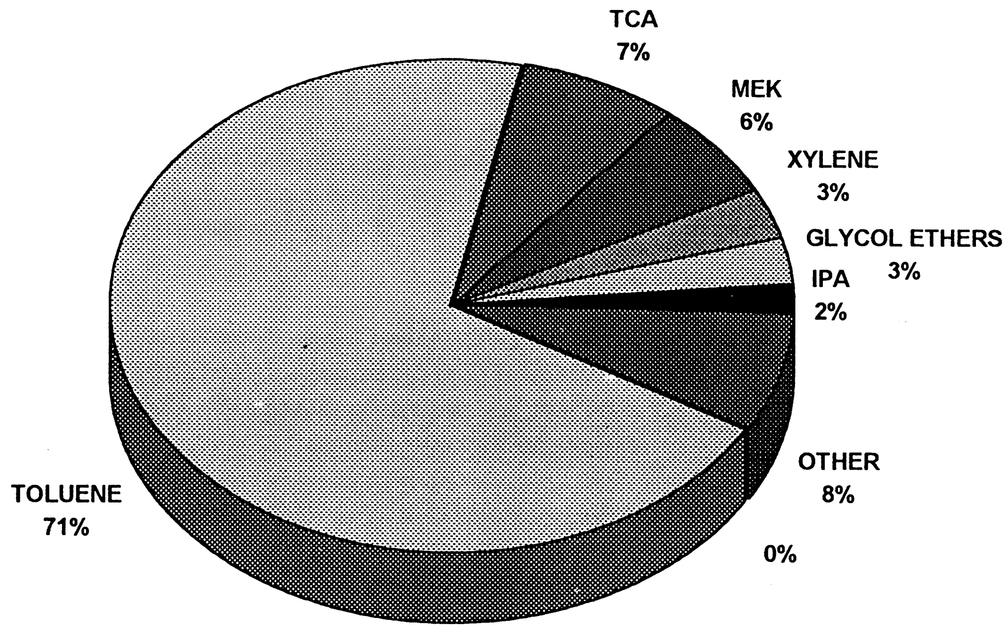
Printing presses are also categorized according to whether they print on continuous rolls or on individual sheets of paper or other substrate. Web presses, used for large production runs, print on continuous rolls, which are then cut and trimmed to size. Sheet-fed presses print on individual sheets of substrate.

Potential sources of hazardous wastes, volatile organic compounds (VOCs), and wastewater contaminants generated by printing operations are summarized in **Table 2**. Wastes and emissions, as well as source reduction opportunities, depend largely on the printing process being used.

Releases and transfers reported for firms in SIC 27 under the 1989 Toxic Release Inventory (TRI) are shown in **Figure 2**. Note that of the total reported releases in Figure 2, over 90 percent of the releases are to the air. The chemicals that comprise the reported releases are shown in **Figure 3**; the great majority of these releases are volatile organic compounds. Primary sources of the reported VOC releases are inks and cleanup solvents.

Total releases from all printing processes in the United States are substantially higher than those reported under TRI for SIC 27 for several reasons. As noted earlier, many printing operations are not covered by SIC 27. Small businesses, of which there are many in the printing industry, typically do not need to report under TRI. Alcohol emissions from lithographers' fountain solutions are not normally required to be reported (unless manufactured by the strong acid

Figure 3. TRI Reported Releases for Printing Industry by Chemical (1989 U.S. total, all media)



method). Finally, in printing, as in other industries, some companies that are required to report under TRI do not do so.

Waste reduction programs for printers

Several major efforts have been launched recently to accelerate greater waste reduction in the printing industry. The large size of this industry, the broad distribution of printing firms throughout the country, and the relatively small size of the companies, all combine to make printers prime candidates for achieving compliance and more through source reduction, rather than through end-of-stack control approaches. The U.S. Environmental Protection Agency (EPA) is currently in the midst of its Design for the Environment (DFE) printing project, a major outreach project being conducted in concert with several trade associations for printers. This project recently decided to focus on three key waste reduction opportunities for printers: (1) reducing solvent usage from blanket washes in lithography; (2) reducing solvent usage from screen reclamation in screen printing; and (3) use of alternative inks in flexography.

In the Great Lakes region, the Council of Great Lakes Governors, working with the Environmental Defense Fund and representatives of the printing industry, has initiated the Great Printers Project to prepare a pollution prevention strategy for printers in the region. These projects are in addition to coordinated efforts within the industry conducted by such groups as the Printing Industries of America, the Environmental Conservation Board, and the Graphical Arts Technical Foundation.

In Wisconsin, pollution prevention technical assistance to printers from the University of Wisconsin Solid and Hazardous Waste Education Center (SHWEC) is being coordinated with small business assistance offered by other state agencies under the Clean Air Act Amendments implementation. Pollution prevention assistance to the printing community can be most effectively accomplished by leveraging efforts through cooperation with industry and nonprofit groups.

Source Reduction Opportunities

A list of the principal source reduction opportunities available to printers is shown in **Table 3**. These opportunities fall into the following key categories:

• ***Improve accountability for waste generation and incentives for reduction.***

SHWEC experts, who provide on-site assessments for businesses of all sorts across Wisconsin, are constantly amazed by how many businesses know so little about their waste streams. Waste generation data that are collected are typically used to meet regulatory reporting requirements, but only rarely as tracking and feedback tools. Companies that institute accurate tracking methods, provide this information as feedback to employees, and make departments financially accountable for their waste streams can achieve waste reductions of at least 20 percent, apart from additional technological improvements.

• ***Improve control over inventory and the printing processes.***

Inks, developing chemicals, and photosensitive films are among the various supplies that can become outdated and require management as hazardous wastes; reduction of these wastes requires a rigorous inventory control program. Dispensing of all solvents should be handled by a central source, and usage should be tracked by the individual press or operator. Personal caches of solvents and other hazardous materials should be strongly discouraged. By improving control over production processes, waste allowances built into the planning of production runs can be reduced, decreasing costs of wastes and raw materials.

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• ***Substitute less hazardous materials.***

Examples include waterborne inks, no-alcohol fountain solutions, and aqueous, nonhazardous platemaking systems. Also, although their use is now uncommon, inks containing chromium, cadmium, and lead should be replaced by less toxic substitutes.

Table 3. Waste and Emissions Reduction Opportunities for Printers

Good Housekeeping
- Cover all solvents.
- Use pump or squeeze bottles, rather than pails, to wet cleanup cloths.
- Keep hazardous wastes segregated from nonhazardous and each other.
- Do not allow personal caches of hazardous materials (e.g., cleanup solvents).

Waste Accounting
- Collect accurate data on waste and emissions generation.
- Establish accountability for waste generation and provide incentives for reduction.
- Provide feedback on waste reduction performance to employees.

Inventory
- Order and manage to minimize data expiration of materials.
- Centralize responsibility for storing and distributing solvents.
- Use returnable containers.
- Use returnable plastic or wood pallets.
- Require that all potentially hazardous samples be pre-approved and vendor must accept unused portion.

Photochemicals
- Extend lives of photo and film developing baths by adding replenishers and regenerators.
- Reclaim and recycle silver from wastewater.
- Use countercurrent rinsing.
- Keep sensitive process baths covered.
- Increase use of electronic imaging.
- Recycle photographic film and paper.

Platemaking
- Use countercurrent rinsing.
- Reduce drag-in of contaminants. Reduce drag-out of solution by adding dripboards and extending drip time.
- Use nonhazardous developers and finishers.
- Increase use of direct-to-plate technologies that allow preparation of plates from computer images without intermediate steps.

Alternative Materials
- Use inks that reduce VOC emissions: e.g., vegetable-based; water-based; ultraviolet; and electron beam drying.
- For jobs still using inks with heavy metals, find alternatives.
- Eliminate or reduce alcohol in fountain solution.
- Consider using waterless offset printing.
- Use non-hazardous, low- or no-VOC solution to clean equipment.

Printing
- Use standard sequence on process colors to minimize color changes for presses.
- Improve quality control to reduce rejects.
- Improve accuracy of counting methods, reducing excess quantities printed to accommodate inaccuracy.
- Use web break detector and automatic splicer.
- Properly store ink to prevent skin from forming.
- Use refrigerative cooling to reduce evaporative losses of fountain solution.
- Run similar jobs simultaneously to reduce cleanup.
- Reuse waste paper or collect for recycling.

Cleanup
- Use automatic blanket washes.
- Wring or centrifuge used cloths to recover solvent and reuse solvent in parts washer or for additional press cleaning.
- Avoid soaking cloths in solvent; use plunger or squeeze bottle to dampen cloth.
- Use parts washing equipment to wash press trays.
- Use cleanup solution with lower VOC content and lower vapor pressure.
- Clean ink fountains only when changing color; use spray skin overnight.
- Provide marked, accessible containers for segregated collection of used solvents.

Waste Inks
- Consider reusing as house colors.
- Carefully label and store special-order colors for future reuse.
- Mix to make black ink for internal or external use.
- Recycle after processing.
- Donate for reuse by printing schools or others.

Finishing
- Use water-based adhesives.
- Minimize coatings that hinder recycling.

• ***Reduce and reuse solvents.***

When solvents are essential to a process or cleanup, usage can typically be reduced substantially by good management practices. Employee education regarding employee health benefits, cost impacts to the company, and environmental benefits is essential. Efforts should focus on reducing evaporative losses, especially from open containers, rags, and cleaning processes, and should emphasize segregated collection to maximize potential for either recycling or in-house reuse.

• ***Extend lives of plating and developing baths.***

Waste reduction principles here are the same as those for metal platers; reduce contamination from drag-in of soils; minimize drag-out of solutions to rinse tanks; monitor and adjust baths rather than batch-dump; use pretreated water; and send used solutions for recycling whenever possible.

• ***Recycle inks, developers, and films.***

Several major suppliers offer customers recycling services for used photographic and plating solutions. Recycling of negatives should be standard practice. Ink wastes can be greatly reduced through improved operating practices, in-plant reuse, and ink recycling services.

Customer choices and specifications do affect environmental impacts of a printing process, and it is important that customers receive the right information and pricing signals to encourage purchasing decisions that reduce environmental impacts.

• ***Educate Customers.***

Effective pollution prevention in printing, as well as other industries, requires partnerships with suppliers and customers. Customer choices and specifications do affect environmental impacts of a printing process, and it is important that customers receive the right information and pricing signals to encourage purchasing decisions that reduce environmental impacts. Printers that help customers understand the process and environmental implications that their choices of inks, papers, and coatings have can help to ensure that their customers' performance specifications are met using the most environmentally-benign materials and processes.

Pollution prevention technical assistance efforts can help printers reduce costs, liabilities, and environmental impacts by using the above opportunities. A key part of such technical assistance should be to assemble and disseminate case studies that illustrate the technical and economic feasibility of practical waste reduction strategies. Usually, large production firms will lead the way in pushing the technological learning curve, while small- and medium-size firms benefit from the transfer of knowledge regarding innovative waste reduction methods. Firms of all sizes, however, usually can benefit from technical assistance that draws focused attention to such operational issues as solvent usage, run coordination, waste accountability, and integration of pollution prevention with broader total quality management programs.

Higher quality and lower cost are the competitive edges that printers are constantly seeking to improve, and well-reasoned pollution prevention strategies should help them do just that. Printers that understand the importance of quality improvement principles, such as achieving quality control within the process itself rather than at the end of the conveyor, statistical process control, and management-labor teamwork to solve problems, are also the most likely to adopt and benefit from pollution prevention approaches. Likewise, technical assistance efforts are most effective when they help printers make the connection between pollution prevention and better control of their processes for overall quality improvement and cost reduction.

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Printing Waste Reduction in Practice

The examples below show how some printers have already made impressive progress in reducing their air emissions and hazardous wastes.

Managing solvents and cleanup rags

Throughout the printing industry, cleanup cloths (referred to as wipes, towels, or rags) are used to wipe ink and soils from equipment and to clean equipment when changing inks. The cloths are used with any of several different solvents when oil-based inks are used. In the shop, cleaning cloths are generally referred to as rags. In discussions with regulators, however, printers are usually careful to call them "wipes" or "wipers," because regulations for "rags" often differ from those for wipers. The hazards presented by the used cloths, and whether they must be managed as hazardous wastes, depend on the fluid used to clean and the residues that were cleaned by and remain on the cloth. Typically the cloths are sent for washing to an industrial laundry, which often leases the cloths to the printer. Emissions from both the laundry and the printer can be substantially reduced by good management techniques for the cleaning cloths and the solvents with which they are used.

The problems presented by printers' towels and the waste reduction opportunities available are illustrated by the circumstances of an industrial laundry that recently called the University of Wisconsin's SHWEC for technical assistance. This laundry was using detergents to wash solvent-soaked towels from printers. The owner of the laundry had called to discuss the feasibility of using a condensing recovery unit to reduce solvent in the plant's stack emissions.

After assessing the relative merits of condensers, carbon adsorption units, and other control technologies, SHWEC suggested that the laundry consider centrifuging the towels prior to laundering them to remove excess solvent and minimize the amount of solvent introduced to wash water. A few weeks later the laundry owner called back to say that he had turned an old washing machine into a centrifuge and was now recovering three to ten gallons of solvent from each drum of printers' towels. The recovered solvent was being sent for fuel blending, and laundry employees stated that this was the first time in years that they could see suds in the rinsewater and smell air in the plant that was free of solvents.

SHWEC then provided materials that the laundry could pass along to its printer customers, describing ways to reduce solvents in cleanup cloths. Both SHWEC and the laundry hope that these materials will prompt solutions even more directly related to the original source of generation. Although, for safety reasons, use of a washing machine as a centrifuge is not recommended, the example illustrates the possibilities that open up when the emphasis is shifted from end-of-stack solutions to front-end management.

The importance and benefits of properly managing solvent-soaked cloths is illustrated by the success of an in-house program at the John Roberts Company in Minneapolis, Minnesota. The company that laundered the printer's towels alerted its printer customers that residual solvents in the towels were creating effluent problems for the laundry and the local municipal wastewater treatment plant. The laundry asked its major printer customers and the Printing Industry of Minnesota, Inc. to help develop a workable solution. Printers wanted to cooperate to find a solution because, unless they could continue to lease reusable cloth wipers, they would need to use disposable cloths, which would be classified as hazardous wastes.

The John Roberts Company developed and implemented an impressive program that included use of a less volatile solvent and methods to reduce the amount of solvents left in the cloths. Specific measures to reduce solvent in used towels included: (1) minimizing the use of solvent by using a plunger or squeeze bottle to moisten cleanup cloths, rather than soaking the cloth by pouring solvent onto it; (2) ensuring that employees collect used solvents in covered, marked containers, rather than pouring them into containers of used cloths; and (3) spinning the cloths in an explosion-proof centrifuge prior to shipment to the laundry. The centrifuge recovers 2.5 to 3.5 gallons of solvent from each load of 220 rags. This recovered solvent is reused throughout the plant in parts washers to clean press ink trays, and is eventually sent to a fuel blender. The $15,000 centrifuge saves the company $34,000 a year, resulting in a payback period of 5.3 months. (See *Pollution Prevention Review*, Autumn 1991, pages 419-424 for further details on this program.)

Many printers are changing over to no- and low-IPA fountain solutions, especially printers located in ozone nonattainment areas.

Alternative fountain solutions

Isopropyl alcohol (IPA) is used to decrease the surface tension of lithographic fountain solutions, allowing the solution to adhere more readily to the nonimage area of the plate cylinder. Most of the IPA evaporates, contributing to ozone creation in the lower atmosphere. Emissions from heatset presses can be reduced with an afterburner. Newer, low-volatility fountain solutions use surfactants, glycols, and glycol ethers in place of the IPA to cut surface tension. Many printers are changing over to no- and low-IPA fountain solutions, especially printers located in ozone nonattainment areas. A Control Technology Guideline (CTG) currently being developed by EPA for offset lithographers proposes restricting IPA content of fountain solution to levels substantially lower than conventionally used, and will further accelerate the use of alternative solutions.

Printers that switch over to alternative fountain solutions indicate that they work well, but often require an adjustment period as press operators learn how to fine-tune their equipment to accommodate the new solutions.

Printers that switch over to alternative fountain solutions indicate that they work well, but often require an adjustment period as press operators learn how to fine-tune their equipment to accommodate the new solutions. Involving supervisors, press operators, and suppliers in planning the changeover, as well as a firm commitment by management to making it work, are often cited as the most important factors in making the change to no-alcohol printing a success.

Neyler Color-Lith and Zimmermann Printing are two Wisconsin printers that successfully switched over to no-alcohol fountain solutions. Neyler Color-Lith, a commercial printer in Waukesha, Wisconsin, with 150 employees, coupled the use of a new, no-alcohol fountain solution with implementation of a computerized distribution and recycling system for the solution. The system constantly checks the quality of the fountain solution, cleaning and recycling the solution as needed. Neyler estimates that the alternative fountain solution and distillation system reduced VOC emissions from the press area by 95 percent. Along with these changes, Neyler Color-Lith increased the use of water-based chemicals in its pre-press rooms.

Zimmermann Printing is a thirty-five-employee commercial printer in Sheboygan, Wisconsin, specializing in business folders, annual reports, and brochures. Zimmermann has noted that although the no-alcohol fountain solutions require tighter tolerances and greater operator attention, the company has realized the following operational benefits: (1) printing quality has improved because presses must run to tighter ink/water tolerances and negative effects of alcohol on ink are eliminated; (2) press rollers do not shrink as they do with alcohol, and require less frequent replacement; and (3) the substitute is less expensive because it evaporates less quickly, reducing the need for replenishment.

A new development in lithography, called waterless or dry printing, eliminates alcohol and fountain solutions altogether. Waterless printing uses silicone rubber in lieu of fountain solution to repel ink from nonimage areas of the printing plate. This printing method allows inks to be applied at higher densities, creating sharper images. Although originally developed by 3M, waterless printing is presently far more prevalent in Japan and Europe than in the United States. A recent market study by a printing equipment suppliers group found that waterless printing is currently being used in the United States by fifty printers on sixty-five presses, most of which are sheetfed.[3] The same study projects that waterless printing will be used by as many as 150 presses by early 1994 and will continue to grow at an increasing rate. Wisconsin printers Burton & Mayer of Brookfield and Suttle Press Inc. of Madison began commercial operation of their waterless offset presses in early 1993, leading the charge in implementation of the technology in this state.

One of the drawbacks to waterless printing is that the inks operate in a much narrower temperature window, requiring cooling of presses. Additionally, current platemaking technologies for waterless printing are solvent-based and therefore can be an additional source of VOCs and hazardous wastes. Printers that choose to adopt waterless technology will, for the foreseeable future, continue to do so primarily for quality reasons. The selection of appropriate pollution prevention approaches will, for the most part, be secondary, based on the selected printing technology.

Alternative inks

The types of inks used by a printer may have significant impacts on the shop's generation of hazardous wastes and the release of VOCs from the printing and cleanup operation. Oil-based inks are comprised of ink oils, resins, pigments, and various additives. Ink oils used can be either petroleum-based or vegetable-based. Soy and other vegetable-based inks have lower solvent content and accordingly produce somewhat lower VOC emissions than petroleum-based inks. (For more on the environmental advantages of products made from plant matter, see pages 383-396 in this issue.) Oil-based inks used for gravure, letterpress, and screen printing usually also contain hydrocarbons to reduce viscosity. Lithographic and letterpress inks are thick and pasty, with little or no added solvent.

Inks that use pigments containing heavy metals, such as chromium, cadmium, lead and mercury, can generate hazardous wastes from waste inks and disposable cleanup wipes. Use of heavy-metal pigmented inks has been greatly reduced in recent years.

Many printers observe that these water-based inks have more vibrant colors and print more crisply than their oil-based counterparts.

Water-based inks include water, emulsion resins, other resins, pigments, and additives. To date, water-based inks have been used most broadly among flexographic printers, especially when printing on paper substrates such as corrugated containers. Many printers observe that these water-based inks have more vibrant colors and print more crisply than their oil-based counterparts. The sharper definition possible with water-based inks allows printers to use finer dot patterns in screened process printing. Water-based inks are also available for gravure printing, but are not used as widely as they are in flexography. Water-based inks cannot be used by lithographers, because the lithographic process is based on the repulsion between an oil-based ink and a water-based fountain solution or hydrophobic surface.

When evaluating the VOC reduction opportunities available from substitute inks, it is important to understand the difference between various types of inks and their drying mechanisms. For example, most of the VOC content in nonheatset inks used for offset lithography is retained in the applied ink. Nonheatset inks dry primarily through penetration into the substrate and oxidation, rather than evaporation.[4] Recent tests completed by the Graphic Arts Education and Research Foundation indicate that, on average, 7 percent of the VOCs in sheetfed nonheatset inks are released during printing.[5] EPA's draft CTG for offset lithography estimates these emissions at 5 percent of ink VOC content.[6] Heatset inks for offset printing are dried by evaporating the ink oils with indirect hot air dryers. EPA's draft CTG estimates that these inks release approximately 80 percent of their VOC content. Publication gravure inks, on the other hand, are low viscosity inks that may contain as much as 80 percent solvent content when applied. Virtually all of the solvent evaporates during printing, drying, or shortly afterward.[7]

One of the first printers in Wisconsin to make extensive use of soy-based inks was Terry Printing in Janesville. A recipient of a Governor's Award for Excellence in Hazardous Waste Reduction in 1990, Terry also implemented an aqueous plate development system.

Marathon Press in Wausau successfully switched inks as part of a larger pollution prevention program that also included switching to a no-alcohol fountain solution, increased reuse of leftover special-order inks, and increased recycling of scrap paper.

Another Wisconsin printer using soy- and other vegetable-based inks in much of its printing is Marathon Press in Wausau. A commercial offset printer with eighty-five employees, Marathon successfully switched inks as part of a larger pollution prevention program that also included switching to a no-alcohol fountain solution, increased reuse of leftover special-order inks, and increased recycling of scrap paper. These efforts earned Marathon a Governor's Award for Excellence in Hazardous Waste Reduction in 1993.

Sunrise Packaging, a flexographic printer in Oak Creek, Wisconsin, produces packaging films, primarily for cheese and processed meats. The firm won a Governor's Award in 1988 for its pioneering work in converting its presses to water-based inks, as well as switching to water-based adhesives. Sunrise Packaging estimates that these changes save the firm over $100,000 a year in raw material costs.

Reducing ink wastes

Ink wastes increase the costs of raw materials and waste disposal. If inks do not contain heavy metals, they can usually be disposed of as nonhazardous wastes. State regulations or restrictions imposed by landfill operators prohibit waste inks from landfill disposal in some areas. Because of these barriers or internal concerns about liability, many printers send ink wastes to fuel blenders for incineration. Waste ink can often be reduced significantly through focused, common-sense measures.

Quad/Graphics is a 5,300-employee web offset and rotogravure printer of catalogs, magazines, and coupon inserts for newspapers headquartered in Pewaukee, Wisconsin. A group of press operators at Quad/Graphics was asked by company management to study ink waste generation at the company's plants and to recommend a reduction plan. The team found that the Pewaukee plant was generating more than seventeen fifty-five gallon drums of waste heatset ink each month from its web offset operations. Plant managers and staff sprang into action by improving ink management practices and by setting up recyclable ink stations to recover ink for reuse. Consequently, ink wastes dropped to one drum a month, saving more than $257,000 a year in ink purchases and nearly $39,000 a year in ink disposal costs.

The importance of common sense and attention to detail when attacking ink wastes is illustrated by the successful waste reduction program implemented by a small sheetfed offset printer in the Minneapolis area. The company, General Litho Services, had previously purchased almost all of its inks pre-mixed to job color specifications. Orders always included "a little extra" so that the press wouldn't run out in the middle of a job.

Over the past few years over $7,000 of extra ink had accumulated in the storeroom. General Litho was considering disposing of this ink, some of which would need to be disposed of as hazardous waste. Instead, the company came up with a plan that would avoid disposal costs while also using these ink supplies it had already paid for. As part of its plan, the company decided to begin mixing its own inks for small jobs. To do this, the company purchased an inexpensive computer program called MixMaster that stores a profile of a company's existing ink inventory, and develops a recipe for using these existing inks to mix specified colors for customers' jobs. (MixMaster is licensed by PanTone, Inc., and is available from many ink vendors.) In addition, all jobs for which the printer selects the color, such as generic office forms and message pads, are run with inks from existing excess stock. General Litho's production manager felt that additional waste reduction could be achieved by increasing the accuracy of its ordering process for inks used on incoming jobs. Realizing that different colors of ink have different coverages, she generated a table that helps production staff accurately estimate ink requirements when using various colors. This tool, plus an emphasis by management on accurate ordering of ink, has led to substantial reductions in ink wastes and purchase costs.

Technology is also now available for on-site recycling of ink wastes remaining after reduction and reuse efforts.

Technology is also now available for on-site recycling of ink wastes remaining after reduction and reuse efforts. Pro Active Ink Recycling, headquartered in Owen Sound, Ontario, operates a mobile ink recycling plant, installed on a semi-tractor trailer, that will process used heatset and nonheatset inks from offset web presses on-site. The company, which recently expanded operations into the United States, is able to recycle all four colors of web offset inks.

Pro Active works with press operators to emphasize the importance of keeping ink colors separate, and free from contaminants, during collection. Large, screened containers are provided for this purpose. The realization that they will be getting back their own ink after it is processed gives printers greater confidence and control, but also helps underscore the importance of contamination-free collection. When sufficient ink waste has been collected, a mobile recycling unit drives to the printer's plant to process the ink. The ink is heated, centrifuged, filtered, and acceptance-tested. Recycling waste ink costs about two-thirds of the cost of an equivalent amount of virgin ink. In addition, disposal costs of $200 a drum or more are avoided. Two large printers that are successfully recycling their inks with Pro Active are Maclean-Hunter, in Aurora, Ontario, and RBW Printers, in Owen Sound, Ontario.

Employee education and incentives

Press operators are at the heart of print quality, and likewise, will make or break a shop's waste reduction program. To greatly increase the probability of sustained success, explain your objectives, genuinely engage them in developing workable alternatives, and give them a strong dose of management support for waste reduction activities. Treat them like mushrooms—kept in the dark and fed a lot of garbage—and failure will be assured.

Press operators tend to be highly resistant to change, largely because of concern about impacts on product quality.

Press operators tend to be highly resistant to change, largely because of concern about impacts on product quality. Operators understand the importance that customers give to print quality and the difficulties entailed in properly adjusting their equipment to consistently achieve high quality. To make pollution prevention an ingrained, companywide ethic and strategy, it is essential that the corporate definition of quality include environmental impact. Operators need to know that management has done its homework, is anticipating the types of problems that might crop up during changeover to a new ink, fountain solution, or cleanup solvent, is prepared to address the problems, and will commit the resources necessary to fight through to success.

A VOC reduction program that did an excellent job of educating and involving employees was conducted by Serigraph, a 790-employee specialty screen and lithographic printer headquartered in West Bend, Wisconsin. Serigraph developed a flyer that asked, and answered in layperson's terms, the question, "What is a VOC?" The flyer then went on to encourage employees to submit suggestions on how to reduce the company's VOC emissions. The flyer also created a bounty system by which employees could earn rewards from $40 to $750 for acceptable, measurable VOC reductions. The effort resulted in a VOC reduction plan based primarily on low-capital, operational changes that were projected to reduce the company's VOC emissions by over 50 percent. Serigraph's program was particularly effective in helping employees understand why VOC reduction is important, extending a genuine invitation and mechanism for their input, and providing incentives to make it worth their effort.

Another good example of a printer employee education was part of the solvent management program described earlier at the John Roberts Company. The company had decided to replace its blanket wash with a less volatile mixture, reducing VOC emissions and eliminating the use of 1,1,1-trichloroethane. The replacement solvent mix was not as aggressive or fast-drying as the blanket wash that was being replaced. Accordingly, the company developed a new procedure for cleaning press blanket, which the company summarized along with answers to anticipated questions in a four-page leaflet distributed to all press operators. The leaflet addressed questions about the details of the new cleaning procedures, the rationale behind the new cleaning procedures, and even addressed expected impacts on cleanup time and productivity. The leaflet demonstrated to press operators that management understood and was addressing their concerns, while also emphasizing the company's commitment to making the changeover a success.

Enhancing Technical Assistance

The following guidelines can help enhance the quality of technical assistance to the printing community:

There's no such thing as a typical printer

The printing industry is extremely diverse in terms of the processes and materials used and in the profiles of the individual companies. Also, there are substantial amounts of printing activity occurring in companies and organizations that are not usually considered part of the printing industry. Reaching all of these printers with source reduction training and technical assistance requires that the pie be sliced in many different directions.

Don't go it alone

To achieve maximum impact, outreach programs should include partners with local, regional, and national industry groups. Trade organizations for printers are trying hard to help members address environmental, cost, and quality issues, and are usually receptive to working with nonthreatening sources of technical information.[8]

Although the natural tendency is often to look for high-tech solutions, VOC emissions, wastewater toxics, and hazardous wastes can usually be greatly reduced at most print shops with common-sense measures.

Teach while demand is high

The 1990 Clean Air Act Amendments, combined with hazardous waste costs and liability issues, have created great need for and interest in alternative technologies and materials in the printing industry. Many smaller businesses will come under the regulatory umbrella, and printers in ozone nonattainment areas will find it hard to expand unless they reduce emission rates. There is now an important opportunity to help printers achieve compliance through up-front source-reduction methods.

Start with common-sense operational improvements

Although the natural tendency is often to look for high-tech solutions, VOC emissions, wastewater toxics, and hazardous wastes can usually be greatly reduced at most print shops with common-sense measures. Proper cleanup techniques, accountability for waste generation, elimination of open solvent containers, and accessible containers for segregated collection of recyclable materials, go a long way in reducing wastes and costs.

Expect technological change to accelerate

Environmental concerns, coupled with a drive for constantly improving the quality of printing, will lead an increasing number of printers to revise their processes and the materials they use. Water-based inks will continue to improve in quality and breadth of application, waterless printing will grab a larger share of the offset market, and the electronic imaging and printing frontier will continue to grow. Large, high-volume printers will lead the change. Pollution prevention technical assistance centers can accelerate the transfer of appropriate technologies to the broader printing community by providing safe, nonbiased sources of technical information.

General Conclusions

Through its review of pollution prevention progress and opportunities in the printing field, this article has demonstrated that source reduction strategies are not just pie-in-the-sky wishes, but are real, practical, and "green" with respect to impacts on both the corporate bottom line and waste generation. Printers are not unlike other types of businesses in their corporate interests and motivations. For example, most printers are very concerned about maintaining and, whenever possible, improving the quality of their products. In addition, the large majority of printing firms really do want to be in compliance with environmental requirements; however, they are also concerned about the impacts of compliance efforts on the bottom line and product quality. Like other businesses, printers also want to be sure that the regulations they are being forced to meet are being applied with equal force to the competitor's shop down the road. Given these interests and strategies, pollution prevention, if it is to be successful, must be presented and pursued in ways that advance quality and cost objectives. This connection is not all artificial; after all, in the words of automobile industrialist Henry Ford, "If it doesn't add value, it's waste."

Environmental quality, like product quality, is best achieved by improvements internal to the manufacturing process, rather than end-of-conveyor inspection or end-of-stack control.

Environmental quality, like product quality, is best achieved by improvements internal to the manufacturing process, rather than end-of-conveyor inspection or end-of-stack control. Although large numbers of businesses have grasped the benefits of TQM and related continuous improvement strategies, many have yet to fully realize the closely related benefits and practical applications of pollution prevention. Helping businesses to more fully realize these opportunities and effectively benefit from them is an opportunity ripe for focused, creative outreach from trade associations, university extension programs, manufacturing technology centers, and other sources of industrial technical assistance. Those willing to step up and deliver the goods can expect strong support from their industrial clientele.

Notes

1. The author gratefully acknowledges technical review of this article by Scott Schuler, environmental director for Printing Industry of Minnesota, Inc. and Gary Jones, manager of environmental information for the Graphic Arts Technical Foundation. Opinions expressed remain those of the author. The information presented in this article is based on materials developed or gathered by the University of Wisconsin's Solid and Hazardous Waste Education Center (SHWEC). SHWEC is a free, non-regulatory service offering training and technical assistance to Wisconsin businesses and local governments. SHWEC is currently developing partnerships with trade associations of printers to expand knowledge and implementation of source reduction opportunities among Wisconsin's printers.

2. United States Environmental Protection Agency, "Use Cluster Analysis of the Printing Industry," Draft Final, May 1992.

3. NPES The Association for Suppliers of Printing and Publishing Technologies, "A Market Assessment of Dry or Waterless Printing within the North American Printing Industry," conducted by Thomas H. Barton & Company, Inc. New York, 1993.

4. Jones, Gary A., "Nonheatset Lithographic VOC Emissions and Their Reduction," *GATFWORLD*, Volume 2, Issue 3, 1990.

5. "GAERF Sends ECB-Managed Ink-Oil Study Results to EPA," ECB *Environmental Update*, March/April, 1993.

6. United States Environmental Protection Agency, "Draft Control Technology Guideline for Offset Lithography," 9/6/91.

7. United States Environmental Protection Agency, "Compilation of Air Pollutant Emission Factors," Publication No. AP-42, Fourth Edition, September 1985.

8. The following organizations can be helpful sources of technical information or contacts in pollution prevention outreach to various sectors of the printing community:

Environmental Conservation Board of the Graphic Communications Industries (ECB), 1899 Preston White Drive, Reston, VA 22091-4367, 703-648-3218.

EPA Design for Environment Printing Project, c/o EPA Pollution Prevention Information Clearinghouse, 401 M Street, SW, (PM-211A), Washington, DC 20460, 202-260-1023.

Flexible Packaging Association, 1090 Vermont Avenue NW, Suite 500, Washington, DC 20005, 202-842-3880.

Flexographic Technical Association, 900 Marconi Avenue, Ronkonkoma, NY 11779, 516-737-6020.

Graphic Arts Technical Foundation (GATF), 4615 Forbes Avenue, Pittsburgh, PA 15213-3796, 412-621-6941.

Graphic Arts Education and Research Foundation (GAERF), 1899 Preston White Drive, Reston, VA 22091, 703-264-7200.

Gravure Association of America, 1200-A Scottsville Road, Rochester, NY 14624, 716-436-2150.

National Association of Printers and Lithographers, 780 Paliside Avenue, Teaneck, NJ 07666, 800-642-NAPL or 201-342-0700.

Printing Industries of America (PIA), 100 Daingerfield Road, Alexandria, VA 22314, 703-519-8100.

Technical Association of the Pulp and Paper Industry (TAPPI), Technology Park, P.O. Box 105113, Atlanta, GA 30348, 404-446-1400.

Pollution Prevention Plans—A Practical Approach

Dennis G. Willis

Preparing a pollution prevention plan allows manufacturers to evaluate their facility's bottom-line performance while helping to limit their future environmental risk and liability. Plan preparation begins with a qualified assessment team performing a chemical inventory of the facility and evaluating each facility operation to determine the flow of hazardous materials. The team identifies alternative waste-reducing processes and determines the feasibility, risk and economics of each option. Based on this information, the team develops a written plan which includes the analysis of each waste reduction alternative and objectives for implementing the selected options.

POLLUTION PREVENTION PLANS have entered the environmental scene as yet another regulatory requirement being placed on American industry. A growing number of states are enacting legislation that requires manufacturing facilities to prepare a formal plan delineating methods to decrease their generation of hazardous waste. Most of this legislation also requires periodic reporting of progress being made toward achieving the goals of this plan.

Although many consider these regulated plans but another act of government interference into a process better accomplished by private initiative, the regulated plans have actually resulted from a lack of significant progress toward reducing waste generation. Progress toward waste minimization, waste reduction, pollution prevention, or whatever title is given to the concept of reducing waste generation at its source, has been painfully slow. The reluctance of industry to implement waste reduction technologies, coupled with an ever-increasing public outcry against any form of pollution, has resulted in the need to regulate not only environmental compliance but environmental planning as well.

Nobody in the private sector wants to have their planning and strategies regulated, but the advent of pollution prevention legislation may, in fact, have been the only practical way to get the source reduction concept rolling. The enactment of this type of legislation or even the threat of such legislation has pushed industry to seriously consider pollution prevention as an option to "waste management" and "pollution control." It is also forcing all generators to stand back and take a good look at other manufacturing technologies in light of their plant's efficiency and, therefore, their bottom-line performance. This formal review of technologies may not be required by law. Even so, reducing environmental compliance costs through the use of more efficient processes should be a critical part of any business plan, whether mandated or not.

Preparing a Pollution Prevention Plan

The first obstacle in the preparation of a pollution prevention plan is the tendency to dwell on the plan's regulatory requirements. These

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requirements should not be the primary concern of the company personnel preparing the plan. Preparation of the plan should be viewed as a method of improving a manufacturer's business in the environmental area, not as an exercise to fulfill regulatory requirements. The practical approach is to plan pollution prevention for the business and the need to stay competitive in the new era of environmental progress.

Preparation of the plan should be viewed as a method of improving a manufacturer's business in the environmental area, not as an exercise to fulfill regulatory requirements.

Once the regulatory fear element is de-emphasized, the preparation of the plan can be approached from a practical standpoint. This will, no doubt, require an assessment of existing processes, procedures, and materials by a qualified assessment team. Some precautions and basic rules for selecting an assessment team are worth mentioning.

The assessment team

The team should be of a workable size. Although all disciplines within the company must participate in the final implementation of the pollution prevention plan, each does not need a representative on the team. A better approach is to keep the team small and involve other personnel through interviews, either with individual team members or with the collective team. A permanent team of five appears to be a manageable size. Teams of ten, fifteen, or twenty members often cause unnecessary diversions and extend the time frames by the pure inefficiency of a larger group.

The team must also have a clear leader, either appointed by upper management or elected by the team members with the concurrence of upper management. The leader must have the time and energy to devote to pollution prevention and the skills to organize and operate small group activity. This effort cannot be another job added to a list of existing responsibilities. It also cannot be a fill-in task to do only when time permits. It must be a high-priority, major responsibility for the leader, with other responsibilities removed or at least minimized.

It is the leader's responsibility to assign specific tasks to the team members, to assure that all functional groups within the organization are contacted, and to see that each group's input is incorporated into the plan. It is also the leader's responsibility to communicate the purpose of the team's work and the progress being made to all personnel within the organization. Strong internal public relations will greatly assist the team in collecting information and ideas from all levels of the organization. The goal of the team is not simply to prepare a pollution prevention plan but, rather, to prepare a plan that can and will be implemented in order to realize the business benefits.

External members on the team are often beneficial as a means of providing new viewpoints. In a multifacility company, this external member can be from another plant or from the corporate group. He or she could also be a paid consultant. If a consultant is used, however, it is important to define his or her participation, which can vary from total involvement to very limited technical input on selected issues.

It is also important to use consulting firms whose emphasis is on pollution prevention. Most consulting firms provide some expertise in pollution prevention, but it may be secondary to their prime business of remediation or analytical services. As the purpose of the pollution prevention plan is to accomplish workable pollution prevention projects, the consultant should have well-established credentials in this specialized area.

Plant assessment: materials inventory and process analysis

Once the team is established, its purpose communicated throughout the organization, the leader determined, and the outside resource, if any, selected, the team can proceed with the plant assessment. This activity starts by collecting a complete list of chemicals used in the facility and the amounts of each of these materials processed. This list must not only include purchased chemicals, but also those chemicals used in metal stocks and other raw materials that have the potential for discharge to the air, water, or ground. This inventory will be used to determine which processes use hazardous materials and have the potential to generate hazardous wastes and emissions. From this inventory the quantities of hazardous constituents are determined using the material safety data sheets (MSDSs). Both the chemical inventory and a file of current MSDSs are required by OSHA's Worker Right-To-Know regulations and should be readily available.

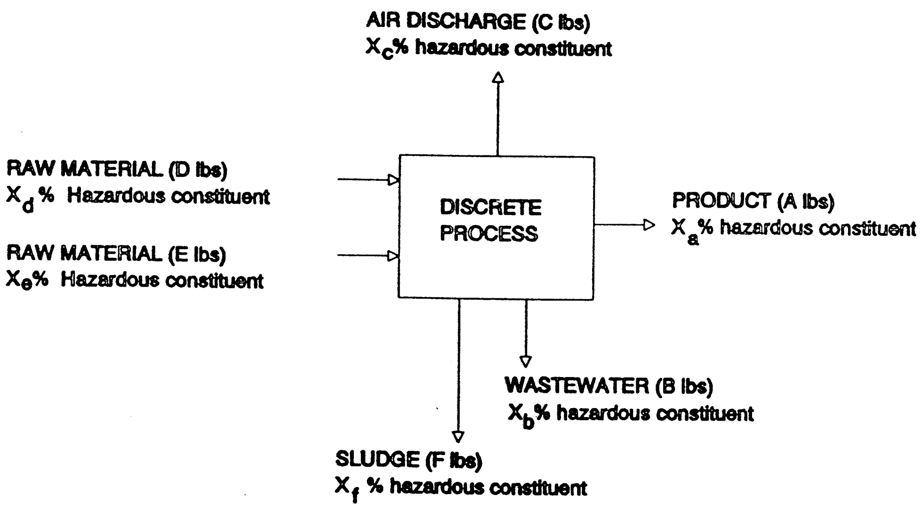
Hazardous constituents will be listed on the MSDS, but the information is not always reliable. Many vendors use claims of proprietary information or simply do not provide adequate detail on the MSDS. If this is suspected, the vendor should be contacted and required to provide generic formulations and approximate concentration ranges. The quantities of these materials used must also be recorded. Both purchasing and inventory records can be used to provide these data. Much of the information required for the pollution prevention analysis has already been accumulated for those facilities required to submit Tier I/II reports or Form R reports under the SARA regulations. This information will only cover reportable components, but it does provide another source of data that can shorten the time required for data collection.

The most practical approach to this assessment is to subdivide the facility into discrete functional operations in order to minimize the complexity of material flow.

The pollution prevention team must now assess each process that used hazardous materials as determined by the inventory. The most practical approach to this assessment is to subdivide the facility into discrete functional operations in order to minimize the complexity of material flow. In other words, process stages should be grouped together on the basis of hazardous constituents used in the process. A plating line consisting of more than one metal should be separated by metal, but it is not necessary to separate the rinse stages of each metal from its respective plating tank. Thus, copper plating with two rinse stages is defined as one process whereas a subsequent nickel plating bath with two rinses would be a second process. Any adjacent equipment such as filters or recovery equipment would be grouped with the primary metal it is handling. This will greatly simplify the analysis when compared to treating plating (which may include copper, nickel, zinc, chrome, and so on) as a single process. Similarly, a paint process might include the spray booth and oven, but should not include a pretreatment stage due to the difference in chemicals being handled.

Each discrete process is diagrammed as a "black box" with its appropriate material inputs and outputs as shown generically in **Figure 1**.

Figure 1. "Black Box"



Much of the data needed to numerically define the process will have been collected from purchasing, MSDS reviews, existing analytical data, process records, regulatory reporting, and so forth. If the information is not available, it can be determined by sampling and analysis or a simple mass balance of the black box.

As an example of this concept, consider a decorative hexavalent chrome plating process with a plating tank, two rinse stages, and an air capture system with a water scrubber. In such a process, the hazardous constituent of concern would be the chrome. The inputs would be the parts, the chromic acid, other plating bath components, and rinsewater. The outputs would include wastewater from the rinse overflows and the scrubber discharge, sludge removed from the tanks periodically, air discharged through the scrubber and fugitive air emissions, and the plated parts. Our model or black box must contain two air discharges (fugitive and the scrubber exhaust) as well as two wastewater discharges (rinse overflow and scrubber discharge). As chrome plating is a heavily regulated process, most of this data would be readily available from the production, purchasing, and engineering sources. If all the information is available except one input or output, it can be determined by mass balance.

In this example, the steel parts coming from a previous plating process will contain no chrome (any chrome in the metal alloy is discarded as insignificant). The chrome in the plating chemical will be well defined by the MSDS. The wastewater streams in most plants would have been identified by chemical analysis because they are a feed stream of the wastewater treatment system. Sludge generation rates and concentrations can be determined from maintenance and disposal records. Fugitive emissions and the air discharge from the scrubber are usually insignificant compared to chrome in the wastewater. The chrome on the parts may be known from production tests or quality checks. However, uneven plating thickness and unknown surface areas make these techniques unreliable. A mass balance can determine the chrome on the parts by:

chrome in = chrome out
chrome in parts + chrome in chemical = chrome plated on parts + chrome in rinse overflow + chrome in scrubber water discharge + chrome sludge

or:

$$Q_P + Q_C = Q_{PP} + Q_{RO} + Q_{SW} + Q_S + Q_{FA} + Q_{SA}$$

Q_P, Q_{FA}, and Q_{SA} are assumed to be negligible, yielding:

$$Q_C = Q_{PP} + Q_{RO} + Q_{SW} + Q_S$$
$$X_C M_C = Q_{PP} + X_{RO} M_{RO} + X_{SW} M_{SW} + X_S M_S$$

where

Q = quantity of chrome (Q = concentration x mass flow)
X = concentration of chrome (lbs./lb.)
M = mass flow (lbs./time)
$_P$ = parts
$_C$ = chemical
$_{PP}$ = plated parts
$_{RO}$ = rinse overflow
$_{SA}$ = scrubber air
$_{SW}$ = scrubber wastewater
$_{FA}$ = fugitive air
$_S$ = sludge

The chrome on the plated parts can be calculated by substituting all of the known concentrations and flows and solving for Q_{PP}. This information then totally defines the chrome process for future waste reduction planning and implementation. Although the mass balance technique requires technical expertise, it is often the most practical method of totally defining the process flow of hazardous constituents.

Review of alternative processes

After the processes that generate waste are reviewed, the plan of how to alter these processes can be developed. This is basically a three-step process of identifying viable alternatives, determining the feasibility of success for each option, and looking at the economics of implementation.

Process alternatives can be determined for most industrial processes. Before initiating the selection of alternatives, the team should list all generating processes matched to their generation volume and toxicity. This will prioritize the processes and allow the alternative selection to be aimed at the processes most requiring waste reduction. For each process listed, a set of options is determined. These options can be as simple as changing raw materials to as complex as replacing the entire process with a different technology.

Before initiating the selection of alternatives, the team should list all generating processes matched to their generation volume and toxicity.

Options should be researched by the assessment team and should include as many approaches as can be determined. This information can be gathered from many sources such as professional societies, trade associations, state and federal technical assistance programs (TAPs), other manufacturers, vendors, and consultants. Many successful waste reduction approaches are well publicized in trade journals, government publications, vendor literature, and technical publications. It is important to use inside as well as outside sources to obtain different points of view and ideas. Machine operators and maintenance personnel are valuable sources of ideas and should not be neglected. The team should also tap all in-house personnel including engineering, production, and marketing in order to obtain everyone's ideas.

Once the list of options is developed, the feasibility of each option must be determined. Input is again required from engineering, production, and marketing in order to assure that the processes can meet each area's requirements or whether the requirements can be changed to allow the process change to be successful. Review of similar operating processes within the facility or at other facilities is the most practical method of determining the operational variables of a new source. Vendors can, and in most cases will, set up appointments at firms using the new process so that the process can be examined under "real-life" conditions. This information can be coupled with the knowledge and experience of facility personnel to assign a risk to each option. The team should attempt to be as objective as possible in assigning the risks. Using the wealth of information now gathered from all sources, a risk scale or matrix can be developed to rank the options as to probable success and operational consequences. The most practical approach is to use a simple ranking system, but the complexity of the risk scale will vary based on the skill of the team and the resources of the company.

Once the alternatives, their feasibility, and their risks are known, the economics must be calculated and considered. Most pollution prevention options offer excellent paybacks by reducing the cost of handling and disposing of waste, improving the efficiency of the manufacturing process, decreasing raw material usage, and eliminating the indirect costs of dealing with regulated waste. The economics will vary depending on the size of existing wastestreams and the complexity of the process. The economic analysis can range from a single return on investment calculation to a complex internal rate of return analysis. Whichever method is used, it must accumulate all costs and savings, both direct and indirect. The final analysis must also be tempered with intangible benefits such as improved quality, better public relations, and improved employee working conditions.

At this point, the economic input is added to the risk and feasibility matrices to select the best options. It should be emphasized that the best option is not necessarily the one with the best return. Rather, it is the option that accomplishes the greatest degree of pollution prevention, provides the most feasible production implementation, provides equal or better product quality, and, most importantly, will be accepted by the company as a worthwhile environmental and operational improvement. It must also provide "acceptable" economics based on the company's capital availability and required return on pollution prevention projects due to the enormous risk and liability of continued generation. Many firms have generated extraordinary returns by implementing pollution prevention.

The final analysis must also be tempered with intangible benefits such as improved quality, better public relations, and improved employee working conditions.

A simplified example using the chrome plating process defined earlier demonstrates the technique for process options. For decorative chrome plating, an assessment team would most likely identify alternatives such as the elimination of plating, changing from hexavalent to trivalent chrome, recovering chrome in wastewater via ion exchange, installing a dead rinse tank, and concentrating and reusing chrome with an evaporator. These options can be evaluated by the matrices of data shown in **Table 1.**

This analysis presents a comparative picture of the identified options that is useful in selecting the best alternative for the existing chrome plating process. The elimination of plating as an option is not feasible due to perceived or actual market needs for the decorative chrome plating. The dead rinse and evaporation options are highly feasible and low risk, but they do not eliminate all of the chrome discharges. These options also have lower economic benefits. If capital is not a constraint, the ion exchange option offers excellent economics and feasibility with good economic payback. Ion exchange can recover up to 90 percent of the chrome in the wastewater streams.

The trivalent option has been applied in many plating shops but has a moderate risk due to its more complex process control requirements. The economics of trivalent chrome are excellent, but the slight difference in color of the plated parts could cause market objections. However, this process eliminates a known carcinogen

Table 1. Data Matrices for Evaluation Options

Option	*Feasibility*	*Risk*	*Required Capital**	*Process Economics**	*Comments*
Eliminate plating	no	high	low	excellent	Market need
Trivalent chrome	good	moder-ate	high	excellent	More process control, color difference, eliminates carcinogen
Recovery with ion exchange	excellent	low	high	good	More process control
Dead rinse	excellent	low	low	fair	Partial solution
Evapora-tion	excellent	low	low	fair	More process control, partial solution

* In a real case both the required capital and the process economics can be quantified.

(hexavalent chrome) and the associated heavy regulations. Where feasible the use of trivalent chrome is an excellent option.

The plan document

The process described up to this point has dealt with the practical routine of evaluating pollution prevention and not with the details of a regulated plan. Whether or not a plan is required, completing the plan will provide the working document for the pollution prevention activity and serve as a basis for measuring success. The information gathered now must be formalized in a document meeting the requirements of the regulatory agency or the needs of the company. This document should follow the requirements used by most states that mandate pollution prevention plans. These are:

- *A policy statement of management support for the plan*—Management support is essential if pollution prevention is to be successful.
- *A description of current processes generating or releasing hazardous materials, including types, sources and quantities*—This is the analysis of the black box that the team must generate.

- *A description of current and past hazardous waste reduction practices and an evaluation of their effectiveness*—The assessment will uncover these historical practices.
- *An assessment of technically and economically feasible options available to eliminate or reduce the generation or release of hazardous materials*—This is the list of options developed by the team.
- *Plan objectives including evaluation of technologies, procedures and personnel training programs*—These are the selected options evaluated by the feasibility, risk, and economics matrices.

The written plan will evolve from the activities of the assessment team. This plan will serve as the basis for implementation similar to any business plan.

Summing Up

Pollution prevention plans should be a practical business plan for attacking today's environmental concerns through the reduction or elimination of waste at its source of generation. They should be developed through a systematic series of steps including a chemical inventory, a process assessment, a black box analysis of the processes, and a review of acceptable alternatives determined on the basis of feasibility, risk, and economics. The generation of this plan and its implementation will provide long-term solutions to today's environmental concerns and provide manufacturers with a means of limiting their future environmental risk and liability. ◆

Illustration 1: Valley Paints, Inc

Valley Paints, Inc. is a fifty year old, small specialty paint manufacturing company located in the Connecticut River Valley. Besides the owner and his two sons, there are twelve employees. The firm specializes in ready-mixed paints for architectural purposes. Three-quarters of their paint products are solvent-based; the remaining are water-based paints. The equipment is fairly dated and the processes are mostly manual. The firm serves a stable but increasingly competitive market and has sales of about $5 million per year.

The primary raw materials used by the facility include resins, solvents, drying oils, pigments, bactericides, fungicides and extenders. The solvents used include aliphatics, aromatics, ketones and glycol ethers. The wastes include equipment cleaning wastes, obsolete stock, off-specification products, spills, spent filter bags and empty cans and packaging.

All of the paints are produced in batch processes employing large mixing vats capable of 500-1000 gallon production runs. The production process follows a set of simple steps including:

- dry mixing of resins and pigments in high-speed mixers,
- grinding and milling of the powders,
- mixing in tints and thinners in agitation tanks,
- filtering to remove no-dispersed pigments,
- decanting into cans, and
- packaging and labeling.

At present the firm practices fairly conventional pollution

- solvent-based tanks and containers are washed with caustic solution,
- water-based tanks are flushed with water,
- wastes are discharged to the sewer and periodic inspections have found occasional violations of the wastewater discharge permit, and
- obsolete stock and off-specification products are sent to a licensed hazardous waste facility at increasing expense.

A small TUR planning team has examined many options for reductions and has determined that the following are presently feasible from an economic and technical perspective.

- solvent cleaning processes could be replaced by an aqueous-based process,
- the flush water system could be replaced with a high-pressure hose that would greatly reduce waste water volume,
- reserving tanks for single colors would reduce the frequency of tank cleaning,
- eliminating the use of chromium in pigments and mercury in bactericides can reduce some of the toxic metals in the waste water,
- off-specification products could be reduced by switching to different mixing procedures or offering the paint for sale as a lower grade product, and
- obsolete product could be reduced by better inventory and contract management

APPENDIX A-1

COATED FINE PAPER MILL

Company Background

This specialty paper mill is part of a larger corporation of pulp, paper, and coating mills. The mill is not integrated, i.e. does not manufacture pulp. Most of the pulp used by the mill is purchased, via pipeline, from a neighboring bleached kraft mill. The mill supplements this pulp with a small amount of purchased market pulp. The mill produces approximately 190 tons per year of a variety of uncoated, and on-machine and off-machine coated papers, carbonizing, book and release base paper. The coating used is a latex (i.e. non-solvent) formulation containing clay, styrene butadiene, starch, and polymers.

Environmental Management

The mill first created an environmental department in 1988. The department consists of one engineer who reports to mill's Operations Manager. This engineer manages environmental and safety compliance and projects at the site, including oversight of the mill's only two permitted sources of pollutants--fuel oil burners and starch mixing tanks. To eliminate exposure to employees and the surrounding community, the engineer successfully persuaded mill management to replace the chlorine gas-based fresh water purification system with one using sodium hypochlorite. Although sodium hypochlorite still poses some handling risk to employees, it is safer than chlorine.

The mill produces a significant quantity of broke (i.e. unsalable paper product) that it cannot reuse. This problem is typical of specialty paper mills that produce many different grades, and frequently change from one grade to another on the same paper machine. The mill recycles 75% of this broke at other paper and paperboard mills and landfills the remainder.

Since it does not have its own wastewater treatment facility, wastewater from the mill is pumped to the neighboring mill for treatment. This wastewater constitutes between 10 and 12% of the neighboring mill's wastewater flow. In the per ton flow, TSS and BOD for the subject mill is reportedly higher than the industry average. The neighboring mill has asked the subject mill to reduce wastewater flow, although no such measures have been put into effect to date.

Wastewater treatment price was negotiated between the mill and the neighboring mill in 1977, and is based on the following formula:

finished tons produced x no. gallons discharged x cost factor = treatment charge

The treatment charge is not based on TSS or BOD so the subject mill has no direct economic incentive to reduce TSS and BOD in its wastewater. The contract between the mills establishes a ceiling for wastewater flow, BOD and TSS from the mill. Currently, the mill is meeting its flow limit, but is substantially exceeding its contract limits on BOD and TSS. In 1992, the neighboring mill will be required to significantly reduce its effluent BOD load and has, in turn, required the mill to reduce the BOD content of its wastewater prior to pumping it to the treatment plant. The subject mill is currently exploring BOD reduction options.

The treatment contract will be renegotiated in 1993, but it is not clear whether, or how, the terms will be changed. However, the environmental engineer speculated that the charge rate formula might be changed to include a BOD or TSS variable, and that the overall cost could increase.

Capital Budgeting and Project Analysis

A proposed project moves through three steps prior to implementation. First, a feasibility study is conducted to assess the technical aspects of the problem and the proposed solution. Second, a cost justification or Capital Appropriations Request (AR) is prepared for the project. The AR contains a detailed economic analysis of the project costs and savings; a narrative describing the need for, and benefits of, the project; and a financial spreadsheet printout containing a discounted cash flow analysis of the project for a 10-year period. The spreadsheet reports several financial indicators, including ROI, ROAE (return on assets employed), IRR, NPV and payback. The mill uses payback as a screening device for project profitability, and loosely applies a 2 year hurdle rate to discretionary, profit-adding projects. The AR form has a standard format for investment cost estimates with the following categories:

1. Direct costs:

    site preparation
    site improvements
    civil/structural/architectural
    process equipment
    support services
    spare parts

2. Indirect costs:

    permits/licenses
    AR preparation
    engineering
    process simulation/trials
    training
    project management
    construction management
    start-up costs
    tax
    escalation
    contingency

There is, however, no standard format for estimation of project benefits. Benefits quantified in the AR vary from project to project, but future liability and other intangible costs are not monetized.

Finally, once the AR is approved by management, the third step--an engineering design--is prepared and the project is implemented.

Perspectives on TCA

The environmental engineer, the likely champion of environmental projects within the mill, finds it difficult to justify economically projects that are not required by regulation. While he is interested in the TCA approach, he does not feel that it is possible to develop a credible estimate of future liability for use in a financial analysis. He cited a specific project in which he proposed to construct a containment system around the truck unloading area. Such as system would prevent spilled chemicals from running into the nearby river in the event of an accident. While he would have liked to estimate the avoided liability cost associated with this project, he felt that it was not possible to develop a defensible estimate.[1]

Project Background

Papermachine white water, a mixture of water and residual fiber and filler (clay and calcium carbonate) that drains out of the sheet of paper as it travels across the paper machine, is typically captured by a white water collection system dedicated to one papermachine. Typically, some or all white water is recycled back into the papermaking system to recapture water, fiber and filler. In some cases white water is passed through a saveall screening device to separate fiber and filler from water; fiber, filler and water are then recycled back into the system. The saveall produces a clear stream of water that can be used in numerous papermachine operations.

In this mill, two paper machines, sharing a common white water system, produce a variety of paper grades made with either acid, neutral, or alkaline sizing chemistry.[2] Machine 1 has a saveall system that filters fiber and filler prior to discharging into the joint white water system. This material is recycled back into the papermaking system. When the machines are using different sizing chemistry, e.g. when Machine 1 is producing acid-size paper and Machine 2 is producing alkaline-sized paper, the mixed white water from both machines is not reusable, and must be sewered. Under these conditions, a large flow of potentially reusable water from both machines, and fiber and filler from Machine 2, is lost to the sewer.

Prompted primarily by the lack of spare water effluent pumping capacity and a desire to better understand the rather complex, old white water piping system, the mill commissioned a study titled "White Water Recycle Feasibility Study" in 1988. The study, completed in August of 1989, had several objectives: "...to review the design and operation of the mill and recommend changes that would help reduce peak effluent flows, reduce BOD in the effluent and reduce total fresh water intake on a mill wide scale". The resulting report contained detailed engineering drawings of the fresh water, white water, and paper machine systems and two recommendations for process modifications.

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[1] This project has not been implemented.

[2] Sizing is added to pulp to reduce water absorbency in the final paper. The Ph (i.e. acidity or alkalinity) of the pulp must be adjusted according to the type of paper desired and sizing used.

Project Description

The first recommendation (called Phase I) made in the feasibility study is to install a second saveall to handle the white water from Machine 2. Because the white water systems under this scenario would remain separate for Machines 1 and 2, this phase would allow recovery of fiber from white water, but only permit recovery of clarified white water if the grades being produced on the machines are compatible. Otherwise, the water would have to be sewered.

Under Phase II, the white water systems would be split, so that each machine would have a dedicated system. In combination with Phase I, Phase II would permit fiber, filler and water reuse on both machines, at all times. This phase would require installation of a new pump, piping, and controls. Available pulping and stock storage capacity could be used to pulp separately for each machine.

Project Financial Analysis

The feasibility study contains a capital estimate for Phases I and II. No other financial analysis of the project has been conducted by the mill. The capital estimate is 1,145,300 (1989 dollars), and is considered to be +/- 25% accurate. The estimate includes: purchased equipment (including saveall, stock chest, clear white water chest and associated equipment); process control instrumentation; electrical controls and lighting; a new building for the saveall; piping; installation (in-house and contracted labor); engineering; and contingency.

Company and TCA Analyses

At the request of the mill, we have focused our analysis on the combined Phases I and II. This option is most interesting to the mill because it maximizes water, fiber, and filler recovery; and reduction in BOD and solids in wastewater.

The Company Analysis consists of the 1989 capital estimate (adjusted for inflation and escalated by 12.5%[3]), and only those operating costs and savings that the company typically includes in project financial analyses for projects of this type. These are:

a. raw material - fiber and filler;
b. energy and chemical use for new equipment;
c. wastewater treatment fees; and
d. changes in labor costs.

The TCA contains these and other operating costs and savings that were developed in the course of this study. On the benefit side, the TCA includes the following:

a. An average reduction in fiber and filler loss of 1,200 tons/year, for a savings of $429,200/year;

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[3] As suggested by the mill, capital costs were escalated by 12.5% to adjust the feasibility study estimate which was +/- 25%.

b. A reduction in fresh water usage of 1 million gal/day, and a commensurate reduction in cost for fresh water treatment and pumping, for a savings of approximately $112,420/year;

c. A reduction in energy use for fresh water heating amounting to a savings of approximately $377,250; and

d. A reduction in wastewater generation of approximately 1 million gal/day, for a savings of approximately $52,500/year in wastewater pumping and $68,000/year in wastewater treatment fees.

Annual operating costs are expected to increase in the following areas:

a. Chemical flocculating agents used in the saveall to promote solids/water separation will cost approximately $275,000/year;

b. Electric costs for new equipment operation will increase operating costs by approximately $102,870/year; and

c. An increase in labor cost of approximately $3,120/year is expected for operation of new equipment.

The project does not affect wastestreams that require on-site management or disposal, nor does it affect any regulatory compliance activities at the site, therefore the financial analysis does not include costs for these activities. In addition, we do not expect any impacts on revenue since neither product quality nor production rates will be improved, nor does the mill expect to visibly enhance its product or company image. Finally, we do not expect any tangible impact on avoided future liability for this project.

Table A-1.1 summarizes the cost categories addressed in the Company Analysis and the TCA for this project, and Table A-1.2 reports the results of the financial analysis.

Table A-1.1 Comparison of Cost Items in Company and TCA Cost Analyses

X = Cost(s) Included
P = Cost(s) Partially Included

	Company	TCA
Capital Costs		
Purchased Equipment	X	X
Materials (e.g., Piping, Elec.)	X	X
Utility Systems	X	X
Site Preparation	X	X
Installation (labor)	X	X
Engineering/Contractor	X	X
Contingency	X	X
Operating Costs		
Direct Costs:*		
Raw Materials/Supplies	P	X
Labor	X	X
Indirect Costs:*		
Utilities:		
Energy	P	X
Water		X
Sewerage (POTW)	X	X

* We use the term "direct costs" to mean costs that are typically allocated to a product or process line (i.e. not charged to an overhead account) and are typically included in project financial analysis. "Indirect costs" here mean costs that are typically charged to an overhead account and typically not included in project financial analysis.

Table A-1.2. Summary of Financial Data for the White Water and Fiber Reuse Project[4]

	Company Analysis	TCA
Total Capital Costs	$1,743,820	$1,743,820
Annual Savings (BIT)*	$ 116,245	$ 658,415
Financial Indicators		
Net Present Value - Years 1-10	($ 702,855)	$1,242,536
Net Present Value - Years 1-15	($ 587,346)	$1,808,384
Internal Rate of Return - Years 1-10	0%	36%
Internal Rate of Return - Years 1-15	6%	36%
Simple Payback (years)	11.4	2.0

* Annual operating cash flow before interest and taxes

The improvement shown in annual savings and financial indicators for the TCA stems from the inclusion of energy savings in the TCA, but not in the Company Analysis. Specifically, reduced energy consumption for pumping and treating fresh and wastewater, and freshwater heating are included only in the TCA. These savings, which would typically not be included in the mill's calculation of profitability, bring the project in line with the mill's 2 year payback rule-of-thumb. By excluding these savings in the Company Analysis, the project looks highly "unprofitable".

[4] This table contains preliminary results, subject to change upon receipt of complete cost data.

Some uncertainty exists in the wastewater treatment cost estimate. As discussed above, the subject mill will be renewing its contract with the neighboring mill in 1992, and it is possible that treatment fees will increase. To test the sensitivity of the project analysis to these potential changes, we recalculated the TCA twice, doubling and tripling the wastewater treatment costs. In both cases, the financial indicators changed slightly: 40% IRR (years 1-10) and 1.8 payback for double the cost, and 44% (years 1-10) IRR and 1.7 payback for triple the treatment cost. While we do not see a dramatic change in projected profitability, a tripling of wastewater treatment costs, may make this project somewhat more competitive with other projects competing for capital in a particular budget year. This may be especially true if the firm applied its rule-of-thumb, 2 year payback criteria as a screening test for the project.

Detailed reports of the Company Analysis, TCA, and associated cost calculation documentation follows.

APPENDIX A-1
COATED FINE PAPER COMPANY

Project 1 - Company Analysis

WHITE WATER AND FIBER REUSE PROJECT

Project: Whitewater/Fiber Reuse Project

CAPITAL COSTS

page 1

Date: 11/4/91

Capital Costs	Cost	Totals	Ref.	Notes:
Purchased Equipment				
Equipment - Phase I	$330,853			Saveall and associated pumps and tanks
Equipment - Phase II	$15,132			White water pump
Sales tax				
Price for Initial Spare Parts		$345,985		
Materials				
Piping	$183,690			
Electrical	$67,721			
Instruments	$68,465			
Structural	$54,946			
Insulation/Piping		$374,822		
Utility Connections and New Utility Systems				
Electricity				
Steam				
Cooling Water				
Process Water				
Refrigeration				
Fuel (Gas or Oil)				
Plant Air				
Inert Gas		$0		
Site Preparation				
Demolition, Clearing, etc.		$0		
Installation				
Vendor				
Contractor	$397,148			
In-house Staff		$397,148		
Engineering/Contractor (In-house & Outside)				
Planning				
Engineering	$166,946			15% of materials and labor
Procurement				
Consultants	$44,100	$211,046		Consultant feasibility study, 1989

Project: Whitewater/Fiber Reuse Project

Date:

Capital Costs (continued)	Cost	Totals	Ref.	Notes:
Start-up/Training				
Vendor/Contractor				
In-house				
Trials/Manufacturing Variances				
Training		$0		
Contingency				
	$140,403	$0		10% of materials, labor, and engineering
Permitting				
Fees				
In-house Staff		$0		
Initial Charge of Catalysts and Chemicals				
		$0		
Working Capital (Raw Materials, Product, Inventory, Materials and Supplies)				
		$0		
Salvage Value				
		$0		

Project: Whitewater/Fiber Reuse Project
Operating Costs

Costs are positive
Savings and revenues are negative

Date: 11/4/91

CURRENT PROCESS Item	Annual Cost ($/year)	Total	Ref	ALTERNATIVE PROCESS Item	Annual Cost ($/year)	Total	Ref	Difference (Cur. - Alt.)
Raw Materials/Supplies				**Raw Materials/Supplies**				
Fiber loss (includes transport)	$457,000		1a	Fiber loss (includes transport)	$91,500		1b	
Filler loss (includes transport)	$79,700		1a	Filler loss (includes transport)	$16,000		1b	
				Flocculating agents for saveall	$275,200		1c	
		$536,700				$382,700		$154,000
Waste Management *(disposal, hauling, insurance, storage, etc.)*				**Waste Management** *(disposal, hauling, insurance, storage, etc.)*				
		$0				$0		$0
Utilities (elec., steam, water, sewerage)				**Utilities (elec., steam, water, sewerage)**				
Freshwater Pump. and Treat.			2a	Freshwater Pump. and Treat.			2b	
Freshwater Heating			2c	Freshwater Heating			2d	
Wastewater Pumping			2e	Wastewater Pumping			2f	
Wastewater Treatment	$273,000		2g	Wastewater Treatment	$204,765		2h	
		$273,000		Elec. for Equipment Operation	$102,870	$307,635	2i	($34,635)
Labor				**Labor**				
				Equipment Operation	$3,120		3a	
		$0				$3,120		($3,120)
Other				**Other**				
		$0				$0		$0
Regulatory Compliance *(manifesting, reporting, monitoring, testing, labeling, etc.)*				**Regulatory Compliance** *(manifesting, reporting, monitoring, testing, labeling, etc.)*				
		$0				$0		$0
Insurance				**Insurance**				
		$0				$0		$0
Revenues				**Revenues**				
		$0				$0		
Revenues - Marketable By-products				**Revenues - Marketable By-products**				
		$0				$0		$0
Total		$809,700				$693,455		$116,245

Project: Whitewater/Fiber Reuse Project

Date: 11/4/91

CAPITAL AND OPERATING COST SUMMARY

Capital Costs	$
Equipment	$345.985
Materials	$374.822
Utility Connections	$0
Site Preparation	$0
Installation	$397.148
Engineering/Contractor	$211.046
Start-up/Training	$0
Contingency	$0
Permitting	$0
Initial Catalysts/Chemicals	$0
Depreciable Capital	$1.329.001
Working Capital	$0
Subtotal	$1.329.001
Interest on Debt	$0
Total Capital Requirement	$1.329.001
Salvage Value	$0
% Equity	100%
% Debt	0%
Interest Rate on Debt, %	12.0%
Debt Repayment, years	5
Equity Investment	$1.329.001
Debt Principal	$0
Interest on Debt	$0
Total Financing	$1.329.001
Depreciation period	15
Income Tax Rate, %	40%
Escalation Rates, %	5.0%
Cost of Capital (for NPV)	16.00%

Operating Costs		Current	Alternative	Difference (Cur. - Alt.)
Raw Materials/Supplies		$536.700	$382.700	$154.000
Waste Management		$0	$0	$0
Utilities		$273.000	$307.635	($34.635)
Labor		$0	$3.120	($3.120)
Other		$0	$0	$0
Regulatory Compliance		$0	$0	$0
Insurance		$0	$0	$0
Maintenance - % of Capital				
Labor	0%		$0	$0
Materials	0%		$0	$0
Overhead - (% of Labor)	0%	$0	$0	$0
Labor Burden	0%	$0	$0	$0
Revenues		$0	$0	$0
Revenues - Marketable By-products		$0	$0	$0
TOTAL		$809.700	$693.455	$116.245

Future Liability	Ref.	Year Expected	Cost (Curr. - Alter.)
(Year expected = 1,2,3, etc.)			

Project: Whitewater/Fiber Reuse Project

Profitability Analysis — Date: 11/4/91

erating Year	0	1	2	3	4	5	6	7	
Escalation Factor	1.000	1.050	1.103	1.158	1.216	1.277	1.341	1.408	..478
REVENUES									
Revenue (prod. rate or value)		$0	$0	$0	$0	$0	$0	$0	$0
Marketable By-products		$0	$0	$0	$0	$0	$0	$0	$0
Annual Revenue		$0	$0	$0	$0	$0	$0	$0	$0
OPERATING (COSTS)/SAVINGS									
Raw Materials/Supplies		$154,000	$169,862	$178,332	$187,264	$196,658	$206,514	$216,832	$227,612
Waste Management		$0	$0	$0	$0	$0	$0	$0	$0
Utilities		($34,635)	($38,202)	($40,107)	($42,116)	($44,229)	($46,446)	($48,766)	$0
Labor		($3,120)	($3,441)	($3,613)	($3,794)	($3,984)	($4,184)	($4,393)	($51,191)
Other		$0	$0	$0	$0	$0	$0	$0	($4,611)
Regulatory Compliance		$0	$0	$0	$0	$0	$0	$0	$0
Insurance		$0	$0	$0	$0	$0	$0	$0	$0
Maintenance		$0	$0	$0	$0	$0	$0	$0	$0
Overhead		$0	$0	$0	$0	$0	$0	$0	$0
Labor Burden		$0	$0	$0	$0	$0	$0	$0	$0
Liability		$0	$0	$0	$0	$0	$0	$0	$0
		$0	$0	$0	$0	$0	$0	$0	$0
Total Operating (Costs)/Savings		$116,245	$128,219	$134,612	$141,354	$148,445	$155,884	$163,673	$171,810
CAPITAL COSTS									
Investment	$1,329,001								
Book Value	$1,329,001	$1,240,401	$1,075,014	$931,679	$807,455	$699,794	$606,488	$542,647	$478,806
· Depreciation (by Straight-line, 1/2 yr)		$88,600	$88,600	$88,600	$88,600	$88,600	$88,600	$88,600	[illegible]
. Depreciation (by Double DB, 1/2 yr)		$88,600	$165,387	$143,335	$124,224	$107,661	$93,306	$80,865	[illegible]
Tax Depreciation (by DDB switching to SL)		$88,600	$165,387	$143,335	$124,224	$107,661	$93,306	$63,841	$63,841
Debt Balance	$0	$0	$0	$0	$0	$0	$0	$0	$0
Interest Payment at : 12.0%		$0	$0	$0	$0	$0	$0	$0	$0
Principal Repayment		$0	$0	$0	$0	$0	$0	$0	$0
CASHFLOW									
Revenues		$0	$0	$0	$0	$0	$0	$0	$0
+ Operating (Costs)/Savings		$116,245	$128,219	$134,612	$141,354	$148,445	$155,884	$163,673	$171,810
Operating Cash Flow (BIT)		$116,245	$128,219	$134,612	$141,354	$148,445	$155,884	$163,673	$171,810
· Depreciation		$88,600	$165,387	$143,335	$124,224	$107,661	$93,306	$63,841	$63,841
· Interest on Debt		$0	$0	$0	$0	$0	$0	$0	$0
Taxable Income		$27,645	($37,168)	($8,723)	$17,130	$40,784	$62,578	$99,832	$107,969
· Income Tax at: 40.0%		$11,058	($14,867)	($3,489)	$6,852	$16,314	$25,031	$39,933	$43,188
Net Income		$16,587	($22,301)	($5,234)	$10,278	$24,470	$37,547	$59,899	$64,781
+ Depreciation		$88,600	$165,387	$143,335	$124,224	$107,661	$93,306	$63,841	$63,841
Debt Repayment		$0	$0	$0	$0	$0	$0	$0	$0
Investment (Less Debt Princ	($1,329,001)								
Working Capital	$0								
· Salvage Value									
fter-Tax Cashflow	($1,329,001)	$105,187	$143,086	$138,101	$134,502	$132,131	$130,853	$123,740	$128,622
umulative Cashflow	($1,329,001)	($1,223,814)	($1,080,728)	($942,627)	($808,125)	($675,994)	($545,141)	($421,401)	($292,779)
iscounted Cashflow	($1,329,001)	$90,678	$106,336	$88,475	$74,284	$62,909	$53,708	$43,783	$39,233

	Years 1 - 10	Years 1- 15
et Present Value	($702,855)	($587,346)
ternal Rate of Return	0%	6%
ayback	11 4 years	

Project: Whitewater/Fiber Reuse Project

page 6

Profitability Analysis (continued)

Date: 11/4/91

		9	10	11	12	13	14	15
Operating Year Number		9	10	11	12	13	14	15
Escalation Factor		1.552	1.630	1.712	1.798	1.888	1.982	2.081
REVENUES								
Revenue (production rate or value)		$0	$0	$0	$0	$0	$0	$0
Marketable By-products		$0	$0	$0	$0	$0	$0	$0
Annual Revenue		$0	$0	$0	$0	$0	$0	$0
OPERATING (COSTS)/SAVINGS								
Raw Materials/Supplies		$239,008	$251,020	$263,648	$276,892	$290,752	$305,228	$320,474
Waste Management		$0	$0	$0	$0	$0	$0	$0
Utilities		($53,754)	($56,455)	($59,295)	($62,274)	($65,391)	($68,647)	($72,075)
Labor		($4,842)	($5,086)	($5,341)	($5,610)	($5,891)	($6,184)	($6,493)
Other		$0	$0	$0	$0	$0	$0	$0
Regulatory Compliance		$0	$0	$0	$0	$0	$0	$0
Insurance		$0	$0	$0	$0	$0	$0	$0
Maintenance		$0	$0	$0	$0	$0	$0	$0
Overhead		$0	$0	$0	$0	$0	$0	$0
Labor Burden		$0	$0	$0	$0	$0	$0	$0
Liability		$0	$0	$0	$0	$0	$0	$0
Total Operating (Costs)/Savings		$180,412	$189,479	$199,012	$209,008	$219,470	$230,397	$241,906
CAPITAL COSTS								
Investment								
Book Value		$414,965	$351,124	$287,283	$223,442	$159,601	$95,761	$31,920
Tax Depreciation (by Straight-line, 1/2 yr)		$88,600	$88,600	$82,693	$82,693	$82,693	$82,693	$82,693
Tax Depreciation (by Double DB, 1/2 yr)		$63,841	$55,329	$46,817	$38,304	$29,792	$21,280	$12,768
Tax Depreciation (by DDB switching to SL		$63,841	$63,841	$63,841	$63,841	$63,841	$63,840	$63,841
Debt Balance		$0	$0	$0	$0	$0	$0	$0
Interest Payment at :	12.0%	$0	$0	$0	$0	$0	$0	$0
Principal Repayment		$0	$0	$0	$0	$0	$0	$0
CASHFLOW								
Revenues		$0	$0	$0	$0	$0	$0	$0
+ Operating (Costs)/Savings		$180,412	$189,479	$199,012	$209,008	$219,470	$230,397	$241,906
Operating Cash Flow (BIT)		$180,412	$189,479	$199,012	$209,008	$219,470	$230,397	$241,906
- Depreciation		$63,841	$63,841	$63,841	$63,841	$63,841	$63,840	$63,841
- Interest on Debt		$0	$0	$0	$0	$0	$0	$0
Taxable Income		$116,571	$125,638	$135,171	$145,167	$155,629	$166,557	$178,065
- Income Tax at:	40.0%	$46,628	$50,255	$54,068	$58,067	$62,252	$66,623	$71,226
Net Income		$69,943	$75,383	$81,103	$87,100	$93,377	$99,934	$106,839
+ Depreciation		$63,841	$63,841	$63,841	$63,841	$63,841	$63,840	$63,841
- Debt Repayment		$0	$0	$0	$0	$0	$0	$0
- Investment (Less Debt Princ.)								
- Working Capital								
+ Salvage Value								$0
After-Tax Cashflow		$133,784	$139,224	$144,944	$150,941	$157,218	$163,774	$170,680
Cumulative Cashflow		($158,995)	($19,771)	$125,173	$276,114	$433,332	$597,106	$767,786
Discounted Cashflow		$35,179	$31,560	$28,325	$25,428	$22,832	$20,504	$18,421

APPENDIX A-1
COATED FINE PAPER COMPANY

Project 1 - TCA

WHITE WATER AND FIBER REUSE PROJECT

Project: Whitewater/Fiber Reuse Project — CAPITAL COSTS — page 1

Date: 11/4/91

Capital Costs	Cost	Totals	Ref.	Notes:
Purchased Equipment				
Equipment - Phase I	$330.853			Saveall and associated pumps and tanks
Equipment - Phase II	$15.132			White water pump
Sales tax				
Price for Initial Spare Parts		$345.985		
Materials				
Piping	$183.690			
Electrical	$67.721			
Instruments	$68.465			
Structural	$54.946			
Insulation/Piping		$374.822		
Utility Connections and New Utility Systems				
Electricity				
Steam				
Cooling Water				
Process Water				
Refrigeration				
Fuel (Gas or Oil)				
Plant Air				
Inert Gas		$0		
Site Preparation				
Demolition. Clearing. etc		$0		
Installation				
Vendor				
Contractor	$397.148			
In-house Staff		$397.148		
Engineering/Contractor (In-house & Outside)				
Planning				
Engineering	$166.946			15% of materials and labor
Procurement				
Consultants	$44.100	$211.046		Consultant feasibility study. 1989

Project: Whitewater/Fiber Reuse Project

Date:

Capital Costs (continued)	Cost	Totals	Ref.	Notes:
Start-up/Training				
Vendor/Contractor				
In-house				
Trials/Manufacturing Variances				
Training		$0		
Contingency				
	$140.403	$0		10% of materials, labor, and engineering
Permitting				
Fees				
In-house Staff		$0		
Initial Charge of Catalysts and Chemicals				
		$0		
Working Capital (Raw Materials, Product, Inventory, Materials and Supplies)				
		$0		
Salvage Value				
		$0		

Project: Whitewater/Fiber Reuse Project
Operating Costs

Costs are positive
Savings and revenues are negative

Date: 11/4/91

CURRENT PROCESS Item	Annual Cost ($/year)	Total	Ref	ALTERNATIVE PROCESS Item	Annual Cost ($/year)	Total	Ref	Difference (Cur. - Alt.)
Raw Materials/Supplies				**Raw Materials/Supplies**				
Fiber loss (includes transport)	$457.000		1a	Fiber loss (includes transport)	$91.500		1b	
Filler loss (includes transport)	$79.700		1a	Filler loss (includes transport)	$16.000		1b	
				Flocculating agents for saveall	$275.200		1c	
		$536.700				$382.700		$154.000
Waste Management *(disposal, hauling, insurance, storage, etc.)*				**Waste Management** *(disposal, hauling, insurance, storage, etc.)*				
		$0				$0		$0
Utilities (elec.. steam. water. sewerage)				Utilities (elec.. steam. water. sewerage)				
Freshwater Pump. and Treat.	$168.630		2a	Freshwater Pump. and Treat.	$56.210		2b	
Freshwater Heating	$565.850		2c	Freshwater Heating	$188.600		2d	
Wastewater Pumping	$210.000		2e	Wastewater Pumping	$157.500		2f	
Wastewater Treatment	$273.000		2g	Wastewater Treatment	$204.765		2h	
		$1.217.480		Elec. for Equipment Operation	$102.870	$709.945	2i	$507.535
or				Labor				
				Equipment Operation	$3.120		3a	
		$0				$3.120		($3.120)
Other				Other				
		$0				$0		$0
Regulatory Compliance *(manifesting, reporting, monitoring, testing, labeling, etc.)*				Regulatory Compliance *(manifesting, reporting, monitoring, testing, labeling, etc.)*				
		$0				$0		$0
Insurance				Insurance				
		$0				$0		$0
Revenues				Revenues				
		$0				$0		$0
Revenues - Marketable By-products				Revenues - Marketable By-products				
		$0				$0		$0
Total		$1.754.180				$1.095.765		$658.415

Project: Whitewater/Fiber Reuse Project

Date: 11/4/91

CAPITAL AND OPERATING COST SUMMARY

Capital Costs	$
Equipment	$345,985
Materials	$374,822
Utility Connections	$0
Site Preparation	$0
Installation	$397,148
Engineering/Contractor	$211,046
Start-up/Training	$0
Contingency	$0
Permitting	$0
Initial Catalysts/Chemicals	$0
Depreciable Capital	$1,329,001
Working Capital	$0
Subtotal	$1,329,001
Interest on Debt	$0
Total Capital Requirement	$1,329,001
Salvage Value	$0
% Equity	100%
% Debt	0%
Interest Rate on Debt, %	12.0%
Debt Repayment, years	5
Equity Investment	$1,329,001
Debt Principal	$0
Interest on Debt	$0
Total Financing	$1,329,001
Depreciation period	15
Income Tax Rate, %	40%
Escalation Rates, %	5.0%
Cost of Capital (for NPV)	16.00%

Operating Costs	%	Current	Alternative	Difference (Cur. - Alt)
Raw Materials/Supplies		$536,700	$382,700	$154,000
Waste Management		$0	$0	$0
Utilities		$1,217,480	$709,945	$507,535
Labor		$0	$3,120	($3,120)
Other		$0	$0	$0
Regulatory Compliance		$0	$0	$0
Insurance		$0	$0	$0
Maintenance - % of Capital				
Labor	0%		$0	$0
Materials	0%		$0	$0
Overhead - (% of Labor)	0%	$0	$0	$0
Labor Burden	0%	$0	$0	$0
Revenues		$0	$0	$0
Revenues - Marketable By-products		$0	$0	$0
TOTAL		$1,754,180	$1,095,765	$658,415

Future Liability	Ref.	Year Expected	Cost (Curr. - Alter.)
(Year expected = 1,2,3, etc.)			

Project: Whitewater/Fiber Reuse Project

Profitability Analysis

Date: 11/4/91

Operating Year	0	1	2	3	4	5	6	7	8
..lation Factor	1.000	1.050	1.103	1.158	1.216	1.277	1.341	1.408	1.478
REVENUES									
Revenue (prod. rate or value)		$0	$0	$0	$0	$0	$0	$0	$0
Marketable By-products		$0	$0	$0	$0	$0	$0	$0	$0
Annual Revenue		$0	$0	$0	$0	$0	$0	$0	$0
OPERATING (COSTS)/SAVINGS									
Raw Materials/Supplies		$154,000	$169,862	$178,332	$187,264	$196,658	$206,514	$216,832	$227,612
Waste Management		$0	$0	$0	$0	$0	$0	$0	$0
Utilities		$507,535	$559,811	$587,726	$617,163	$648,122	$680,604	$714,609	$750,137
Labor		($3,120)	($3,441)	($3,613)	($3,794)	($3,984)	($4,184)	($4,393)	($4,611)
Other		$0	$0	$0	$0	$0	$0	$0	$0
Regulatory Compliance		$0	$0	$0	$0	$0	$0	$0	$0
Insurance		$0	$0	$0	$0	$0	$0	$0	$0
Maintenance		$0	$0	$0	$0	$0	$0	$0	$0
Overhead		$0	$0	$0	$0	$0	$0	$0	$0
Labor Burden		$0	$0	$0	$0	$0	$0	$0	$0
Liability		$0	$0	$0	$0	$0	$0	$0	$0
Total Operating (Costs)/Savings		$658,415	$726,232	$762,445	$800,633	$840,796	$882,934	$927,048	$973,138
CAPITAL COSTS									
Investment	$1,329,001								
Book Value	$1,329,001	$1,240,401	$1,075,014	$931,679	$807,455	$699,794	$606,488	$542,647	$478,806
Tax Depreciation (by Straight-line, 1/2 yr)		$88,600	$88,600	$88,600	$88,600	$88,600	$88,600	$88,600	$88,600
Tax Depreciation (by Double DB, 1/2 yr)		$88,600	$165,387	$143,335	$124,224	$107,661	$93,306	$80,865	$72,353
Depreciation (by DDB switching to SL)		$88,600	$165,387	$143,335	$124,224	$107,661	$93,306	$63,841	$63,841
Debt Balance	$0	$0	$0	$0	$0	$0	$0	$0	$0
Interest Payment at : 12.0%		$0	$0	$0	$0	$0	$0	$0	$0
Principal Repayment		$0	$0	$0	$0	$0	$0	$0	$0
CASHFLOW									
Revenues		$0	$0	$0	$0	$0	$0	$0	$0
Operating (Costs)/Savings		$658,415	$726,232	$762,445	$800,633	$840,796	$882,934	$927,048	$973,138
Operating Cash Flow (BIT)		$658,415	$726,232	$762,445	$800,633	$840,796	$882,934	$927,048	$973,138
Depreciation		$88,600	$165,387	$143,335	$124,224	$107,661	$93,306	$63,841	$63,841
Interest on Debt		$0	$0	$0	$0	$0	$0	$0	$0
Taxable Income		$569,815	$560,845	$619,110	$676,409	$733,135	$789,628	$863,207	$909,297
Income Tax at: 40.0%		$227,926	$224,338	$247,644	$270,564	$293,254	$315,851	$345,283	$363,719
Net Income		$341,889	$336,507	$371,466	$405,845	$439,881	$473,777	$517,924	$545,578
Depreciation		$88,600	$165,387	$143,335	$124,224	$107,661	$93,306	$63,841	$63,841
Debt Repayment		$0	$0	$0	$0	$0	$0	$0	$0
Investment (Less Debt Princ	($1,329,001)								
Working Capital	$0								
Salvage Value									
After-Tax Cashflow	($1,329,001)	$430,489	$501,894	$514,801	$530,069	$547,542	$567,083	$581,765	$609,419
Cumulative Cashflow	($1,329,001)	($898,512)	($396,618)	$118,183	$648,252	$1,195,794	$1,762,877	$2,344,642	$2,954,061
Discounted Cashflow	($1,329,001)	$371,111	$372,989	$329,811	$292,752	$260,692	$232,755	$205,846	$185,888

	Years 1 - 10	Years 1- 15
Present Value	$1,242,536	$1,808,384
Internal Rate of Return	36%	38%
Payback	2.0 years	

Project: Whitewater/Fiber Reuse Project

Profitability Analysis (continued)

Date: 11/4/91

Operating Year Number	9	10	11	12	13	14	15
Escalation Factor	1.552	1.630	1.712	1.798	1.888	1.982	2.081
REVENUES							
Revenue (production rate or value)	$0	$0	$0	$0	$0	$0	$0
Marketable By-products	$0	$0	$0	$0	$0	$0	$0
Annual Revenue	$0	$0	$0	$0	$0	$0	$0
OPERATING (COSTS)/SAVINGS							
Raw Materials/Supplies	$239,008	$251,020	$263,648	$276,892	$290,752	$305,228	$320,474
Waste Management	$0	$0	$0	$0	$0	$0	$0
Utilities	$787,694	$827,282	$868,900	$912,548	$958,226	$1,005,934	$1,056,180
Labor	($4,842)	($5,086)	($5,341)	($5,610)	($5,891)	($6,184)	($6,493)
Other	$0	$0	$0	$0	$0	$0	$0
Regulatory Compliance	$0	$0	$0	$0	$0	$0	$0
Insurance	$0	$0	$0	$0	$0	$0	$0
Maintenance	$0	$0	$0	$0	$0	$0	$0
Overhead	$0	$0	$0	$0	$0	$0	$0
Labor Burden	$0	$0	$0	$0	$0	$0	$0
Liability	$0	$0	$0	$0	$0	$0	$0
Total Operating (Costs)/Savings	$1,021,860	$1,073,216	$1,127,207	$1,183,830	$1,243,087	$1,304,978	$1,370,161
CAPITAL COSTS							
Investment							
Book Value	$414,965	$351,124	$287,283	$223,442	$159,601	$95,761	$31,920
Tax Depreciation (by Straight-line, 1/2 yr)	$88,600	$88,600	$82,693	$82,693	$82,693	$82,693	$82,693
Tax Depreciation (by Double DB, 1/2 yr)	$63,841	$55,329	$46,817	$38,304	$29,792	$21,280	$12,768
Tax Depreciation (by DDB switching to SL	$63,841	$63,841	$63,841	$63,841	$63,841	$63,840	$63,841
Debt Balance	$0	$0	$0	$0	$0	$0	$0
Interest Payment at : 12.0%	$0	$0	$0	$0	$0	$0	$0
Principal Repayment	$0	$0	$0	$0	$0	$0	$0
CASHFLOW							
Revenues	$0	$0	$0	$0	$0	$0	$0
+ Operating (Costs)/Savings	$1,021,860	$1,073,216	$1,127,207	$1,183,830	$1,243,087	$1,304,978	$1,370,161
Operating Cash Flow (BIT)	$1,021,860	$1,073,216	$1,127,207	$1,183,830	$1,243,087	$1,304,978	$1,370,161
- Depreciation	$63,841	$63,841	$63,841	$63,841	$63,841	$63,840	$63,841
- Interest on Debt	$0	$0	$0	$0	$0	$0	$0
Taxable Income	$958,019	$1,009,375	$1,063,366	$1,119,989	$1,179,246	$1,241,138	$1,306,320
- Income Tax at: 40.0%	$383,208	$403,750	$425,346	$447,996	$471,698	$496,455	$522,528
Net Income	$574,811	$605,625	$638,020	$671,993	$707,548	$744,683	$783,792
+ Depreciation	$63,841	$63,841	$63,841	$63,841	$63,841	$63,840	$63,841
- Debt Repayment	$0	$0	$0	$0	$0	$0	$0
- Investment (Less Debt Princ.)							
- Working Capital							
+ Salvage Value							$0
After-Tax Cashflow	$638,652	$669,466	$701,861	$735,834	$771,389	$808,523	$847,633
Cumulative Cashflow	$3,592,713	$4,262,179	$4,964,040	$5,699,874	$6,471,263	$7,279,786	$8,127,419
Discounted Cashflow	$167,935	$151,757	$137,156	$123,961	$112,026	$101,223	$91,482

APPENDIX A-1 - COATED FINE PAPER MILL

Project 1 - Whitewater Recycling Project for:

Costing and Financial Analysis Documentation

Phase I - Installation of Saveall, and
Phase II - Separation of Paper Machine No 9 and 11 White Water Systems

A. Capital Costs

Note: All costs, originally reported in 1989 dollars, have been inflated by 5% per year, and marked-up by 12.5% (engineering design estimates were +/- 25%.

See Page 1 of Financial Analysis Report.

B. Operating Costs

Key:
M - thousand
MM - million
GD - gallons/day

Current Process

1. Raw Materials

1.a. Fiber and Filler Loss (includes freight)

Estimated solids loss - 1,500 tons/yr
Whitewater solids = 67% fiber and 33% filler

Fiber loss:
1,500 tons/yr x 0.67 = 1005 tons/yr
Fiber cost = $445/ton
Cost of lost fiber = 1005 tons/yr x $455/ton = $457,275/yr

Filler loss:
1,500 tons/yr x 0.33 = 495 tons/yr
Filler cost = $161/ton
Cost of lost filler = 495 tons/yr x $161/yr = $79,695/yr

White Water and Fiber Reuse

1.b. Fiber and Filler Loss (includes freight)

Estimated recoverable solids by Phases I & II - 1,200 tons/yr
Estimated solids loss - 1,500 - 1,200 tons/yr = 300 tons/yr

Fiber loss:
300 tons/yr x 0.67 = 201 tons/yr
Cost of lost fiber = 201 tons/yr x $455/ton = $91,455/yr

Filler loss:
300 tons/yr x 0.33 = 99 tons/yr
Cost of lost filler = 99 tons/yr x $161/ton = $15,939/yr

1c. Flocculating Agents for Saveall

Avg. whitewater flow through saveall - 600 GPM (864 MGD)

Chemical Costs:
Cationic polymer cost - $0.056/Mgal
Anionic polymer cost - $0.035/Mgal
total $0.91/Mgal

864 MGD x $0.91/Mgal x 350 days/yr = $275,200/yr

Current

2. **Utilities**

2.a. Freshwater Pumping and Treatment

Average annualized freshwater use - 1.5MMGD

Chemicals Costs:

	$/MGD
Alum	0.025
Sodium aluminate	0.009
Polymer	0.034
Sodium hypochorite	0.003
Total $	**0.071**

Energy Costs:

	$/period*	$/MGD
Variable freshwater pumping	$133,098	$0.234
Misc.	1,479	0.0026
Total	$134,577	**$0.237**

*period = 8 months, 1990
total use freshwater - 566,460MGD

Chemicals + Energy costs = $0.308/MMGD

1.5MMGD x 365 days/yr x ($0.308x1000)/MMGD = $168,630

2.c. Freshwater Heating

1.5MMGD freshwater comes in at 57°, must be raised to 95°

1.5MMGD x 1 Btu/lb-°F x 8.4 lb/gal x (95 - 57°F) = 4.788×10^{8} Btu/day

Fuel cost (No. 6) = $0.39/gal
Estimated boiler efficiency = 82.5%

4.788×10^{8} Btu/day x 1 gal No.6 fuel/1.4×10^{5} Btu x $0.39/gal x 1/0.825 x 350 days/yr = $565,850/yr

2.e. Wastewater Pumping

4MMGD x 350 days/yr x $150/MMGD = $210,000/yr

Whitewater and Fiber Reuse

2.b. Freshwater Pumping and Treatment

Estimated freshwater use - 0.5MMGD

0.5MMGD x 365days/yr x ($0.308 x 1000)/: $56,210/

2.d. Freshwater Heating

0.5MMGD freshwater ------> $188,600/yr

2.f. Wastewater Pumping

3MMGD ------> = $157,500/yr

Current

2.g. Wastewater Treatment

- Average, annualized wastewater discharge rate - 4.0 MMGD
- Wastewater treatment cost - $187/MMGD

4.0MMGD x 365 days/yr x $187/MMGD = $273,000/yr.

3. Labor

Whitewater and Fiber Reuse

2.h. Wastewater Treatment

-Average, annualized wastewater discharge rate - 3.0MMGD

3.0MMGD x 365 days/yr x $187/MMGD = $204,765/yr

2.i. Energy for Equipment Operation

Electricity cost = $0.08/kWh

Phase I - New Equipment:	HP
Drive Pump	1 HP
Scoop Pump	1
Pressure Pump	40
Feed Pump	20
Recovered Stock Chest Agitator Motor	5
Recovered Stock Chest Pump	25
Clear White Water Chest Pump	125
Phase II - New Equipment:	
White Water Surge Pump	125
Total	342 HP

342 HP x 0.6 x 0.746 kW/HP x 8,400 hr/yr x $0.08/kWh = $102,870/yr

3.a. Equipment Operation - Saveall

4 hours/week labor
$15/hour - fully loaded wage rate

4 hrs/wk x 52 wk/yr x $15/hr = $3,120/yr

APPENDIX A-2

PAPER COATING MILL

Company Background

This mill employs approximately 900 people in its research center, corporate office, and manufacturing plants. The mill has extensive facilities for coating, laminating and converting a variety of (purchased) film, paper and foil substrates. Products made at this facility find use in a variety of industries, including electronics, graphic arts, publishing, engineering, and instant photography.

Before March 1991, this mill was a division of a publicly held, large multinational corporation. The division was further divided into three sub-divisions that reflected product lines: photographic and specialty coated materials used in imaging, electronics, graphic arts and other applications; paper and films for use in pen and electrostatic plotters, diazo printing and xerographic copying; and plastic-coated, non woven materials used for book coverings, diaries, albums, menus and other products.

Today, the mill is held privately by a group of investors who also own several other mills that were formerly part of the same corporation. Approximately 50% of the companies volume comes from coated film production and the remainder from coated papers.

As of March 1991, the mill had not yet changed hands, and the effect of the change on the financial and environmental practices of the firm were largely unknown. Therefore, this case study primarily reflects the procedures used under the former ownership, though we do refer to several changes in capital budgeting anticipated by management.

Environmental Management

Environmental affairs in the paper coating business are managed by an Environmental, Safety, and Health Manager (ES&H) who reports to the site manager who, in turn, reports to the president of the business. A manager of safety, a manager of health, and several environmental engineers report to the ES&H. Manager, including a senior environmental engineer, responsible for regulatory compliance and environmental community and public relations. The primary person responsible for environmental affairs in the film coating business is the Manager of Research and Development and Environmental. This manager relies on staff resources within the paper coating business for support on environmental projects.

Environmental management characterized the mill as "operationally driven--faster, better, cheaper, aiming to maximize revenue dollars per machine hour; while at the same time seeking to maximize environmental protection". Though they consider waste reduction projects to be an important component of their environmental strategy, the companies operational goals are seen as driving environmental protection strategies toward end-of-pipe solutions. The business generally considers an end-of-pipe approach as less threatening to product quality and production rates. Several other barriers to implementation of such projects: high cost; inability to find the technology--equipment and materials--to implement certain measures; difficulty in recognizing and focusing on the "right" project; insufficient staff resources to identify and justify prevention projects; and an inability to justify long-term projects.

The last barrier was illustrated by a description of a long-considered end-of-pipe wastewater filtration project designed to remove coating solids from wastewater prior to discharge to the POTW. Though the mills wastewater is in compliance with the current, POTW discharge standards, the sewering of unfiltered wastewater to the POTW has, on occasion caused discoloration of POTW's discharge to the river. While there was a recognition that relations with the POTW and the town would be improved by implementing the filtration project, the company began to seriously pursue the project when they made the decision to begin the conversion to aqueous coating.

Two and a half years ago, the mill made a pledge to the surrounding community to reduce VOC emissions by 50%. Since that time, the mill has invested several million dollars to cut VOC emissions from its solvent-based coating operations through a combination of VOC incinerator and solvent recovery system improvements, and source reduction measures (including conversion of some coating to aqueous).[5] Despite these reductions, the mill remains a significant VOC emitter in the region.

Capital Budgeting and Project Financial Analysis

Capital projects fall into three categories: profit sustaining--must do maintenance and regulatory compliance projects; profit adding--cost reduction projects; and expansion projects--projects that increase market share. Profit adding projects generally have to pass a 50% Return on Assets Employed (ROAE)[6] hurdle rate. Projects that fall into the profit sustaining category (e.g. the majority of environmental projects), are not subjected to the ROAE hurdle rate.[7] Since there are often many projects within this category competing for capital, environmental management would like to shift environmental projects into the profit adding category by showing a return for the project. They often try to represent these projects as "operational projects" rather than environmental projects.

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[5] The mill estimates that VOC emissions have been reduced from 1,200 tons/yr in 1989, to 635 tons/year in 1991. A small percentage of the reduction is a result of a decline in production.

[6] This firm calculates ROAE as follows:

(income after depreciation x 100)/(fixed + working capital)

and

ROI as follows:

(income after tax and depreciation x 100)/(fixed capital)

[7] For the next year or two, as a result of the change in ownership, the mill will make investment decisions on the basis of cash flow from the investment, rather than ROAE.

However, they generally find it difficult to develop profit adding justifications for environmental projects that can pass the 50% ROAE hurdle.

Project ideas are typically initiated by middle level managers within the mill. Once initiated, the project is assigned to an engineer who will prepare an Appropriations Request (A.R.) containing: a discussion of the need for the project; a description of the proposed technical approach and rationale for approach; proposed process outline and schematics; and project cost estimate. Based on the cost estimate, an accountant within the appropriate operations group develops the project financial analysis. Mill engineers do not include non-disposal waste management costs, pollution control costs, or regulatory compliance costs in project cost estimates. Raw material and energy costs are typically included. Potential liability costs associated with waste disposal and penalties and fines are commonly considered in a qualitative fashion in the A.R.

Perspectives on TCA

We encountered a great deal of enthusiasm, within the environmental department, for the objectives of, and approaches to TCA. This enthusiasm was demonstrated by their eagerness to subject one of their projects to an in-depth TCA study. Several possible barriers, however, to TCA adoption within the company were cited: difficulty in changing the practices of the company as a whole when the need for more and better environmental investments is not uniformly understood; difficulty in modifying the A.R. format and procedure to include less-obvious environmental costs; difficulty in obtaining the necessary technical and cost data for a TCA; and extra time involved in preparing a more thorough TCA project analysis (one Environmental Manager stated at the conclusion of the in-depth project analysis, that he could only justify the time necessary to develop a TCA for projects with a capital cost of $2 million or more).

Of particular interest to the company was the inclusion of developmental and start-up costs in project analyses. They would like to be able to better predict, and include in a project analysis, the costs associated with laboratory testing (this mill must match coating colors to color standards), and lost productivity due to pilot tests and the "learning curve" associated with virtually all process changes.

As we learned in the in-depth project analysis described below, the Company's procedure for allocating certain costs to product lines may work against the objectives of a TCA approach. The company allocates solvent recovery costs to the paper and film coating businesses on the basis of quantity of coating prepared. While the paper coating prevention project analyzed will reduce solvent use and therefore the solvent flow to the recovery system, the current allocation system will not be sensitive to this effect. Management speculated that even if a decision is made to change the allocation system, for various business reasons this coated paper line may still be required to subsidize the recovery system in excess of its proportional share.

Project Background

The paper coating business produces a line of coated paper that is used for book publishing, binders, labels, menus and other related applications. The business purchases the paper, applies a pigmented base coat and clear top coat, embosses, cuts and ships the paper to its customers. While coating used to produce colored grades contains solvent and a small amount of heavy metal-based pigment, white grades have been made with an aqueous-based coating for the last several years. The mill has long considered converting colored grades to aqueous, and more recently to an aqueous/heavy metal-free coating, for several reasons (as cited in a recent memo): "develop manufacturing flexibility"--to position themselves to respond to solvent-free/heavy metal-free market demand[8]; "reduce environmental impacts"--by reducing VOC emissions, and "improve health and safety"--by reducing worker exposure to fugitive solvent emissions and hazards associated with nitrocellulose (a solvent coating ingredient) handling and storage.

After expending $222,000 in capital in 1988 to begin the conversion to aqueous, the mill halted the project for two reasons: possible relocation of the plant and difficulty in meeting product specifications during aqueous trial runs. In September of 1990, the business resumed the process of converting the base coat mixture for colored grades to aqueous/heavy metal-free[9], and plans to continue until 80% of its production is converted. While their goal is 80% conversion by mid 1993, progress is slower than planned. Reasons cited are: capital constraints (exacerbated by the change in ownership), concern over higher raw material costs for aqueous versus solvent coating; concerns over increased aqueous wastewater; slower than expected manufacturing rates (i.e. tons per machine-hour) for aqueous; and labor resource constraints.

With a TCA for the aqueous project, Environmental Management hoped to improve the financial picture of the conversion project to overcome the economic barriers and shorten the conversion timeline.

Project Description

Currently, the majority of colored, coated papers are produced in two steps, as illustrated in Figure A-2.1. First the paper is coated with a pigmented base coat, consisting of a variety of solvents, nitrocellulose, clay, calcium carbonate, and in approximately 50% of colored grades contain a small amount of lead, chromium, and cadmium-based pigments. The base-coated paper is run through a dryer where most of the solvent is driven off and the remaining materials set on the paper. In the second step, the paper is coated again with a top coat of solvent and nitrocellulose. The paper is dried again and rolled onto a reel; ready for converting. The vaporized solvent from the first and second dryers is collected and sent to a solvent recovery system. In the recovery process, vaporized solvent is adsorbed onto a carbon filter bed, distilled to separate and purify the different types of solvent, and drummed for reuse in the base and top coat mix, and for washing operations (off-specification solvents are also reused for washing). Waste solvents generated in equipment washing are sent directly to the distillation system for recovery. The distillation system bottoms (or "still bottoms"), consist of residual solvent, coating pigments, and other impurities carried into the recovery system. Approximately 2,220 drums per year of hazardous still bottom waste are generated and incinerated off-site.

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[8] The European Economic Committee is expected to set a lead-free packaging standard which would apply to the products manufactured at this plant.

[9] The term "aqueous/heavy metal-free" base coat is used functionally, not absolutely. The new aqueous coating contains small amount of solvent--4%--and, some barium, but does not contain lead, chromium, and cadmium found in the solvent-based coating.

VOC emissions are generated at three points in the process. VOCs not recovered in the solvent recovery system are sent through 3 high efficiency tail gas combusters, and residual VOCs are emitted into the atmosphere. Fugitive VOCs from base coat mixing and from the coating operation are emitted into the plant and then ultimately to the atmosphere.

The aqueous coating process, pictured in Figure A-2.2, involves the basic steps described for solvent coating, with several modifications. The base coat consists of water, acrylic latex resin, and a small amount of ammonia and solvent; pigments are heavy-metal free (with the exception of barium). Currently, the wash water waste generated in the base coating section is treated (i.e. flocculated and settled) in holding tanks prior to discharge to the POTW. If a recently submitted A.R is approved, the waste water will be sent to a new ultrafiltration system before discharge. Under this system the water fraction will be sewered, and the solid fraction will either be reused in the coating process or landfilled as a non-hazardous waste. Vaporized solvent and wash solvent from the second dryer and top coater, respectively, will be sent to the solvent recovery system.

Water-based coating has a shorter shelf-life than solvent-based coating (3 months compared to 5 years) since it is vulnerable to microbiological contamination. The mill expects approximately 100 drums of aqueous coating each year to spoil. The mill will lose the raw material value of this product and will pay for its management and disposal. In addition, unlike solvent coating, aqueous coating can freeze in cold weather. Therefore, the mill must install a new steam heating system in the coating storage area.

Under the aqueous system, emissions of VOCs from the coating process will be reduced by 209 tons/year, but not completely eliminated. Solvent will still be used in the top coat, and a small amount of solvent (4%) will be used in the pigmented coating mixture. Fugitive emissions of ammonia from the base coat mix process and from coating will be emitted into the plant and then to the atmosphere. Approximately 810 fewer drums of hazardous still bottoms will be generated and disposed.

To convert this coating system to aqueous will have to make several capital investments that total to approximately $654,000 (1991 dollars). They are summarized below:

1. Waste water treatment system - ultrafiltration;
2. Coater upgrade (to increase drying capability);
3. Drum shed heating system; and
4. Mix room and coating machine modifications (implemented 1987 to 1990).

Figure A-2.1 SOLVENT/HEAVY METAL PAPER COATING

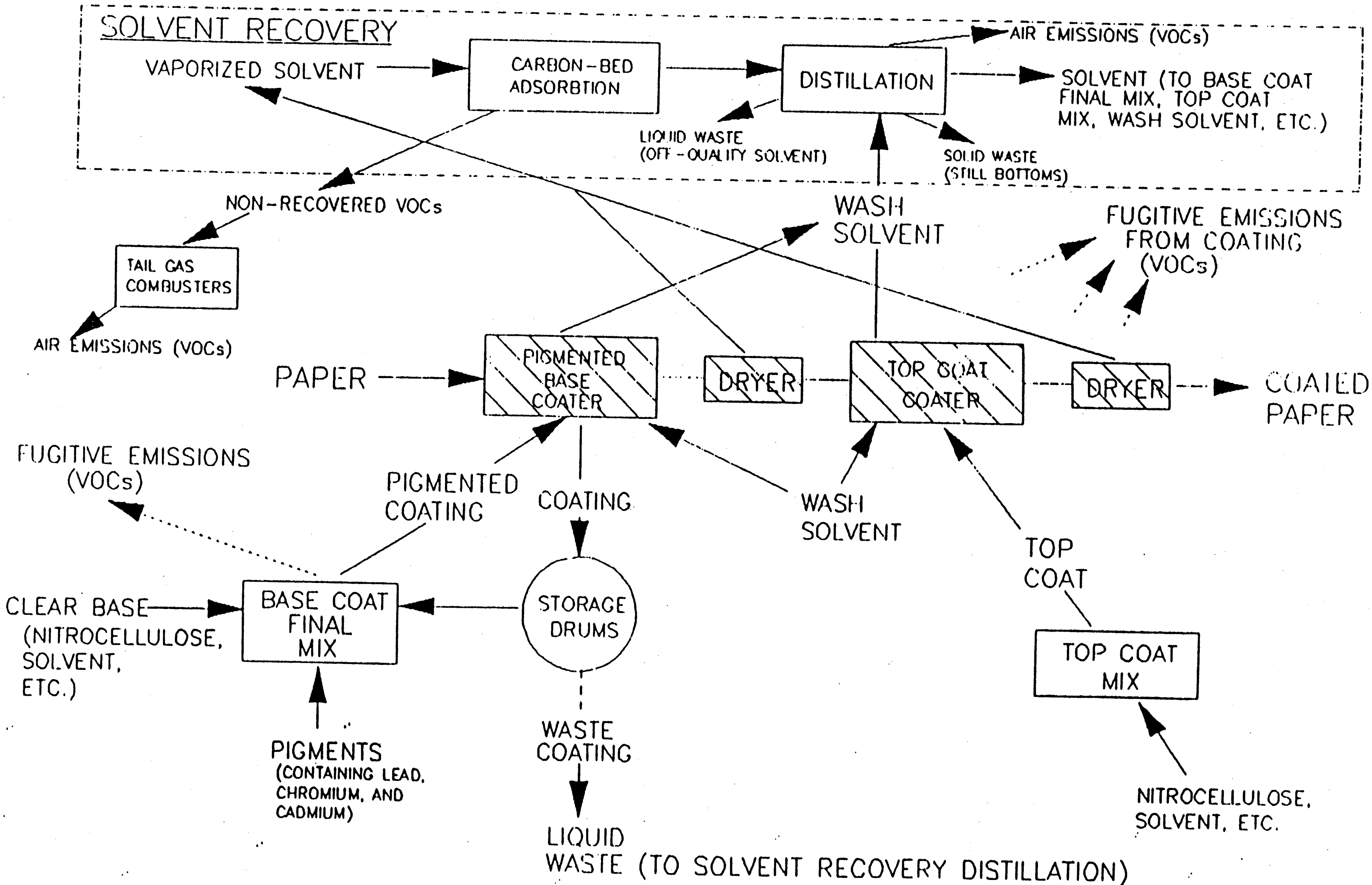
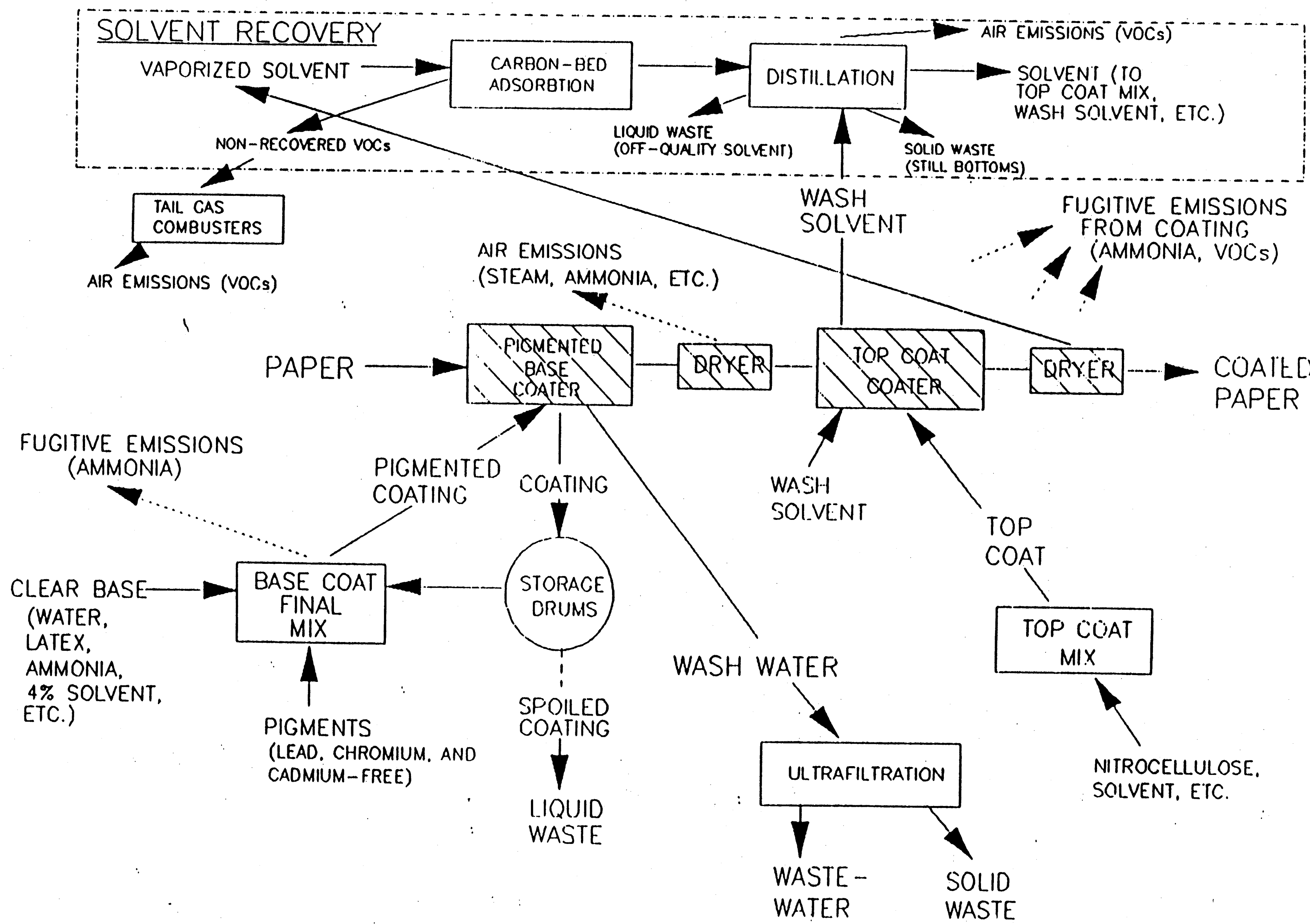


Figure A-2.2 AQUEOUS/HEAVY METAL-FREE PAPER COATING



The conversion will reduce costs related to waste management, solvent recovery, and regulatory compliance; increase utility costs; and have a mixed effect on raw material costs. These are described below:

Waste Management. Under the aqueous coating system, fewer drums of hazardous still bottom waste will be generated each year. In addition to lowering waste disposal costs, the mill expects costs associated with drum handling, storage, transportation, and state hazardous waste-end fees to be reduced. Two new waste streams will be created by the change -- spoiled coating, and concentrated waste from the wastewater ultrafiltration system -- offsetting the gains made at the solvent recovery plant.

Regulatory Compliance. Fewer drums mean fewer manifests to fill out and manage, and fewer drums to label and inspect that translates into a labor cost savings to the mill. The mill also expects to reduce laboratory analysis costs owing to an expected cut in waste generation. However, a new wastewater sampling and analysis regimen will be required for the ultrafiltration system, adding a new cost to the aqueous process.

Despite anticipated reductions in VOC emissions and waste generation, the mill does not expect to realize a reduction in RCRA, TRI and state TUR reporting costs.

Solvent Recovery. Solvent from this product line constitutes 60% of the flow of solvent to the recovery system; the balance coming from plastic film coating. It is estimated that this line will send only 10% of its current solvent stream to the recovery system (top coat solvent) when the aqueous conversion is made. While this effect will result in a reduction in variable costs for the recovery system, fixed costs will be unchanged. However, since the mill currently runs two recovery units, they are considering either using the freed-up recovery capacity to capture fugitive VOC emissions or completely shutting down of one units.

Raw Materials. The higher solid content of aqueous coating requires fewer wet pounds of base coating, but the cost of heavy-metal free pigments drives the base coat cost up over that for solvent/heavy-metal. To achieve adequate protection of an aqueous base-coated sheet, greater coat weight of clear top coat is needed, driving up the top coat cost for the aqueous system. Controlled and fugitive solvent emission losses for the solvent system base and top coat constitute a loss of valuable raw material. These losses, i.e. costs will be reduced through aqueous conversion. Anticipated aqueous coating spoilage will result in the loss of the value of spoiled material. The net result of these financial effects on raw material costs is a somewhat higher cost for the aqueous system.

Utilities. Aqueous coating requires more energy for drying than solvent-based coating. The mill estimated that it will spend more each year for steam. Steam and electricity consumption will increase further for drum storage heating and for the ultrafiltration system.

Project Financial Analysis

In 1987, the mill developed an A.R. for the conversion of basecoat for color grades to aqueous. At that time, the mill was not considering a switch from heavy metal-based to non-heavy metal pigments. The A.R. cost estimate included the following items:

1. **Capital Costs**

a. Various mix room modifications
b. Various coating machine modifications
c. Wash water waste dilution system

2. **Operating Costs**

a. coating materials
b. wash solvents
c. hazardous waste disposal - wash still sludge
d. controlled and fugitive solvent emission losses

The A.R. reported the results of financial calculations as follows:[10]

Fixed Capital Required	$ 340,000
" " Return	$1,016,000
" " R.O.I.*	153.3%
" Payback*	0.61 Years

* R.O.I. and payback include tax effects

The A.R. contained an untitled section that stated:

"In addition to the cost savings associated with the aqueous conversion, the major reductions in levels of fugitive emissions, and amounts of solid hazardous waste going to landfill, is very positive from a regulatory and community standpoint."

This section also mentioned several other possible financial benefits (which were not monetized in the financial analysis), including possible shutdown of the solvent recovery process thereby eliminating energy costs.

Another section, titled "Safety/Health Impact of Converting From solvent to Aqueous Coatings" listed several improvements in plant "safety/industrial hygiene" that will result from the conversion, including:

I. Safety
A. Flammability
1. Minimize need for static control devices and procedures to maintain static free work environment.
2. Reduce risk of fire in chemical storage, mixing and coating areas.
3. Minimize need for explosion proof electrical systems in lacquer handling areas.

[10] This analysis was done prior to consideration of conversion from heavy metal to heavy metal-free pigments.

B. Material Handling

1. Nitrocellulose
   a. Minimize special storage requirements in the drum lot.
   b. Minimize special handling procedures for fire safety control.
   c. Minimize employee physical activity and fire risk when loosening and removing nitrocellulose from drums.
   d. Minimize special clean up activities to reduce threat of dried nitrocellulose.

C. Industrial Hygiene

1. Minimize employee exposure to organic vapors reducing health risks and need for IH monitoring and record keeping.
2. Minimize odor complaints in mill and the administration building when retained solvents are released during converting or solvents are used to clean converting equipment.

The last section, called "Product Quality Impact" cited several product quality improvements that the mill expected from the conversion.

An A.R. was recently developed for the waste water ultrafiltration system. Consistent with our earlier discussion of the capital budgeting/financial analysis protocol used at the mill, this investment analysis did not include a calculation of financial indices since it is considered a profit sustaining investment. Rather, it contained only a capital and operating cost estimate.

Company Analysis Versus TCA[11]

Because the mill has already started to convert this product line to aqueous, and has already purchased and installed some of the required equipment, it was necessary to establish a baseline scenario in order to test the effect of a TCA approach on the bottom-line of the project. In conjunction with the company, we decided that the "current process" analyzed will be a 100% solvent base coat system, and the "alternative process" analyzed will be a 100% aqueous base coat system; setting 1992 as the year in which the conversion (hypothetically) would be made, and then bringing all capital costs already expended up to 1991 dollars.

1. Company Analysis

The cost items contained in the Company Analysis come from the 1987 A.R., the 1990 A.R. for the waste water ultrafiltration system, and several internal memos generated by the company. Since the 1987 A.R. dealt only with the conversion to aqueous, but not the conversion to heavy metal-free coating, the Company Analysis developed in this study is not comparable to the financial analysis in the A.R..

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[11] Certain cost data for raw materials and utilities have been modified to protect confidential business information. However, annual savings and financial indicators for the Company and TCA presented in this report are identical to those for analyses developed with true raw material and utility cost data.

2. TCA Analysis

The TCA contains many costs omitted from the Company Analysis, including costs for non-disposal waste management, water, sewerage, solvent recovery, regulatory compliance, and future liability. The documentation attached to the financial analyses provides detail of cost calculations. The estimation of future liability cost deserves further discussion here.

Future Liability. The conversion to aqueous coating will significantly reduce the amount of hazardous waste generated in the solvent recovery distillation system. Using General Electric's TCA method "Financial Analysis of Waste Management Alternative", we have developed an estimate of potential, avoided future liability associated with a reduction in this waste stream. This cost is incorporated into the TCA as a one time cost in year 13.

The methodology for estimating future liability using the GE method is described in Appendix B. The mill sends its waste to a hazardous waste incinerator. On a rating scale of 3 to 9, 9 meaning the highest risk facility, this incinerator scored 3.5 based on surrounding population, water supply proximity, and leak history. As directed by the method, this risk score was adjusted according to the type of TSDF. Since the multiplier for incinerators is 0.15, we end up with a score of 0.175 for this incinerator.[12] Future liability per ton for this waste stream is estimated as follows:

$/ton = 0.175 x $350/6
10.2

where $350 is an average liability cost/ton for a landfill with an average score of 6

To estimate the projected year that liability costs may be incurred, we used the GE method that makes a prediction based on waste toxicity and mobility. We averaged the projected years for three major components of the still bottom waste stream, as follows:

		Year Predicted
acetone		16
toluene		12
MEK		12
	avg.	13

Finally, we calculated total liability cost for year 13 as follows:

Total tons avoided = 810 drums/year reduced x 55 gallon/drum x 12 lb/gal x 1 ton/2,000lb x 13 year

3432

(assuming an average waste density of 12 lb/gallon)

[12] As a point of reference, the multiplier for a landfill is 1.0, 2.0 for an injection well, 0.8 for a surface impoundment, and 0.1 for stabilization/solidification.

and **Total avoided liability** = 3432 tons x $10.20/ton

$35,000

In Tables A-2.1,A-2.2, and A-2.3, we present a comparison of cost items included, financial indicators, and operating cost categories for the Company Analysis and the TCA, respectively. Following these tables are the detailed results of the Company Analysis, TCA and associated cost calculation documentation.

Table A-2.1 Comparison of Cost Items in Company and TCA Cost Analyses

X = Cost(s) Included
P = Cost(s) Partially Included

	Company	TCA
Capital Costs		
Purchased Equipment	X	X
Utility Systems		X
Engineering/Contractor	X	X
Start-up/Training	X	X
Operating Costs		
Direct Costs:*		
Raw Materials/Supplies	P	X
Waste Disposal	P	X
Labor	X	X
Indirect Costs:*		
Waste Management:		
Hauling		X
Storage		X
Handling		X
Waste-end Fees/Taxes		X
Utilities:		
Energy		X
Water		X
Sewerage (POTW)		X
Pollution Control/ Solvent Recovery		X
Regulatory Compliance		X
Future Liability		X

* We use the term "direct costs" here to mean costs that are typically allocated to a product or process line (i.e. not charged to an overhead account) and are typically included in project financial analysis. "Indirect costs" here mean costs that are typically charged to an overhead account and typically not included in project financial analysis.

Table A-2.2. Summary of Financial Data for the Aqueous Conversion Project

	Company Analysis	TCA
Total Capital Costs	$623,809	$653,809
Annual Savings (BIT)*	$118,112	$216,874
Financial Indicator		
Net Present Value - Years 1-10	($98,829)	$232,817
Net Present Value - Years 1-15	$13,932	$428,040
Internal Rate of Return - Years 1-10	12%	24%
Internal Rate of Return - Years 1-15	16%	27%
Simple Payback (years)	5.3	3.0

* Annual operating cash flow before interest and taxes

Table A-2.3. Summary of Cost Categories and Differences for the Company Analysis and TCA

	Company Analysis	TCA	Difference
Capital Costs	$623,809	$653,809	($30,000)
Net Operating Savings/(Costs):[1]			
a) Raw Material (Spoiled Coating)	$18,112	($27,488)	($45,600)
b) Waste Management	$121,500	$243,871	$122,371
c) Utilities	($5,000)	($87,029)	($82,029)
d) Labor	($8,000)	($8,000)	0
e) Other	($3,500)[2]	$84,520[3]	$88,020
f) Regulatory Compliance	($5,000)	$11,000	$16,000
Total	$118,112	$216,874	$98,762
g) Future Liability[4]	0	$35,000	$35,000

1. Before interest and taxes
2. Filters for wastewater ultrafiltration
3. Filters for wastewater ultrafiltration and solvent recovery
4. Not included in Annual Savings

APPENDIX A-2
PAPER COATING MILL

Project 2 - Company Analysis

AQUEOUS/HEAVY METAL-FREE COATING PROJECT

Project: Aqueous/Heavy Metal-Free Conversion

CAPITAL COSTS

page 1
Date: 7/24/91

Capital Costs	Cost	Totals	Ref.	Notes:
Purchased Equipment				
Mix Room and Coater Modifications	$269,640		1	1987-88 expenditure of $177,620 adjusted
Process Equipment	$91,740		2	to 1991 dollars
Waste Water Treatment System	$163,000		3	
Coater Upgrade	$150,000		4	
Taxes				
Delivery				
Price for Initial Spare Parts		$404,740		
Materials				
Piping				
Electrical				
Instruments				
Structural				
Insulation/Piping		$0		
Utility Connections and New Utility Systems				
Electricity				
Steam			5	For drum storage shed
Cooling Water				
Process Water				
Refrigeration				
Fuel (Gas or Oil)				
Plant Air				
Inert Gas		$0		
Site Preparation				
Demolition, Clearing, etc.		$0		
Installation				
Vendor				
Contractor				
In-house Staff		$0		
Engineering/Contractor (In-house & Outside)				
Planning	$110,500		6	Technical and manufacturing
Engineering	$85,410		7	1987-88 costs (adjusted) and 1991 costs
Procurement				
Consultants		$195,910		

Project: Aqueous/Heavy Metal-Free Conversion

page 2
Date: 7/24/91

Capital Costs (continued)	Cost	Totals	Ref.	Notes:
Start-up/Training				
Vendor/Contractor				
In-house				
Trials/Manufacturing Variances	$23,159		8	
Training		$23,159		
Contigency				
		$0		
Permitting				
Fees				
In-house Staff		$0		
Initial Charge of Catalysts and Chemicals				
		$0		
Working Capital (Raw Materials, Product, Inventory, Materials and Supplies)				
		$0		
Salvage Value				
		$0		

Project: Aqueous/Heavy Metal-Free Conversion

OPERATING COSTS

Costs are positive
Savings and revenues are negative

Date: 7/24/91

Current Process

Item	Annual Cost ($/year)	Total	Ref
Raw Materials/Supplies			
Coating and Wash Solvents	$4,317,300		2a
Solvent emission losses:			
a. controlled	$48,276		2c
b. fugitive	$84,672		2c
		$4,450,248	
Waste Management (disposal, hauling, insurance, storage, etc.)			
Wash still sludge disposal	$180,000		3a
Drum handling			3c
Drum storage			3e
Drum transportation			3g
State waste-end fees			3i
		$180,000	
Utilities (electricity, steam, water, sewerage)			
Steam for coater			4a
		$0	
Labor			
		$0	
Other			
Solvent Recovery			6a
		$0	
Regulatory Compliance (manifesting, reporting, monitoring, testing, labeling, etc.)			
Managing manifests			7a
Drum labeling			7c
RCRA, TRI and TURA reporting			7e
Inspections			7g
Lab analysis - haz. waste			7i
		$0	
Insurance			
		$0	
Revenues			
		$0	
Revenues - Marketable By-products			
		$0	
Total		$4,630,248	

Alternative Process

Item	Annual Cost ($/year)	Total	Ref	Difference (Cur. - Alt.)
Raw Materials/Supplies				
Coating and Wash Solvents	$4,404,920		2b	
Solvent emission losses (from top coat)				
a. controlled	$21,168		2d	
b. fugitive	$6,048		2d	
Coating spoilage (value of material)			2e	
		$4,432,136		$18,112
Waste Management (disposal, hauling, insurance, storage, etc.)				
Wash still sludge disposal	$58,500		3b	
Drum handling			3d	
Drum storage			3f	
Drum transportation			3h	
State waste-end fees			14b	
Spoiled coating disposal			3k	
Conc. waste disposal - ultrafiltration		$58,500	3l	$121,500
Utilities (electricity, steam, water, sewerage)				
Steam for coater			4b	
Water - aqueous base coat			4c	
Steam heat for drum shed			4d	
Electricity - ultrafiltration	$5,000	$0	4e	
Water - base coat wash-up			4f	
Wastewater treatment (POTW)		$5,000	4g	($5,000)
Labor				
Operator - ultrafiltration	$8,000		5a	
		$8,000		($8,000)
Other				
Solvent Recovery - top coat			6b	
Filters - ultrafiltration	$3,500		6c	
		$3,500		($3,500)
Regulatory Compliance (manifesting, reporting, monitoring, testing, labeling, etc.)				
Managing manifests			7b	
Drum labeling			7d	
RCRA, TRI and TURA reporting			7f	
Inspections			7h	
Lab analysis - haz. waste			7j	
Lab analysis - ultrafiltration	$5,000		7k	
		$5,000		($5,000)
Insurance				
		$0		$0
Revenues				
		$0		$0
Revenues - Marketable By-products				
		$0		$0
Total		$4,512,136		$118,112

Project: Aqueous/Heavy Metal-Free Conversion

page 4

CAPITAL AND OPERATING COST SUMMARY

Date: 7/24/91

Capital Costs	Year 0 $
Equipment	$404,740
Materials	$0
Utility Connections	$0
Site Preparation	$0
Installation	$0
Engineering/Contractor	$195,910
Start-up/Training	$23,159
Contigency	$0
Permitting	$0
Initial Catalysts/Chemicals	$0
Depreciable Capital	$623,809
Working Capital	$0
Subtotal	$623,809
Interest on Debt	$0
Total Capital Requirement	$623,809
Salvage Value	$0
% Equity	100.0%
% Debt	0.0%
Interest Rate on Debt, %	12.0%
Debt Repayment, years	5
Equity Investment	$623,809
Debt Principal	$0
Interest on Debt	$0
Total Financing	$623,809
Depreciation period	15
Income Tax Rate, %	40.0%
Escalation Rate, %	5.0%
Cost of Capital (for NPV)	16.0%

Operating Costs		Current	Alternative	Difference (Cur. - Alt.
Raw Materials/Supplies		$4,450,248	$4,432,136	$18,1
Waste Management		$180,000	$58,500	$121,5
Utilities		$0	$5,000	($5,0
Labor		$0	$8,000	($8,0
Other		$0	$3,500	($3,5
Regulatory Compliance		$0	$5,000	($5,0
Insurance		$0	$0	$
Maintenance - % of Capital				
Labor	0%		$0	$
Materials	0%		$0	$
Overhead - (% of Labor)	0%	$0	$0	$
Labor Burden	0%	$0	$0	$0
Revenues				
Revenues -		$0	$0	$0
Marketable By-products		$0	$0	$0
TOTAL		$4,630,248	$4,512,136	$118,112

Future Liability (Year expected = 1,2,3, etc.)	Ref.	Year Expected	Cost (Curr.-Alter.)

Project: Aqueous/Heavy Metal-Free Conversion

Profitability Analysis

Date: 7/24/91

Operating Year	0	1	2	3	4	5	6	7	8
Escalation Factor	1.000	1.050	1.103	1.158	1.216	1.277	1.341	1.408	1.478
REVENUES									
Revenue (prod. rate or value)		$0	$0	$0	$0	$0	$0	$0	$0
Marketable By-products		$0	$0	$0	$0	$0	$0	$0	$0
Annual Revenue		$0	$0	$0	$0	$0	$0	$0	$0
OPERATING COST/SAVINGS									
Raw Materials/Supplies		$19,018	$19,978	$20,974	$22,024	$23,129	$24,288	$25,502	$26,770
Waste Management		$127,575	$134,015	$140,697	$147,744	$155,156	$162,932	$171,072	$179,577
Utilities		($5,250)	($5,515)	($5,790)	($6,080)	($6,385)	($6,705)	($7,040)	($7,390)
Labor		($8,400)	($8,824)	($9,264)	($9,728)	($10,216)	($10,728)	($11,264)	($11,824)
Other		($3,675)	($3,861)	($4,053)	($4,256)	($4,470)	($4,694)	($4,928)	($5,173)
Regulatory Compliance		($5,250)	($5,515)	($5,790)	($6,080)	($6,385)	($6,705)	($7,040)	($7,390)
Insurance		$0	$0	$0	$0	$0	$0	$0	$0
Maintenance		$0	$0	$0	$0	$0	$0	$0	$0
Overhead		$0	$0	$0	$0	$0	$0	$0	$0
Labor Burden		$0	$0	$0	$0	$0	$0	$0	$0
Liability		$0	$0	$0	$0	$0	$0	$0	$0
Total Operating Costs		$124,018	$130,278	$136,774	$143,624	$150,829	$158,388	$166,302	$174,570
CAPITAL COSTS									
Investment	$623,809								
Book Value	$623,809	$582,222	$504,592	$437,313	$379,005	$328,471	$284,675	$254,709	$224,743
Tax Depreciation (by Straight-line, 1/2 yr)		$41,587	$41,587	$41,587	$41,587	$41,587	$41,587	$41,587	$41,587
Tax Depreciation (by Double DB, 1/2 yr)		$41,587	$77,630	$67,279	$58,308	$50,534	$43,796	$37,957	$33,961
Tax Depreciation (by DDB switching to SL)		$41,587	$77,630	$67,279	$58,308	$50,534	$43,796	$29,966	$29,966
Debt Balance	$0	$0	$0	$0	$0	$0	$0	$0	$0
Interest Payment at: 12.0%		$0	$0	$0	$0	$0	$0	$0	$0
Principal Repayment		$0	$0	$0	$0	$0	$0	$0	$0
CASHFLOW									
Revenues		$0	$0	$0	$0	$0	$0	$0	$0
+ Operating (Costs)/Savings		$124,018	$130,278	$136,774	$143,624	$150,829	$158,388	$166,302	$174,570
Operating Cash Flow (BIT)		$124,018	$130,278	$136,774	$143,624	$150,829	$158,388	$166,302	$174,570
- Depreciation		$41,587	$77,630	$67,279	$58,308	$50,534	$43,796	$29,966	$29,966
- Interest on Debt		$0	$0	$0	$0	$0	$0	$0	$0
Taxable Income		$82,431	$52,648	$69,495	$85,316	$100,295	$114,592	$136,336	$144,604
- Income Tax at: 40.0%		$32,972	$21,059	$27,798	$34,126	$40,118	$45,837	$54,534	$57,842
Net Income		$49,459	$31,589	$41,697	$51,190	$60,177	$68,755	$81,802	$86,762
+ Depreciation		$41,587	$77,630	$67,279	$58,308	$50,534	$43,796	$29,966	$29,966
- Debt Repayment		$0	$0	$0	$0	$0	$0	$0	$0
- Investment (Less Debt)	$623,809								
- Working Capital	$0								
+ Salvage Value									
After-Tax Cashflow	($623,809)	$91,046	$109,219	$108,976	$109,498	$110,711	$112,551	$111,768	$116,728
Cummulative Cashflow	($623,809)	($532,763)	($423,544)	($314,568)	($205,070)	($94,359)	$18,192	$129,960	$246,688
Discounted Cashflow	($623,809)	$78,488	$81,168	$69,816	$60,475	$52,711	$46,196	$39,547	$35,605

	Years 1 - 10	Years 1 - 15
Net Present Value	($98,829)	$13,932
Internal Rate of Return	12%	16%
Payback	5.3 years	

Project: Aqueous/Heavy Metal-Free Conversion

Profitability Analysis (continued)

Date: 7/24/91

Operating Year		9	10	11	12	13	14	15
		1.552	1.630	1.712	1.798	1.888	1.982	2.081
REVENUES								
Revenue (production rate or value)		$0	$0	$0	$0	$0	$0	
Marketable By-products		$0	$0	$0	$0	$0	$0	$0
Annual Revenue		$0	$0	$0	$0	$0	$0	$0
OPERATING COST/SAVINGS								
Raw Materials/Supplies		$28,110	$29,523	$31,008	$32,565	$34,195	$35,898	$37,691
Disposal		$188,568	$198,045	$208,008	$218,457	$229,392	$240,813	$252,842
Utilities		($7,760)	($8,150)	($8,560)	($8,990)	($9,440)	($9,910)	($10,405)
Labor		($12,416)	($13,040)	($13,696)	($14,384)	($15,104)	($15,856)	($16,648)
Supplies		($5,432)	($5,705)	($5,992)	($6,293)	($6,608)	($6,937)	($7,284)
Regulatory Compliance		($7,760)	($8,150)	($8,560)	($8,990)	($9,440)	($9,910)	($10,405)
Insurance/Liability		$0	$0	$0	$0	$0	$0	$0
Maintenance		$0	$0	$0	$0	$0	$0	$0
Overhead		$0	$0	$0	$0	$0	$0	$0
Labor Burden		$0	$0	$0	$0	$0	$0	$0
Liability		$0	$0	$0	$0	$0	$0	$0
Total Operating Costs		$183,310	$192,523	$202,208	$212,365	$222,995	$234,098	$245,791
CAPITAL COSTS								
Investment								
Book Value		$194,777	$164,811	$134,845	$104,879	$74,914	$44,948	$14,983
Tax Depreciation (by Straight-line, 1/2 yr)		$41,587	$41,587	$41,587	$41,587	$41,587	$41,587	$41,587
Tax Depreciation (by Double DB, 1/2 yr)		$29,966	$25,970	$21,975	$17,979	$13,984	$9,989	$5,993
Tax Depreciation (by DDB switching to SL)		$29,966	$29,966	$29,966	$29,966	$29,965	$29,966	$29,965
Debt Balance		$0	$0	$0	$0	$0	$0	$0
Interest Payment at :	12.0%	$0	$0	$0	$0	$0	$0	$0
Principal Repayment		$0	$0	$0	$0	$0	$0	$0
CASHFLOW								
Revenues		$0	$0	$0	$0	$0	$0	$0
+ Operating (Costs)/Savings		$183,310	$192,523	$202,208	$212,365	$222,995	$234,098	$245,791
Operating Cash Flow (BIT)		$183,310	$192,523	$202,208	$212,365	$222,995	$234,098	$245,791
- Depreciation		$29,966	$29,966	$29,966	$29,966	$29,965	$29,966	$29,965
- Interest on Debt		$0	$0	$0	$0	$0	$0	$0
Taxable Income		$153,344	$162,557	$172,242	$182,399	$193,030	$204,132	$215,826
- Income Tax at:	40.0%	$61,338	$65,023	$68,897	$72,960	$77,212	$81,653	$86,330
Net Income		$92,006	$97,534	$103,345	$109,439	$115,818	$122,479	$129,496
+ Depreciation		$29,966	$29,966	$29,966	$29,966	$29,965	$29,966	$29,965
- Debt Repayment		$0	$0	$0	$0	$0	$0	$0
- Investment (Less Debt)								
- Working Capital								
+ Salvage Value								
After-Tax Cashflow		$121,972	$127,500	$133,311	$139,405	$145,783	$152,445	$159,461
Cummulative Cashflow		$368,660	$496,160	$629,471	$768,876	$914,659	######	######
Discounted Cashflow		$32,073	$28,902	$26,051	$23,485	$21,172	$19,085	$17,210

APPENDIX A-2
PAPER COATING MILL

Project 2 - TCA

AQUEOUS/HEAVY METAL-FREE COATING PROJECT

Project: Aqueous/Heavy Metal-Free Conversion

CAPITAL COSTS

page 1

Date: 7/24/91

Capital Costs	Cost	Totals	Ref.	Notes:
Purchased Equipment				
Mix Room and Coater Modifications	$269,640		1	1987-88 expenditure of $177,620 adjusted
Process Equipment	$91,740		2	to 1991 dollars
Waste Water Treatment System	$163,000		3	
Coater Upgrade	$150,000		4	
Taxes				
Delivery				
Price for Initial Spare Parts		$404,740		
Materials				
Piping				
Electrical				
Instruments				
Structural				
Insulation/Piping		$0		
Utility Connections and New Utility Systems				
Electricity				
Steam	$30,000		5	For drum storage shed
Cooling Water				
Process Water				
Refrigeration				
Fuel (Gas or Oil)				
Plant Air				
Inert Gas		$30,000		
Site Preparation				
Demolition, Clearing, etc.		$0		
Installation				
Vendor				
Contractor				
In-house Staff		$0		
Engineering/Contractor (In-house & Outside)				
Planning	$110,500		6	Technical and manufacturing
Engineering	$85,410		7	1987-88 costs (adjusted) and 1991 costs
Procurement				
Consultants		$195,910		

Project: Aqueous/Heavy Metal-Free Conversion

page 2
Date: 7/24/91

Capital Costs (continued)	Cost	Totals	Ref.	Notes:
Start-up/Training				
Vendor/Contractor				
In-house				
Trials/Manufacturing Variances	$23.159		8	
Training		$23.159		
Contigency				
		$0		
Permitting				
Fees				
In-house Staff		$0		
Initial Charge of Catalysts and Chemicals				
		$0		
Working Capital (Raw Materials, Product, Inventory, Materials and Supplies)				
		$0		
Salvage Value				
		$0		

OPERATING COSTS

Costs are positive
Savings and revenues are negative

Date: 7/24/91

Current Process

Item	Annual Cost ($/year)	Total	Ref
Raw Materials/Supplies			
Coating and Wash Solvents	$4,317,300		2a
Solvent emission losses:			
a. controlled	$48,276		2c
b. fugitive	$84,672		2c
		$4,450,248	
Waste Management (disposal, hauling, insurance, storage, etc.)			
Wash still sludge disposal	$180,000		3a
Drum handling	$100,000		3c
Drum storage	$10,000		3e
Drum transportation	$90,000		3g
State waste-end fees	$10,920		3i
		$390,920	
Utilities (electricity, steam, water, sewerage)			
Steam for coater	$189,000		4a
		$189,000	
Labor			
		$0	
Other			
Solvent Recovery	$97,800		6a
		$97,800	
Regulatory Compliance (manifesting, reporting, monitoring, testing, labeling, etc.)			
Managing manifests	$2,500		7a
Drum labeling	$2,500		7c
RCRA, TRI and TURA reportin	$15,000		7e
Inspections	$2,500		7g
Lab Analysis - Haz. Waste	$20,000		7i
		$42,500	
Insurance			
		$0	
Revenues			
		$0	
Revenues - Marketable By-products			
		$0	
Total		$5,170,468	

Alternative Process

Item	Annual Cost ($/year)	Total	Ref	Difference (Cur. - Alt.)
Raw Materials/Supplies				
Coating and Wash Solvents	$4,404,920		2b	
Solvent emission losses (from top coat)				
a. controlled	$21,168		2d	
b. fugitive	$6,048		2d	
Coating spoilage (value of material)	$45,600		2e	
		$4,477,736		($27,488)
Waste Management (disposal, hauling, insurance, storage, etc.)				
Wash still sludge disposal	$58,500		3b	
Drum handling	$50,000		3d	
Drum storage	$2,000		3f	
Drum transportation	$15,000		3h	
State waste-end fees	$3,549		14b	
Spoiled coating disposal	$18,000		3k	
Conc. waste disposal - ultrafiltration	$20,000	$147,049	3l	$243,871
Utilities (electricity, steam, water, sewerage)				
Steam for coater	$226,800		4b	
Water - aqueous base coat	$24,458		4c	
Steam heat for drum shed	$5,500		4d	
Electricity - ultrafiltration	$5,000	$0	4e	
Water - base coat wash-up	$13,083		4f	
Wastewater treatment (POTW)	$1,188	$276,029	4g	($87,029)
Labor				
Operator - ultrafiltration	$8,000		5a	
		$8,000		($8,000)
Other				
Solvent Recovery - top coat	$9,780		6b	
Filters - ultrafiltration	$3,500		6c	
		$13,280		$84,520
Regulatory Compliance (manifesting, reporting, monitoring, testing, labeling, etc.)				
Managing manifests	$500		7b	
Drum labeling	$500		7d	
RCRA, TRI and TURA reporting	$15,000		7f	
Inspections	$500		7h	
Lab analysis - haz. waste	$10,000		7j	
Lab analysis - ultrafiltration	$5,000		7k	
		$31,500		$11,000
Insurance				
		$0		$0
Revenues				
		$0		$0
Revenues - Marketable By-products				
		$0		$0
Total		$4,953,594		$216,874

Project: Aqueous/Heavy Metal-Free Conversion

page 4

CAPITAL AND OPERATING COST SUMMARY

Date: 7/24/91

Capital Costs	Year 0 $
Equipment	$404,740
Materials	$0
Utility Connections	$30,000
Site Preparation	$0
Installation	$0
Engineering/Contractor	$195,910
Start-up/Training	$23,159
Contigency	$0
Permitting	$0
Initial Catalysts/Chemicals	$0
Depreciable Capital	$653,809
Working Capital	$0
Subtotal	$653,809
Interest on Debt	$0
Total Capital Requirement	$653,809
Salvage Value	$0
% Equity	100.0%
% Debt	0.0%
Interest Rate on Debt, %	12.0%
Debt Repayment, years	5
Equity Investment	$653,809
Debt Principal	$0
Interest on Debt	$0
Total Financing	$653,809
Depreciation period	15
Income Tax Rate, %	40.0%
Escalation Rate, %	5.0%
Cost of Capital (for NPV)	16.0%

Operating Costs		Current	Alternative	Difference (Cur. - Alt.)
Raw Materials/Supplies		$4,450,248	$4,477,736	($27,488)
Waste Management		$390,920	$147,049	$243,871
Utilities		$189,000	$276,029	($87,029)
Labor		$0	$8,000	($8,000)
Other		$97,800	$13,280	$84,520
Regulatory Compliance		$42,500	$31,500	$11,000
Insurance		$0	$0	$0
Maintenance - % of Capital				
Labor	0%		$0	$0
Materials	0%		$0	$0
Overhead - (% of Labor)	0%	$0	$0	$0
Labor Burden	0%	$0	$0	$0
Revenues		$0	$0	$0
Revenues - Marketable By-products		$0	$0	$0
TOTAL		$5,170,468	$4,953,594	$216,874

Future Liability (Year expected = 1,2,3, etc.)	Ref.	Year Expected	Cost (Curr.-Alter.)
	8	13	$35,000

Operating Year	0	1	2	3	4	5	6	7	8
Escalation Factor	1.000	1.050	1.103	1.158	1.216	1.277	1.341	1.408	[illegible]
REVENUES									
Revenue (prod. rate or value)		$0	$0	$0	$0	$0	$0	$0	$0
Marketable By-products		$0	$0	$0	$0	$0	$0	$0	$0
Annual Revenue		$0	$0	$0	$0	$0	$0	$0	$0
OPERATING COST/SAVINGS									
Raw Materials/Supplies		($28,862)	($30,319)	($31,831)	($33,425)	($35,102)	($36,861)	($38,703)	($40,627)
Waste Management		$256,065	$268,990	$282,403	$296,547	$311,423	$327,031	$343,370	$360,441
Utilities		($91,380)	($95,993)	($100,780)	($105,827)	($111,136)	($116,706)	($122,537)	($128,629)
Labor		($8,400)	($8,824)	($9,264)	($9,728)	($10,216)	($10,728)	($11,264)	($11,824)
Other		$88,746	$93,226	$97,874	$102,776	$107,932	$113,341	$119,004	$124,921
Regulatory Compliance		$11,550	$12,133	$12,738	$13,376	$14,047	$14,751	$15,488	$16,258
Insurance		$0	$0	$0	$0	$0	$0	$0	$0
Maintenance		$0	$0	$0	$0	$0	$0	$0	$0
Overhead		$0	$0	$0	$0	$0	$0	$0	$0
Labor Burden		$0	$0	$0	$0	$0	$0	$0	$0
Liability		$0	$0	$0	$0	$0	$0	$0	$0
Total Operating Costs		$227,719	$239,213	$251,140	$263,719	$276,948	$290,828	$305,358	$320,540
CAPITAL COSTS									
Investment	$653,809								
Book Value	$653,809	$610,222	$528,859	$458,344	$397,231	$344,267	$298,365	$266,958	$235,551
Tax Depreciation (by Straight-line, 1/2 yr)		$43,587	$43,587	$43,587	$43,587	$43,587	$43,587	$43,587	$43,587
Tax Depreciation (by Double DB, 1/2 yr)		$43,587	$81,363	$70,515	$61,113	$52,964	$45,902	$39,782	$35,594
Tax Depreciation (by DDB switching to SL)		$43,587	$81,363	$70,515	$61,113	$52,964	$45,902	$31,407	[illegible]
Debt Balance	$0	$0	$0	$0	$0	$0	$0	$0	$0
Interest Payment at: 12.0%		$0	$0	$0	$0	$0	$0	$0	$0
Principal Repayment		$0	$0	$0	$0	$0	$0	$0	$0
CASHFLOW									
Revenues		$0	$0	$0	$0	$0	$0	$0	$0
+ Operating (Costs)/Savings		$227,719	$239,213	$251,140	$263,719	$276,948	$290,828	$305,358	$320,540
Operating Cash Flow (BIT)		$227,719	$239,213	$251,140	$263,719	$276,948	$290,828	$305,358	$320,540
- Depreciation		$43,587	$81,363	$70,515	$61,113	$52,964	$45,902	$31,407	$31,407
- Interest on Debt		$0	$0	$0	$0	$0	$0	$0	$0
Taxable Income		$184,132	$157,850	$180,625	$202,606	$223,984	$244,926	$273,951	$289,133
- Income Tax at: 40.0%		$73,653	$63,140	$72,250	$81,042	$89,594	$97,970	$109,580	$115,653
Net Income		$110,479	$94,710	$108,375	$121,564	$134,390	$146,956	$164,371	$173,480
+ Depreciation		$43,587	$81,363	$70,515	$61,113	$52,964	$45,902	$31,407	$31,407
- Debt Repayment		$0	$0	$0	$0	$0	$0	$0	$0
- Investment (Less Debt)	$653,809								
- Working Capital	$0								
+ Salvage Value									
After-Tax Cashflow	($653,809)	$154,066	$176,073	$178,890	$182,677	$187,354	$192,858	$195,778	$204,887
Cummulative Cashflow	($653,809)	($499,743)	($323,670)	($144,780)	$37,897	$225,251	$418,109	$613,887	$818,774
Discounted Cashflow	($653,809)	$132,816	$130,851	$114,607	$100,891	$89,202	$79,157	$69,272	$62,496

	Years 1 - 10	Years 1 - 15
Net Present Value	$232,817	$428,040
Internal Rate of Return	24%	27%
Payback	3.0 years	

Project: Aqueous/Heavy Metal-Free Conversion

Profitability Analysis (continued) Date: 7/24/91

Operating Year	9	10	11	12	13	14	15
	1.552	1.630	1.712	1.798	1.888	1.982	2.081
REVENUES							
Revenue (production rate or value)	$0	$0	$0	$0	$0	$0	$0
Marketable By-products	$0	$0	$0	$0	$0	$0	$0
Annual Revenue	$0	$0	$0	$0	$0	$0	$0
OPERATING COST/SAVINGS							
Raw Materials/Supplies	($42,661)	($44,805)	($47,059)	($49,423)	($51,897)	($54,481)	($57,203)
Disposal	$378,488	$397,510	$417,507	$438,480	$460,428	$483,352	$507,496
Utilities	($135,069)	($141,857)	($148,994)	($156,478)	($164,311)	($172,491)	($181,107)
Labor	($12,416)	($13,040)	($13,696)	($14,384)	($15,104)	($15,856)	($16,648)
Supplies	$131,175	$137,768	$144,698	$151,967	$159,574	$167,519	$175,886
Regulatory Compliance	$17,072	$17,930	$18,832	$19,778	$20,768	$21,802	$22,891
Insurance/Liability	$0	$0	$0	$0	$0	$0	$0
Maintenance	$0	$0	$0	$0	$0	$0	$0
Overhead	$0	$0	$0	$0	$0	$0	$0
Labor Burden	$0	$0	$0	$0	$0	$0	$0
Liability	$0	$0	$0	$0	$66,080	$0	$0
Total Operating Costs	$336,589	$353,506	$371,288	$389,940	$475,538	$429,845	$451,315
CAPITAL COSTS							
Investment							
Book Value	$204,144	$172,737	$141,330	$109,923	$78,516	$47,110	$15,703
Tax Depreciation (by Straight-line, 1/2 yr)	$43,587	$43,587	$43,587	$43,587	$43,587	$43,587	$43,587
Tax Depreciation (by Double DB, 1/2 yr)	$31,407	$27,219	$23,032	$18,844	$14,656	$10,469	$6,281
Tax Depreciation (by DDB switching to SL)	$31,407	$31,407	$31,407	$31,407	$31,407	$31,406	$31,407
Debt Balance	$0	$0	$0	$0	$0	$0	$0
Interest Payment at: 12.0%	$0	$0	$0	$0	$0	$0	$0
Principal Repayment	$0	$0	$0	$0	$0	$0	$0
CASHFLOW							
Revenues	$0	$0	$0	$0	$0	$0	$0
+ Operating (Costs)/Savings	$336,589	$353,506	$371,288	$389,940	$475,538	$429,845	$451,315
Operating Cash Flow (BIT)	$336,589	$353,506	$371,288	$389,940	$475,538	$429,845	$451,315
- Depreciation	$31,407	$31,407	$31,407	$31,407	$31,407	$31,406	$31,407
- Interest on Debt	$0	$0	$0	$0	$0	$0	$0
Taxable Income	$305,182	$322,099	$339,881	$358,533	$444,131	$398,439	$419,908
- Income Tax at: 40.0%	$122,073	$128,840	$135,952	$143,413	$177,652	$159,376	$167,963
Net Income	$183,109	$193,259	$203,929	$215,120	$266,479	$239,063	$251,945
+ Depreciation	$31,407	$31,407	$31,407	$31,407	$31,407	$31,406	$31,407
- Debt Repayment	$0	$0	$0	$0	$0	$0	$0
- Investment (Less Debt)							
- Working Capital							
+ Salvage Value							
After-Tax Cashflow	$214,516	$224,666	$235,336	$246,527	$297,886	$270,469	$283,352
Cummulative Cashflow	$1,033,290	$1,257,956	$1,493,292	$1,739,819	$2,037,705	$2,308,174	$2,591,526
Discounted Cashflow	$56,408	$50,928	$45,989	$41,531	$43,261	$33,861	$30,581

APPENDIX A-2 - PAPER COATING MILL
Project 2 - Aqueous/Heavy Metal-Free Coating Project

Costing and Financial Analysis Documentation

A. Capital Costs

1. 1987-88 capital expenditure - $222,025 on mix room and coating machine modifications
   80% of $222,025 - equipment ———> $177,620
   20% of $222,025 - engineering –

   Adjust 1987-1988 expenditure to 1991 dollars:

   $$\$177{,}620 \times (1+0.11^{*})^{4} = \$269{,}640$$

   * 11% nominal discount rate

2.

Various Mix Room	$30,000
#14 Web Temperature	11,000
Mix Room Drum Handling	11,000
Bulk Resin	21,240
In-line Mixing	18,500
	$91,740 (Expended)

3. Wastewater Treatment System - $163,000
   estimate includes: engineering and design, installation and contingency

4. Coater Upgrade - $150,000

5. Installation of Drum Shed heating system to prevent freezing of aqueous coating - $30,000

6. Labor - Technical and Manufacturing - $110,500 (Expended)
   - Equivalent 2 Man/years + 30% fringe

7. Engineering

a. 1987-1988 Engineering on Capital Projects

$$\$222,025 \times 0.2 = \$44,405$$

Adjust 1987-88 expenditure to 1991 dollars:

$$\$44,405 \times (1+0.11)^4 = \$67,410$$

b. Ultrafiltration System - $18,000

8. Trials and Manufacturing Variances (5/90 - 4/91)

a.	Average Productivity Loss	$17,302
b.	Yield Loss	5,857
		$23,159

B. Operating Costs

Solvent

1. Raw Materials and Supplies

1a. Coating and Wash Solvents

$4,317,300/yr

1c. Solvent emission losses

Controlled:
96 tons/yr x $0.21/lb x 2000 lb/ton = $40,320/yr
Fugitive:
(97+71)tons/yr x $0.21/lb x 2000 lb/ton = $70,560/yr

2. Waste Management

2a. Wash still sludge disposal - from base coat and bottom coat

Disposal Cost - $150/drum

2,200 drums/yr x $150/drum = $180,000/yr

2c. Drum Handling:

2 man yr @ $50,000/yr (including benefits) = $100,000/yr

Aqueous

1b. Coating and Wash Solvents

$4,404,920/yr

1d. Solvent emission losses:

Controlled:
42 tons/yr x $0.21/lb x 2000 lb/ton = $17,640/yr
Fugitive:
12 tons/yr x $0.21/lb x 2000 lb/ton = $ 5,040/yr

1e. Coating Spoilage - value of lost raw material:

Spoilage of stored aqueous coating from micro-bacteriological build-up.

100 drums/yr at a cost of $45,600/year

- estimate 100 drums/yr spoiled

2b. Wash still sludge disposal - from top coat only

390 drums/yr x $150/drums - $58,500/yr

2d. Drum Handling:

1 man yr @ $50,000/yr

Solvent

2e. Drum Storage:

$10,000/yr
estimate, based on calculated cost of $4/sq. ft./year for heating, lighting, and fire protection

2g. Waste Transportation

$90,000/yr - estimate,
based on waste disposal invoices

2i. Massachusetts waste-end fees

1,200 drums wash still sludge/yr x 50 gal./drum x $0.182/gal = $10,920/yr

Tellus estimate based on state waste transportation fee - $0.182/gal

Aqueous

2f. Drum Storage

$2,000/yr

(See 2e)

2h. Waste Transportation

$15,000 - estimate

2j. Massachusetts waste-end fees

390 drums/yr x 50 gal/drum x $0.182/gal - $3,549/yr

(See 2i)

2k. Spoiled coating disposal

Disposal Cost - $18/drum

100 drums/yr x $18/drum = $18,000/yr

(See 2i)

2l. Disposal of concentrated waste from waste water ultrafiltration

Disposal Cost - $0.50/gal

150 gal/day x $0.50/gal x 267 days/yr = $20,000/yr

Solvent	Aqueous
3. Utilities	
3a. Steam for coater	**3a. Steam for coater**
$27/hr x 7,000 hrs/yr = $189,000/yr	1.2($27/hr x 7,000 hrs/yr) = $226,800/yr - Based on an estimated 20% increase in steam needed to dry aqueous coating
	3c. Water for Aqueous Coating Based on 60% water content of coating 1,450,000 lb water/yr x gallon/8.3 lb x $0.14/gal = $24,458/yr
	3d. Steam Heat for Drum Shed Drum shed steam heating will be needed to prevent freezing of aqueous coating Annual Steam Costs = $5,500/yr
	3e. Electricity for Ultrafiltration System $5,000/yr Based on $0.105/kwh
	3f. Water Use for Base Coat Wash-up 3,500 gal/day x 267 day/yr x $0.14/gallon = $13,083/yr

Solvent

4. **Labor**

5. **Other**

5a. Solvent Recovery (S.R.)

	Total	Product Line(60%)
S.R. Ann. Oper. Cost	$1,468,000	$880,800
Fair Market Value of Solvent Produced	1,323,000	783,000
Net Cost	$145,000	$ 97,800

S.R. Annual Cost includes:

- utilities
- labor
- engineering (in-house and consultants)
- supplies
- maintenance

Cost allocated to Product Line based on 60% solvent contribution from Product Line coating. Costs are based on 3 year average.

Aqueous

3g. Wastewater Treatment (POTW) of Washwater

Treatment of wastewater discharge from ultrafiltration system

2,850 gal/day x 267 days/yr x $0.00156/gallon = $1,188/yr

4a. Operator - Ultrafiltration

$8,000/yr

5b. Solvent Recovery

$97,800/yr x 0.1 = $9,780

Solvent recovery of top coat solvents only. Cost based on an estimated 10% of solvents in solvent coating attributed to top coat.

5c. Filters - Ultrafiltration

$3,500/yr

	Solvent	Aqueous
6. Regulatory Compliance*		
Managing Hazardous Waste Manifests	6a. $2,500/yr	6b. $500/yr
Waste Drum Labeling	6c. $2,500/yr	6d. $500/yr
RCRA, TRI and Mass. TURA Reporting	6e. $15,000/yr	6f. $15,000/yr
Inspections	6g. $2,500/yr	6h. $500/yr
Laboratory Analysis-Hazardous Waste	6i. $20,000/yr	6j. $10,000/yr
Lab Analysis - Ultrafiltration		6k. $5,000/yr

*All costs are estimates based on current expenses.

	Solvent	Aqueous
7. Future Liability		$35,000 in year 13 (see project write-up)

WILLIAMS PRECISION VALVE COMPANY, INC.

MASSACHUSETTS FACILITIES

Costing and Financial Analysis
of
Pollution Prevention Projects

September 1991

Marlene R. Wittman

Printed on recycled paper

I. EXECUTIVE SUMMARY

Williams Precision Valve Company is a manufacturer of precision industrial valves and actuators for the chemical, pulp and paper, railroad, and oil industries. The chemical and pulp/paper industries install these valves on pipelines requiring high performance on-off and control valves. In the railroad industry, Williams valves are installed on railroad car connections. Because of the high performance nature of these valves, Williams has designed and manufactured valves for projects requiring unique valves of exacting tolerances, such as NASA projects and the Alaskan pipeline. Williams manufactures valves in a wide variety of materials, sizes and configurations according to the user's technical needs.

As the US subsidiary of a European-based global company specializing in precision equipment and instruments, Williams Massachusetts' operations are guided by a company-wide environmental policy. Williams management decided to turn policy into action by the formation of a cross-disciplinary environmental team. Since 1988, this environmental team has implemented a number of pollution prevention projects, ranging from housekeeping solutions to high-technology equipment enhancements.

The environmental team considered installing a wastewater purification system on the facility's zinc phosphate plating line as a pollution prevention project. They requested proposals from various vendors of this type of technology and reviewed the specifications for a number of systems. The Williams team reviewed the available technology, compared cost estimates on the current and the proposed projects, and consulted with the Massachusetts Office of Technical Assistance. Given the fact that the installation of this wastewater treatment system on a zinc phosphate line is unproven technology, the environmental team decided to delay the decision on its purchase. The Williams team did not want to commit funds to a substantial investment in an untested system that might fail, or alternatively, might not meet regulatory requirements in the upcoming years. In effect, the Williams team based its decision on concern that a wastewater purification system of this design has never been successfully installed on a zinc phosphating line and the product lacks a track record as an established system in a number of companies. They reasoned that it would be more economical to delay purchase until the technology was sufficiently advanced and proven so as to decrease the risk - environmentally and financially - of a project failure.

The Williams team delayed the project despite its economic feasibility and attractiveness as a capital investment. On a discounted cash flow basis, the installation of the closed loop system would have resulted in a favorable net present value of approximately $56,000 over a ten year economic horizon. However, given the experimental nature of the technology, the team decided to give priority to project risks, rather than decide on the project's financial merits.

II. COMPANY BACKGROUND

Williams Precision Valve Company was founded in 1954 and was operated as a stand-alone corporation until 1984, when it was sold to Carson Industries, an Ohio-based manufacturer of testing equipment. In 1988, the company was purchased by a European multinational well-established in the European valve market. Ruffino Instruments acquired Williams Precision Valve for the purpose of expanding its market coverage to the United States; Ruffino was also afforded the opportunity to use Williams' established distribution channels for its products.

In 1990, Williams generated approximately $150 million in sales revenues in the United States. Its US-based distribution network included 200 distributors. Traditionally, Williams produced to stock; within the last four years, however, the company has moved in the direction of made to order production.

Williams Valve operates in an extremely competitive environment; the industrial end-user often demands a valve that solves a particularly complex technical problem (ie., transportation, storage, chemical mixture). Therefore, these valves are sold on quality rather than price. Williams positions itself in the marketplace as the designer and supplier of one-of-a-kind solutions; these valves include quarter-turn rotary and globe control valves, pneumatic, hydraulic and electric actuators and positioners. While valves manufactured for the "Do-It-Yourself" (DIY) market are considered commodities, Williams' product lines are high performance valves designed with complex configurations and for highly specialized applications.

Williams operates two plants in Rundel, Massachusetts, in addition to two plants and one engineering prototype building in Fairhaven, Massachusetts. There are approximately 1,000 employees among the plant locations, 700 non-union manufacturing positions, and 300 management positions. The Massachusetts plants manufacture approximately one million valves per year. The Rundel plants manufacture and test large numbers of small (up to 8 inch) valves; the Fairhaven plants manufacture small numbers of large valves (8 inch to 48 inch).

Williams has experienced a fairly consistent expansion of its physical plant since its establishment in Massachusetts in 1960; for example, it expanded its Fairhaven facilities in 1965-66, constructed the Rundel plant in the 1970-71 period and added a number of engineering buildings in 1980.

III. THE CAPITAL BUDGETING PROCESS

Williams' capital budgeting cycle starts in July every year; each department's staff submits to the head of that department a "wish list." For example, members of the manufacturing engineering department submit to Arthur Manley, Senior Project Manager, a list of desired capital expenditures. Shortly thereafter, Manley meets with the requestors for clarification of the items on the list. This "wish list" usually amounts to $20-30 million of capital investments for the combined departments.

The lists are scrutinized by Manley to discover whether the items fulfill the capital budgeting guidelines established by the company's Three Year Plan, initiated in February 1991. Manley states that resource planning over twelve quarters is a difficult task, requiring a fairly accurate projection of needs over the long time horizon. Corporate headquarters requires a rigorous justification process for the expenditures requested for capital investments. Major acquisitions - investment amounts greater that $250,000 - require corporate approval from the parent company. The justification process must include a discounted cash flow project analysis for a ten year economic lifetime for both major and minor investments; in other words, a capital investment of $250,000 receives the same amount of scrutiny and analysis as an investment of $50,000. The justification process includes a payback calculation, a net present value analysis, and an internal rate of return (IRR) calculation. Williams' hurdle rate for capital investments is an IRR exceeding 15 percent.

IV. ORGANIZATIONAL STRUCTURE

Williams has a number of organizational structures that contribute to the company's ability to integrate its environmental policy into daily operations. These structures provide a flow of information from the shop floor to the managers, a team to oversee projects, motivational opportunities, and feedback loops.

o **The Environmental Team** - The manufacturing engineering department includes approximately 40-45 employees who are involved in product development and manufacturing applications. A small committee from this department is involved in developing, planning and implementing an environmental program for the company's Massachusetts facilities. This environmental committee, headed by Arthur Manley, consists of the plant managers for each of the three Massachusetts-based plants; one environmental specialist with expertise in the regulatory sector; one purchasing professional; and one facilities manager, usually an engineering and maintenance professional. Each professional brings to team meetings input from department employees regarding suggestions for environmental projects. (For example, employees in the maintenance department noticed that many of the plant's heavy machines needed catch pans to limit the company's use of Speedi-Dry). Input from all areas of the plant is encouraged and stimulated by the company's "Awareness" policy, and its company-wide quality training.[1]

This committee meets bi-weekly to discuss any environmental items that need attention, and to consider the suggestions put forth by committee members. The frequent meetings are a part of the company's plant-wide awareness of environmental issues. The team's agenda consists mostly of pollution prevention projects. The corporate attitude towards a pollution

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[1] Williams has trained its managers and employees in Philip Crosby's Quality College, which is one of the leading institutes for quality training. The basis of Crosby's quality training is that "Quality is Free," or, that managers must pursue quality manufacturing and services in order to compete effectively. The hallmark of Crosby's approach is the changing of top management's approach to quality, so that zero defects becomes a management standard and not simply a motivational technique for employees. In the process of engendering quality awareness, management learns how to play a leadership role by increasing employee involvement in quality training and programs. See Philip B. Crosby, *Quality is Free: The Art of Making Quality Certain* (New York: McGraw-Hill, 1979); Harvard Business School Note 9-687-011, *A Note on Quality: The Views of Deming, Juran and Crosby* (Cambridge: Harvard Business School, 1986).

prevention project is that it is not considered as "just another investment." but as a tangible indication of Williams' environmental awareness.

This attitude is likewise reflected in the capital budgeting dynamics for projects initiated by the environmental team. Traditionally, departments in a company compete against each other for capital during each capital budgeting period. Most departments understand that environmental projects that are required for compliance are "mandatory" in the capital budgeting process. As mandatory projects they are approved with little or no quantitative analysis. Pollution prevention projects, however, do not fall in the mandatory category; these projects have to be evaluated in the same manner as other departments' proposed projects. As such, these projects augment the competition for capital allocations amongst departments. Under these circumstances, the added competition for what is perceived by other departments as an "unnecessary project" creates tensions during the justification and approval processes. Williams departs from the traditional company mold in its various departments are not resentful of management allocating resources to pollution prevention projects. This corporate policy of investing in pollution prevention projects is reflected in last year's expenditures: in fiscal year 1990, environmental projects amounted to well over $400,000 (approximately $250,000 in capital investments and $150,000 in resultant operating and maintenance expenses).

o **Focused Factory** - In addition to its environmental teams, Williams has a second organizational change worthy of note. Recently, Williams reconfigured its production processes according to a focused factory approach.[2] When Williams divided its existing facility into individual plants, the company followed a "plant-within-a-plant" (PWP) strategy. Each Williams PWP has its physical space concentrated in one area in which it can focus on a particular manufacturing task, using its work-force management skills, production and quality control. The concentration on one process is meant to increase worker focus, motivation and quality levels.

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[2] The concept of the focused factory was first defined in an article by Wickham Skinner in the May-June 1974 issue of the Harvard Business Review. Skinner's article, *The Focused Factory*, was based on the premise that conventional factories attempt to do too many conflicting production tasks within one set of manufacturing guidelines, resulting in a lack of concentration on the key manufacturing task. He recommended the division of the factory into separate units concentrating on one task, resulting in higher product quality, and improved manufacturing efficiency.

V. THE MANUFACTURING PROCESS

Williams' facilities encompass a number of operations. Its metal cutting and tumbling operations are integral to the manufacture of the product. Numerous lathes, machining centers and ceramic tumblers finish steel rods and castings to very tight tolerances. Essentially, valve parts are cleaned, hot rinsed, pickled, cold rinsed, zinc phosphated, cold rinsed, anti-rusted and dried. The tumbling wastewater is settled in pits and pumped through a separator. The three waste streams - the waste stream emanating from the plating operation, the stream from the industrial washing operation and the wastewater flow from the tumbling system - are combined and discharged to the sewer.

The zinc phosphate conversion coating processes utilize dead rinses followed by reactive countercurrent rinses. The flow from the tumbling system includes traces of ceramic media and an alkaline cleaner. The combined waste stream contains alkaline cleaners and synthetic oils from the wash and rinse tanks, fats, zinc traces, grease, and an unacceptable pH level. All three streams are monitored continuously for pH as they flow into two-stage adjustment sumps and discharged to the POTW. Each pretreatment sump contains a settling and oil skimming stage, a mix tank for pH control, and an effluent chamber for monitoring pH. The alkaline cleaners and rinses at the industrial parts washers are skimmed of oil, then drained to the sumps. Spent baths are neutralized and evaporated. The evaporator sludge and washwater skimmings are manifested as hazardous wastes. (*See* Exhibit I for a process flow diagram).

VI. THE POLLUTION PREVENTION PROJECT

Manley and his environmental team decided to pursue the idea of installing a closed-loop system on the plant's zinc phosphating line. The overall objective of the project was to discharge zero wastewater to the sewer; also, a zero-water discharge system would reduce water and sewer costs and free the company from present and future sewer discharge limits. Furthermore, the team wished to pre-empt potential regulations regarding allowable limits on zinc discharges. Although the discharges from the plating line are currently well within compliance requirements, the team wanted to close the loop in anticipation of more stringent regulations. Moreover, Williams already owned ion-exchange and electrolytic recovery tools, equipment used in closed-loop systems. The team hoped to use a portion of this equipment as part of post-treatment, although it was prepared to scrap its use in the interest of installing a reliable system.

The team sent out requests for proposals in January 1991 to three vendors/designers of wastewater purification technologies. Of these firms one was the supplier of the original equipment installed by Williams approximately two years ago; this equipment, an ion-exchange unit, proved unsatisfactory for the zinc phosphate plating line. The second firm was a vendor of water purification systems, and the third firm specialized in prototype designs. Upon receipt of the proposals, the team reviewed each of the vendor's proposals on technical merits. The team decided to investigate first the proposal submitted by Blake Technologies, the company specializing in water purification systems. Blake offered a lease or purchase deal, in addition to a performance clause in the contract. To demonstrate the efficiency of the water purification system, Blake invited Williams engineers to collect effluent from the plating line, and allow Blake to process the effluent through the unit at the demonstration lab. The Williams effluent returned from the Blake demo labs with a quality exceeding local water regulation levels for all indicators except potability.

Blake estimated that one system would cost approximately $55,000, inclusive of delivery and installation. Williams considered purchasing two systems for each of its plating lines; therefore, the approximate total expenditure for both lines amounted to $100,000+.

Installation of this type of wastewater purification has never been successfully implemented on a zinc phosphate plating line. If the project were implemented, the Williams facility would constitute a beta-site, or a site of experimental applied technology. For this reason, the team was undecided as to how to proceed with the project. Manley asked the Massachusetts Office of Technical Assistance to review the Blake contract and examine the specifications of the proposed system. Also, Manley asked the casewriter to examine the financial impact of the proposed project in light of the relatively high degree of risk involved in the untested product technology.

VII. COSTING AND FINANCIAL ANALYSIS OF THE POLLUTION PREVENTION PROJECT

The environmental team, in conjunction with the casewriter, analyzed the costs for the current operation of the zinc phosphate line and compared them to the operation of the line with the installation of the Blake system. The current zinc phosphate involves operations and maintenances costs of $28,800 per year plus $4,800 in water charges. Additionally, the operation of the line costs $11,185 for sludge disposal expenses. Periodic laboratory analyses amount to $810 annually, and sampling charges amount to $2,640 per year. Regulatory fees are $2,400 per year.

The casewriter compared the costs of the Blake closed-loop system to the costs of the operating the current plating line. The purchase of the Blake system on one line cost approximately $55,000, inclusive of delivery, installation and set-up costs. The casewriter compared some of the less obvious, hidden costs involved in the implementation of this project. Many of the labor costs would remain the same, simply because labor hours devoted to monitoring the operation of the sumps would be rechanneled into supervising filter cake reloading and collection. Other labor costs, such as training, labelling, and recordkeeping would have no incremental impact on expected cash flows.

Based upon these costs and savings, the casewriter performed a discounted cash flow analysis of the project. She incorporated a number of assumptions into the model, including a cost of capital of 11 percent, and a corporate tax rate of 40 percent. This analysis yielded a net present value of approximately $56,000, indicating an economically feasible project. (*See* Exhibit II for a discounted cash flow analysis of this project).

VIII. THE MANAGEMENT DECISION - THE RELEVANCE OF PRODUCT LIFECYCLE

Manley and the Williams environmental team decided to postpone the installation of the closed-loop system; they decided that while the concept of a closed-loop system would be cost effective, the installation of unproven technology might jeopardize product quality. Alternatively, the unproven technology might become obsolete in a few years, necessitating investment in yet another system. Instead of risking a degradation in product quality, or wasting capital on an inadequate system, the Williams team decided to postpone the installation until the technology was sufficiently mature. In other words, the team took into account the *product lifecycle* of closed-loop technology. (*See* Appendix A for the note on product lifecycle).

Closed-loop systems for zinc phosphate plating lines represent a product category that is in the growth stage of its product lifecycle. Once the product - a closed-loop system for zinc phosphate plating lines- becomes an extensively applied technology, the product category moves into the mature stage of its product lifecycle. The Williams team recognized that this technology for zinc phosphate lines is in the early stage of its lifecycle, and as such, is subject to vast and rapid improvements in the course of its cycle. To purchase the system in the early stages might necessitate a second purchase in order to take advantage of later enhancements.

The team also considered the crucial fact that Williams competes in terms of product quality. not product price. The installation of untested technology on the plating line might jeopardize product quality. Since product quality is one of Williams' key success factors in the industry, the choice of technology directly impacts the future competitiveness of the company.

Based upon a consideration of financial factors, the project appeared economically feasible and attractive as a capital investment. **However, the project was rejected on the strength of qualitative factors, namely, the risk involved in an untested product.**

Given these product factors and the competitive nature of the industry, the Williams team decided on the following course of action: continue to track the wastewater recycling industry in order to identify potential vendors of systems compatible with the zinc phosphate plating line; request that the Massachusetts Office of Technical Assistance perform a baseline study of the current zinc phosphating line for investigative purposes (ie., to identify potential low-tech solutions to decreasing amount of contaminants in wastewater); tour and review the operation of a closed loop system installed in a similar metal treating company. The Williams team reasoned that these three steps would provide relevant background information in the event that compatible technology is found.

Appendix A

Product lifecycle is a management concept used to describe the distinct stages in the sales history of a particular product. Managers, especially those responsible for the marketing function in a company, attempt to manage profits and sales revenues through each of these stages. The product lifecycle concept includes the following ideas about a product:

> products have a limited life

> product sales pass through distinct stages, each posing different challenges to the seller

> product profits rise and fall at different stages of the product lifecycle

> products require different marketing, financial, manufacturing, purchasing, and personnel strategies in the different stages of their lifecycle. [1]

The product lifecycle concept dates to management studies from the early 1960s and is prevalent in business decision-making today. In part, the PLC portrays the sales history of a product; the curve is divided into four stages, known as introduction, growth, maturity, and decline:

> **Introduction** - The product is just introduced to the market. The product idea is new, requiring that the manufacturer build awareness in the marketplace of the product's attributes. There are only a few competitors. Due to the lack of the product's track record, there might be technological problems that need correction.

> **Growth** - The market accepts the product, thereby leading to increased usage, and an installed base of products in consumers' homes and businesses. At this time, the seller should experience profit improvement. Competitors with similar product attributes enter the market.

> **Maturity** - The product has achieved acceptance by all potential buyers. There is a slowdown in sales, profits stabilize or decrease as increased marketing is required to meet the competition.

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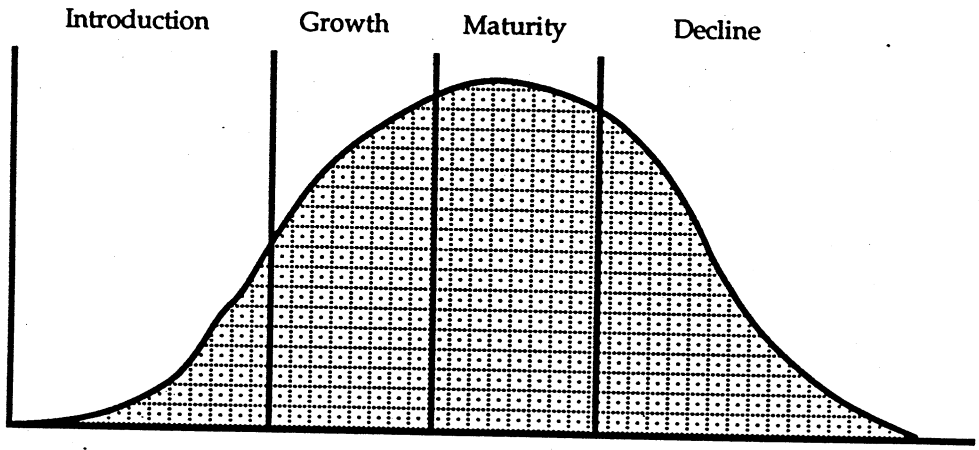
[1] See Philip Kotler, Marketing Management: Analysis, Planning, Implementation and Control (Englewood Cliffs, New Jersey: Prentice Hall), 1988, Chapter 12 - Product Lifecycle. The PLC concept is attributed to Rolando Polli and Victor Cook, "Validity of the Product Life Cycle," *Journal of Business*, October 1969, p. 389, University of Chicago Press.

> **Decline** - Profits drift downward as the product is no longer demanded by the marketplace.



Product Lifecycle

Exhibit I

PROCESS FLOW DIAGRAM
Zinc Phosphate Plating Line

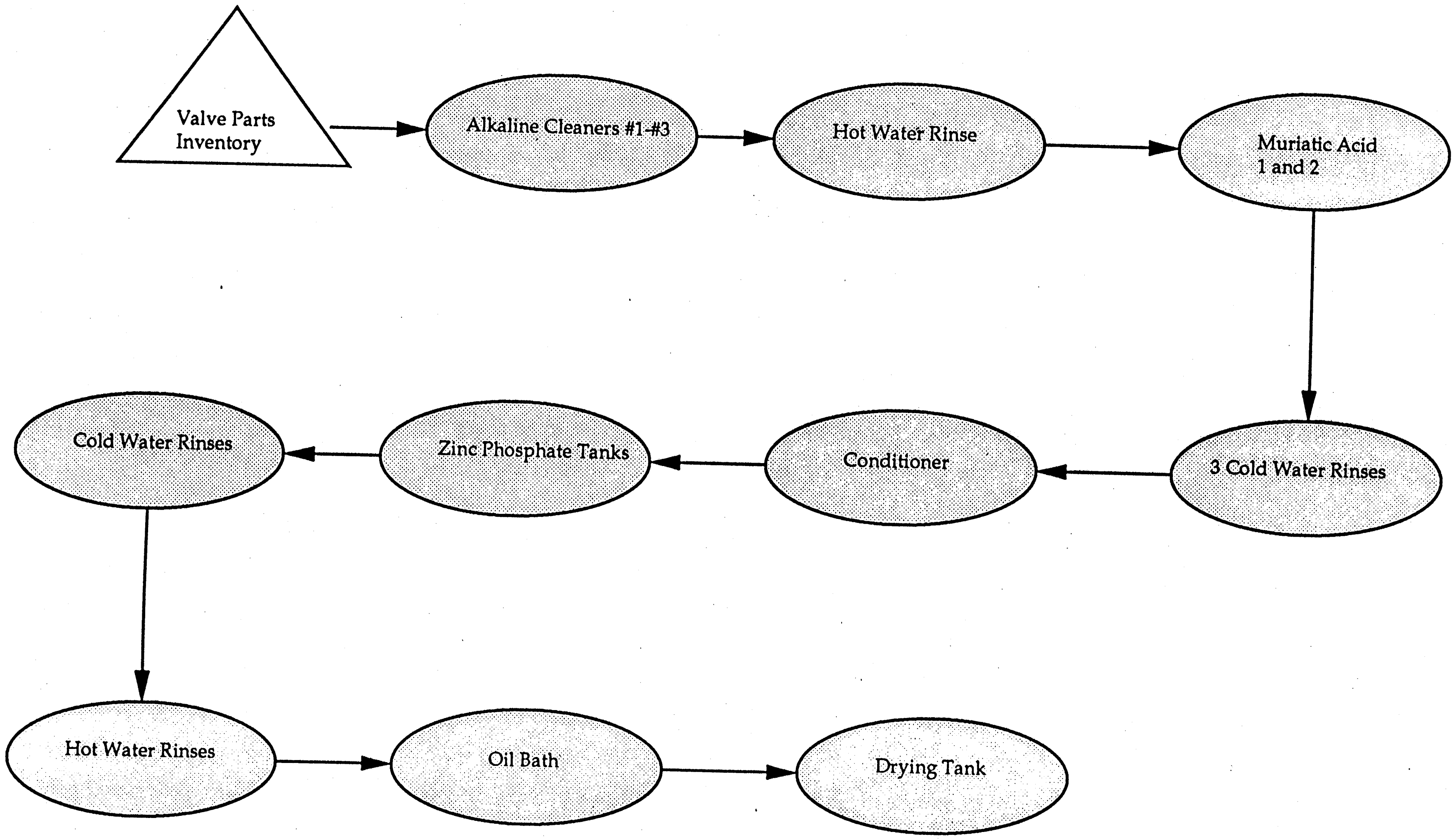


Exhibit II
Williams Precision Valve Company, Inc.
Discounted Cash Flow Project Analysis

Item(s)	Year(s)	BTCF*	ATCF**	Present Value Factor 11% Cost of Capital	Present Value
Purchase Wastewater Recirculating System	0	($55,000)	($55,000)	1	($55,000)
Depreciation New System (Straight Line)	1- 10	$5,500	$2,200	5.8992	$12,978
O&M Current Process Savings	1 - 10	$28,800	$17,280	5.8992	$101,938
Water Savings	1 - 10	$4,800	$2,880	5.8992	$16,990
Disposal Savings	1 - 10	$11,185	$6,711	5.8992	$39,590
Lab Analyses - Savings	1 - 10	$810	$486	5.8992	$2,867
Sampling Costs - Savings	1 - 10	$2,640	$1,584	5.8992	$9,344
Regulatory Fees - Savings	1 - 10	$2,400	$2,400	5.8992	$14,158
Chemical Costs - Savings	1 - 10	$637	$382	5.8992	$2,255

Item(s)	Year(s)	BTCF*	ATCF**	Present Value Factor 11% Cost of Capital	Present Value
O&M New Machine	1 - 10	($20,000)	($12,000)	5.8992	($70,790)
Fibrafil Purchases	1 - 10	($5,000)	($3,000)	5.8992	($17,698)
			Net Present Value =		$56,632

* BTCF = Before Tax Cash Flow
**ATCF = After Tax Cash Flow
Assumptions: Williams' corporate tax rate is 40%, and cost of capital is 11%.

NOTE ON
DISCOUNTED CASH FLOW PROJECT ANALYSIS
Costing & Financial Analysis of Pollution Prevention Projects

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DEFINITIONS

Year = Refers to the year or years in which cash inflows and/or outflows are expected to occur.

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BTCF = Before Tax Cash Flow. Refers to the cash flow before all applicable taxes have been paid.

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PVF = Present Value Factor. Refers to the discount rate chosen for the project under consideration.

PV = Present Value. Refers to the discounted after-tax cash flow, or ATCF x PVF.

NPV = Net Present Value. Refers to the sum of all the present values of the cash flows resulting from the project. The NPV represents the project's value to the company <u>now</u>, taking into account the future resultant cash flows. The basic decision rule for NPV: if NPV is greater than zero, then the project is acceptable on economic grounds.

In this analysis, the items relating to the project, along with the years in which the items are expected to occur, are listed in columns 1 and 2. For each item, the Before Tax Cash Flow is listed (Col.3), and then adjusted for tax effects in the ATCF column (Col.4). The appropriate present value factor is listed in the fifth column, which is multiplied by the ATCF for the present value in Column 6.

ATCF = BTCF adjusted for tax effects

PVF	=	Present Value Factor (from tables)
PV	=	ATCF x Present Value Factor
NPV	=	Net Present Value, or Sum of all PVs

Once all of the items have been listed, cash flows filled in, and present values calculated, the sum of all these PVs is the Net Present Value. The decision rule for NPV is very simple: if the NPV is greater than zero, the project is economically feasible.

In terms of filling in cash flows, one must remember to project estimated cash flows over the economic lifetime of the project. In other words, if the economic lifetime is five years, then items such as labor savings and/or maintenance costs should be estimated over five years. Second, the costs that should be included in the analysis are those that are directly tied to the possession of the equipment. Third, sunk costs should be ignored in this analysis. "Sunk costs" are those costs that have already been paid or committed; this analysis is concerned with incremental, or differently costs, or those that are affected by the implementation of the project. Likewise, costs that are the same for all the alternatives are ignored.

Keep in mind that this analysis is only half the entire picture. This quantitative analysis only indicates the economic attractiveness of a project, and does not account for all the qualitative issues involved in the purchase. For example, worker safety, compliance, market share, and potential liability are a few of the possible qualitative issues. In some cases, the qualitative aspects override the quantitative aspects. For example, the net present value of a particular project might be negative, indicating that the initial capital outlay exceeds the projected inflows. However, in the interests of reducing potential liability resulting from the current operations, the project is implemented on qualitative grounds.

WRAYBURN JEWELRY COMPANY, INC.

SUTTON FACILITY

Costing and Financial Analysis of
Pollution Prevention Projects

July 1991

Marlene R. Wittman

Printed on recycled paper

I. EXECUTIVE SUMMARY

Wrayburn Jewelry Company is a leading US manufacturer and distributor of men's and women's jewelry, personal leather goods, and personal accessory items. Wrayburn's major jewelry manufacturing facility is located in Sutton, a small Massachusetts town, while its distribution facility for its leather line is situated in a nearby Rhode Island city.

Wrayburn has traditionally exceeded regulatory requirements in the interests of creating favorable conditions for its employees. It has also been a community-oriented company, sensitive to the potential environmental concerns of residents and abutters. Over the years, its environmental projects have been very low-profile and without publicity.

While the majority of Wrayburn's environmental projects have been implemented in the interests of its employees and community residents, the company has considered pollution prevention projects on the basis of their economic merits. For example, the Vice President of Quality and Environmental Affairs at the Sutton plant submitted a purchase request for pollution prevention equipment to Wrayburn's corporate headquarters. In his written justification for the expenditure, he estimated that this particular piece of equipment would save the plant in purchase and disposal expenses, labor costs, and toxics use fees. Moreover, his financial analysis indicated a very favorable payback period of only eleven months. He requested that the casewriter review these costs, add any hidden or less obvious costs, and present in a format readily understandable and acceptable to financial managers at corporate headquarters.

The casewriter utilized a discounted cash flow project evaluation format in order to capture the time value of money, tax and inflation effects. This costing and financial analysis of Wrayburn's pollution prevention project yielded a favorable net present value of approximately $60,000 over the project's ten year economic life.

II. COMPANY BACKGROUND

Wrayburn's corporate headquarters and jewelry design teams are located in New York City. While the company has historically been a designer and manufacturer of men's jewelry and personal accessories, it added women's jewelry to its product lines approximately twenty years ago. Currently, the product line comprises 65 percent women's jewelry and 35 percent men's jewelry. The jewelry product lines are mostly high fashion costume pieces and private label brands. Major competitors for the retail/department store lines include costume jewelry lines such as Monet, Napier and 1928; Wrayburn jewelry lines are sold by such retailers as Bloomingdale's, Saks Fifth Avenue and Jordan Marsh. Sales revenue for the jewelry products amounted to over $50 million for 1990.

The women's high-fashion jewelry line includes such fashion accessories as pendants, buttons, and earrings. The New York-based team designs buttons, earrings and pendants for the major fashion houses for each of the two seasons - fall and spring - and for five showings annually. The fashion house pays Wrayburn a royalty for the use of the design. Schematics of the designs are sent to the Sutton manufacturing facility, and produced with Just In Time (JIT) techniques. [1]

The Sutton facility currently employs 400 non-union workers on the shop floor, and 100 in management positions. The manufacturing processes at Sutton are extremely labor intensive with very short cycle and thruput times. [2] The facility operates with a standard costing system, ie., with standard times (in TMUs) set and periodically updated for each of its processes, such as stamping, casting, plating, polishing, soldering, and cementing. [3] Shop floor employees work according to a piece rate incentive system.

III. ORGANIZATIONAL ASPECTS

Wrayburn has traditionally been a maternal company where working conditions are constantly upgraded so as to maintain worker satisfaction. This approach has indeed maintained a steady workforce and employee loyalty; the majority of the shop floor employees have worked in the Sutton plant for over twenty-five years, and some for considerably longer periods of time. This maternalism has not been limited to company employees: the Sutton facility has always been community oriented, and has been aware of the potential environmental concerns of the Sutton community.

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[1] In a just-in-time production system, components are produced as required by the master schedule, rather than produced *in case* they are required. The underlying objective of the system is to improve profits and return on investment through cost reductions, inventory reductions, and quality improvements.

[2] In manufacturing operations, the cycle time is the longest process time and dictates the rate at which the whole process produces output. Thruput time is the cycle time multiplied by the number of operations for a particular process.

[3] In manufacturing, TMUs represent standard time values for various classifications of motions. Times are recorded in a special time unit known as the TMU. (1 TMU = 0.0006 minutes). Standard times for a particular manufacturing process may be derived from the company's historical data, or from visual study of an operation with timing of motions by a stopwatch calibrated in TMUs. Manufacturers often update standard times so as to maintain accurate process times. (Work Simplification Note, Boston, MA: HBS Case Services, Harvard Business School, 1984).

The Sutton facility management includes Vice-Presidents of merchandising, manufacturing and distribution. The casewriter contacted William Sutherland, the Vice-President of Quality and Environmental Affairs, to discuss Sutton's approach to pollution prevention strategies. Because of the company's sensitivity to community issues and environmental concerns, the Sutton plant has maintained a strategy of exceeding regulatory requirements. For example, Wrayburn was twenty years ahead of regulatory requirements when it installed a waste treatment plant in 1968. Likewise, the plant surpassed the requirements of environmental regulations when it installed *extra* exhaust hoods for the comfort of its employees.

In terms of the capital budgeting process, Sutherland drafts the capital budget for his department for the upcoming fiscal year, and presents it directly to a meeting of Wrayburn's Board of Directors. As such, the company does not have an extensive approval process, requiring only the sign-off of the Board. During the course of the fiscal year, Sutherland has the financial discretion to approve expenditures in amounts up to $1000; expenditures in excess of $1000 have to be approved by corporate headquarters.

IV. THE MANUFACTURING PROCESS

Despite the fact that Wrayburn's jewelry designs are constantly changing, the metals used for the jewelry remain the same. Metal sheets are simply molded, stamped, folded, or plated according to each season's design schematics. The plant produces two types of jewelry finishes - white and yellow finishes. White finishes include silver plating, rhodium finishes, and tin-based finishes. [4] Wrayburn's designers and manufacturing engineers, for various artistic and production-related reasons, have found silver to be the most desirable metal to use for the white finishes. Because silver tarnishes, however, the silver plated pieces are lacquer dipped prior to finishing, packaging and shipment. The silver jewelry pieces are strung on the plating racks, and are passed through a dip lacquering system. The silver pieces are then unstrung from the plating racks. The plating racks are stripped of the lacquer with ethyl acetate. Currently, the facility purchases ethyl acetate, uses it to exhaustion, and then pays for its disposal as a hazardous waste. (*See* Exhibit I for the facility's process flow diagram).

[4] In terms of cost, rhodium is the most expensive of the three jewelry finishes. Rhodium is a hard, durable silvery-white precious metal that is often used to form high-temperature alloys with platinum, and is plated on other metals to create a corrosion-resistant coating.

V. THE POLLUTION PREVENTION PROJECT

The casewriter visited the plant in early April 1991 and met with Sutherland and Peter Thorston, the plant's environmental manager. Thorston, formerly responsible for the Sutton plant's waste management activities, was designated the plant environmental manager two weeks prior to the casewriter's visit. Sutherland and Thorston discussed the dip lacquering system (above), and the proposed solution to the high costs of purchasing and disposing of ethyl acetate. They reasoned that a change in equipment and operating procedures was not necessary on regulatory grounds since the facility was already in compliance with all applicable requirements. However, they decided that the purchase of pollution prevention equipment - namely, an ethyl acetate recovery still - would reduce the facility's purchase, disposal and labor costs - while reducing the facility's use of toxics. They saw the opportunity, given the trend set by toxics use reduction acts (TURA) nationally, to reduce Wrayburn's costs by reducing the facility's usage of ethyl acetate. In this case, Sutherland and Thorston predicted that they could completely eliminate the facility's use of ethyl acetate. Consequently, they had queried vendors on various recovery still models and settled upon a model appropriate to the facility's usage and energy requirements. (*See* Exhibit II for the specifications of the chosen model). The cost of this unit was $14,000, with an additional $2,000 in installation costs.

Since this purchase represented a capital investment outside of the annual capital budget formulated by Sutherland, the request for funds had to be submitted to Wrayburn corporate headquarters. Sutherland and Thorston drafted a detailed proposal comparing the costs of the current system with the savings of the recovery still. (*See* Exhibit III). The current method - purchase, use and disposal of ethyl acetate - was compared to the proposed method - purchase, in-house recovery and make-up as required. The current method amounted to $683.00 in purchase and disposal costs per week, compared to $350.28 for the proposed method. Sutherland and Thorston estimated that the installation of the recovery still would result in a weekly savings of $332.72 per week. This costs/savings analysis was extremely thorough, including utility expenses for the operation of the still ($4.25 per week). Based upon these savings, they estimated that the initial $16,000 investment would pay for itself within eleven months of installation and operation.

The estimation of costs and savings was detailed and meticulous. Despite this justification, the proposed equipment purchase has been "languishing" somewhere in corporate headquarters. The casewriter reviewed these costs with Sutherland and Thorston, and discussed the less obvious savings from the equipment purchase. For example, in the current manufacturing process, eight drums of ethyl acetate are generated on a monthly basis. Thorston labels and manifests these drums once per month, spending approximately an hour and a half completing the manifest. Given the reduced ethyl acetate use and disposal with the installation of the still, the facility's labor cost would be reduced: instead of manifesting twelve times per year, Thorston would manifest only four times per year. For the purpose of the analysis, Thorston's wage rate was calculated at $30 per hour, including the cost of employee benefits.

The casewriter reviewed other potentially hidden costs involved in the purchase of the still, including training, protective equipment, monitoring, taxes and fees:

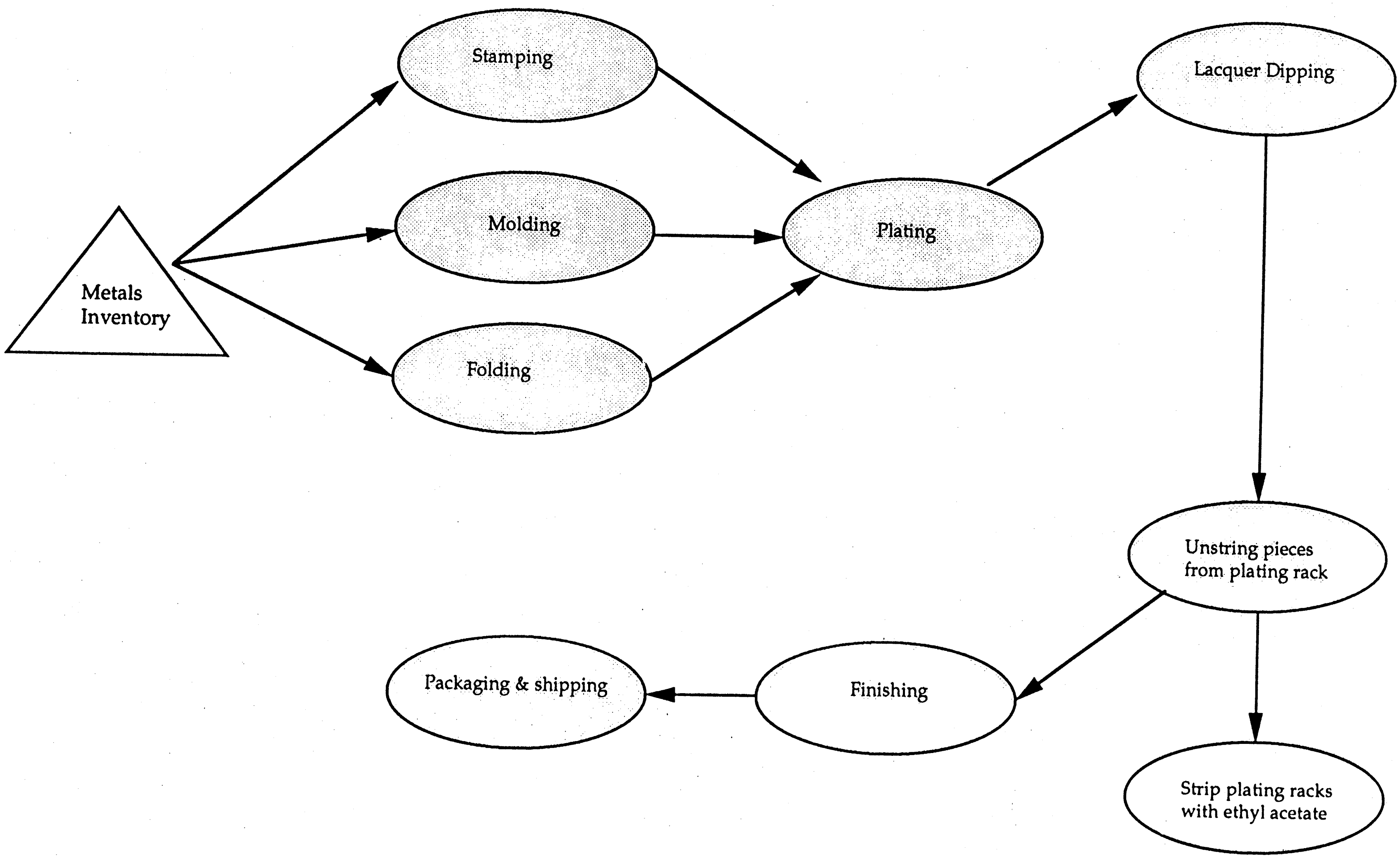
- The amount of time devoted to Right to Know and other types of worker safety training is unchanged with this equipment, given the large numbers of other chemicals on site which require attention in training sessions. In other words, the amount of time spent explaining procedures for the handling of the ethyl acetate could not be disaggregated from the overall expense of the training session.
- The normal monitoring activities occupying Thorston's work day are not radically changed with the still installation. The amount of time spent in periodically checking the still's operation is approximately the same as checking the operation of the dip lacquering system for malfunctions.
- The reduced ethyl acetate usage saves the plant $1100 per year in TURA (Toxics Use Reduction Act) fees.

Since Sutherland received no response from headquarters on the proposal for the purchase of this equipment, he sought the casewriter's assistance in presenting the costs and savings in a financial format. This presentation, he reasoned, would convince management of the attractiveness of the pollution prevention equipment from a cost reduction point of view.

The casewriter performed a discounted cash flow project analysis to estimate the value of the equipment's projected cash inflows over its ten-year economic lifetime. (*See* Exhibit IV). She analyzed Wrayburn's capital structure, and estimated a 12 percent cost of capital for the company. Also, she assumed a 5 percent annual inflation rate, a 10 year economic life for the project, and a 40 percent corporate tax rate. Given the savings from the reduced ethyl acetate purchase and disposal, in addition to the saved TURA fees and reduced labor costs, the project had a very favorable return with a net present value exceeding $60,000. While the payback calculation was convincing (eleven months), the discounted cash flow analysis took into account the time value of money, and all the less obvious savings resulting from the equipment installation. The analysis also yielded a much more realistic, accurate view of the cash inflows and outflows resulting from implementation of the project, in addition to tax and inflation effects. The savings associated with the pollution prevention equipment more than justified the initial capital investment of $16,000.

Wrayburn Jewelry Company - Sutton Facility
Process Flow Diagram
Manufacture of High Fashion & Private Label Jewlery Lines

Exhibit I



In-House Solvent Recovery

Small Volume Batch Feed

Thousands of Installations

Turn your hazardous waste solvent into profits with Finish Company, Inc. in-house solvent recovery equipment. Manufacturing solvent handling equipment for over thirty years, Finish Company has established itself as the industry leader in in-house solvent distillation technology.

Thousands of distillation units operating successfully attest to the reliability of our equipment. Companies worldwide are reclaiming contaminated solvents on-site into clean, reusable solvent for just pennies per gallon.

Advantages

LS Series solvent recovery equipment is uniquely designed and can provide many years of safe, simple and efficient daily operation . . . virtually maintenance-free. This equipment provides typical payback in 6 to 12 months and when properly installed and operated satisfies the most stringent safety and emission standards for in-house solvent reclamation.

Compared to outside reclamation services, in-house distillation with LS equipment can return a purer product, provide a higher recovery yield and allow you to control your distillation schedule — all at exceptionally low operating costs.

In addition, liabilities for transportation and disposal of hazardous waste are substantially reduced. In recent years, the Resource Conservation Recovery Act (RCRA) has given "cradle to grave" responsibility to generators of hazardous waste for its storage, transportation and disposal.

In-house reclamation reduces the staggering cost of handling waste in compliance with EPA regulations.

Capacities

The LS Series is comprised of four basic models designed to process batches of 3-5, 15, 55 or 110 gallons of contaminated solvent per shift. The standard units are capable of handling solvents with boiling points ranging from 100° to 320°F. For solvents with boiling points from 320° to 500°F, use our standard LS Series plus optional vacuum attachment.

Safety Design

Finish Company solvent recovery equipment is unmatched in its attention to daily operator safety and environmental responsibilities. All LS Series units strictly adhere to Class I, Division I, Group D (NEMA 7) electrical code standards. Each LS unit is accompanied by a Stilmanual, which provides careful recommendations on installation and operation.

Made in the U.S.A.

LS equipment is researched, designed, produced and tested at our 50,000 square foot modern manufacturing facility located in Erie, Pennsylvania.

Meeting Your Requirements

Prospective applications are evaluated by our Engineering and R & D Departments to ensure that each unit meets specific usage requirements. In our fully staffed and equipped Laboratory, we conduct daily evaluations concerning all facets of distillation technology.

Contract testing is available. You send a clearly defined sample of your contaminated solvent to be distilled, and Finish Company will provide reports and an LS equipment recommendation. Demonstrations and full scale testing can be arranged on any of the LS Series units.

Consult Those Who Know

Finish Company sales engineers and chemists offer years of experience in solvent distillation covering diverse industrial applications and stringent military specifications. Printers, paint manufacturers and users, fiberglass molders, utility companies, government agencies and metalworking plants are just a few of those reclaiming millions of gallons of solvent on-site each year with Finish Company equipment.

A network of North American and International sales representatives offer continued support. These people have constant direct line access and contact with Finish Company, Inc.

A metal fabricator recovers 99% pure degreasing solvents with a Model LS-15D. Investment payback was realized in just a few months. This is one of thousands of successful installations in use worldwide by printers, fiberglass molders, and manufacturers of paint, adhesives, electronics, auto parts, etc.

A midwest paint manufacturer uses a Model LS-55D to distill 55 gallons per day of solvent contaminated with various paint pigments and resins. Solvents reclaimed include MEK, MIBK, xylene, methanol, and toluene. Payback was realized in a few short months

How it Works . . .

Boiling Chamber Filled
Solvent is poured or pumped into the Teflon*-coated boiling chamber, which the operator lines with a standard Stilbag. In lieu of Stilbag, an optional Teflon-coated Stilpan may be used.

Solvent Heated
After the chamber lid is secured, power to the unit is activated. Heat is transferred from the patented encapsulated heater through the conductive walls of the chamber directly into the solvent.

Vapors Formed
As the solvent boils, vapors form and pass through the vapor tube into a water-cooled shell-and-tube condenser.

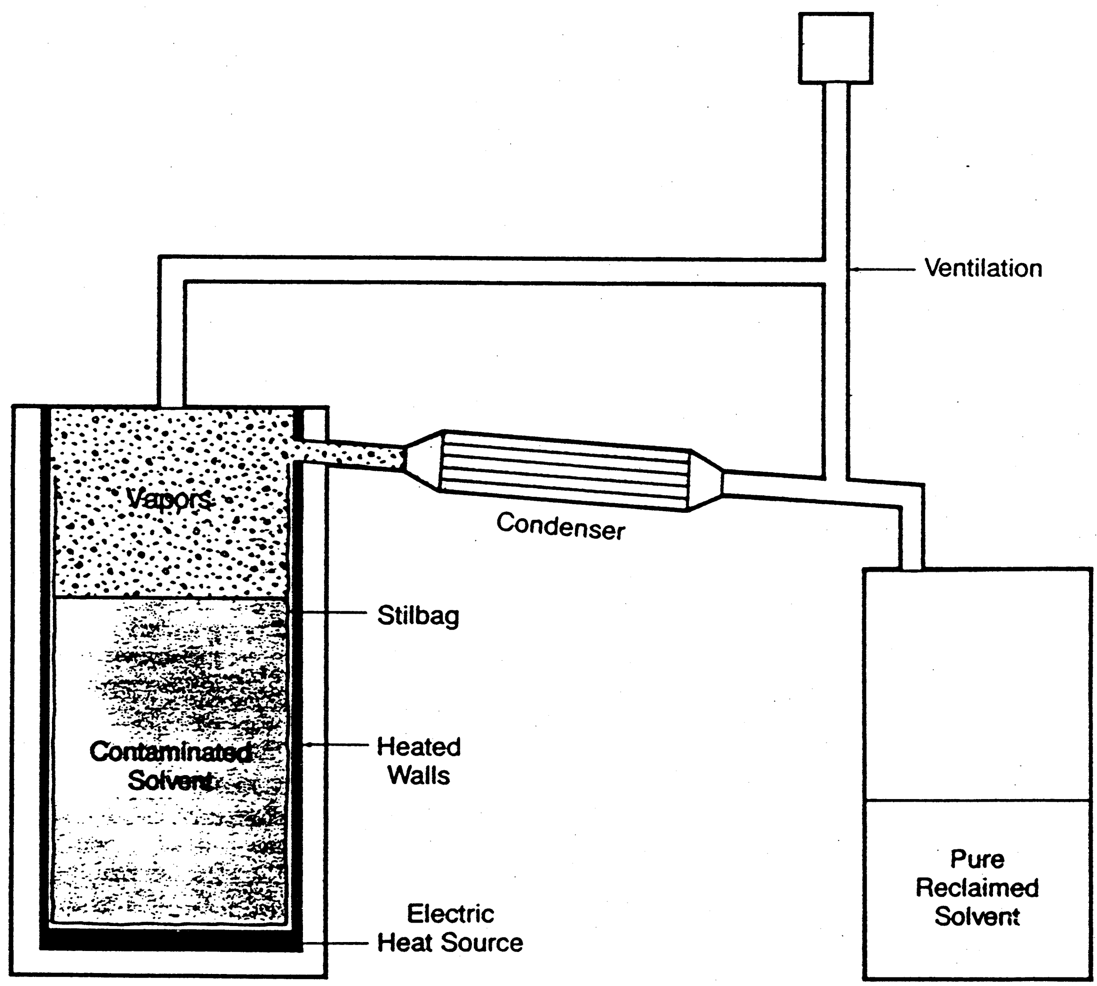
Vapors Condensed
Vapors are condensed into a liquid state. This clean, clear, 99%-pure distillate gravity flows into an approved customer-provided 15- or 55-gallon drum.

Cycle Completed
When visual check through sight glass indicates no further distillate is available, the unit is shut off and allowed to cool.

Residue Removed
After cooling, residue remaining behind in the Teflon-coated boiling chamber is then removed via the Stilbag or optional Teflon-coated Stilpan.

*DuPont registered trademark

Distillation Schematic



Design and Safety Features

Safety Design
Finish Company solvent reclaimers are built to Class I, Division I, Group D (NEMA 7) standards of the National Electrical Code.

Patented Encapsulated Heating Element
Heating element is encapsulated within the vessel bottom insuring direct heat to 100% of the vessel surfaces. This method eliminates the need for inefficient hot oil immersion heating. The encapsulated heater on all LS Series units carry a five year warranty.

Residue Removal System
Residue is contained within disposable Stilbag liner for convenient removal and handling. Teflon-coated Stilpan is optionally available. Distillation chamber is Teflon coated for ease of cleaning.

Water-Cooled Condenser
Efficient shell-and-tube design provides complete condensing of vapors, allows easy cleaning, and eliminates need for pumps or other moving parts. Solvent gravity flows into an approved customer-provided 15- or 55-gallon drum.

Push/Pull Lighted Indicator
Shows on and off positions. Light indicates sufficient water flow through condenser for operation of boiling chamber.

Condenser Water Flow Switch/Interlock
The distillation unit operates ONLY when sufficient volume of cooling water is present. Interruption of water terminates power to unit.

Adjustable Flow Meter
Console-mounted gauge with dial allows personnel to set volume and observe actual flow of cooling water to condenser for efficient usage.

Adjustable Temperature Controller
Operating temperature can be set to 350°F.

Vapor Temperature Gauge
Indicates vapor temperature throughout distillation run. Used to determine the optimum termination point.

Quick Cool Coil
Allows for fast cooling of distillation tank for multi-shift use.

Vacuum Capability
All LS Series units will accept our unique JetVac Attachment allowing recovery of solvents with boiling points up to 500°F.

Dual Thermostat Controls
Two override thermostat controls are provided so that the unit temperature does not exceed the Underwriters Laboratory's recommendation for heater temperature in a Class I, Division I, Group D environment.

Fully Insulated
Total distillation tank including lid is insulated with ceramic fiber for heat retention to provide efficient distillation.

Dual External Venting System (DEVS)
Provides safe transmission of potential vapors away from distillation site when properly customer-installed and operated. DEVS involves:

- Pressure Relief Valves
  a) enables vapors to escape into DEVS from boiling chamber at .5 psi.
  b) prevents pressurization of distillate receiving container.
- Vacuum Attachment Port for installation of modular vacuum attachments.
- Swing Check provides for vapor exhaust under vacuum operation.
- Sight Glasses allow visual inspection of
  a) venting system
  b) reclaimed distillate flow.
- Flame Arrester conforms to NFPA requirements for the emission of vapors.

Installation Guidelines
- Still must be located in an enclosure with only explosionproof electrical devices present and with electrically interlocked floor ventilation.
- Ground all containers.
- Still installation must be approved by an accredited inspector prior to operation.
- Detailed manual and safety instructions accompany each still.

Exhibit IV
Wrayburn Jewlery Company, Inc.
Sutton Facility

Discounted Cash Flow Project Analysis
Capital Budgeting for Installation of Ethyl Acetate Recovery Still

Item	Year	BTCF*	ATCF**	Present Value Factor (12% Cost of Capital)	Present Value (Total for Cost Category)
Purchase Ethyl Acetate Recovery Still	0	($16,000)	($16,000)	1	($16,000)
Depreciation 10 Year Life Assumed Straight Line Method	1 - 10	$1,600	$640	Various	$3,616
Current Purchase Costs Ethyl Acetate ($475.80 per week x 50 weeks) 5% annual inflation	1 - 10	$23,790	$14,274	Various	$96,969
Disposal Costs Saved Ethyl Acetate ($207.20 per week x 50 weeks) 5% annual inflation	1 - 10	$10,360	$6,216	Various	$42,228
Purchase Costs Ethyl Acetate with Still ($113.10 per week x 50 weeks) 5% annual inflation	1 - 10	($5,655)	($3,393)	Various	($23,050)

Item	Year	BTCF*	ATCF**	Present Value Factor (12% Cost of Capital)	Present Value (Total for Cost Category)
Disposal Costs with Still ($237.18 per week x 50 weeks) 5% annual inflation	1 - 10	($12,333)	($7,400)	Various	($50,271)
Utility Costs Recovery Still ($4.25 per week x 50 weeks) 5% annual inflation	1 - 10	($213)	($128)	Various	($866)
Manifesting Costs Saved (1.5 hour/activity x $30/hour wage rate x 8 occurrences per year) 5% annual inflation rate	1 - 10	$360	$216	Various	$1,467
TURA Fees Saved 5% annual inflation	1 - 10	$1,100	$1,100	Various	$7,473
				Net Present Value =	**$61,566**

* BTCF = Before Tax Cash Flow.
** ATCF = After Tax Cash Flow.
Wrayburn's corporate tax rate is 40%.

Cost Savings for Ethyl Acetate Recovery Still

Current Method: Purchase/Use/Dispose

Purchase Costs:

Current consumption of ethyl acetate stripping 600-700 racks per day = 100 gallons/week

Density = 7.8 lbs./gal.

Weekly purchases in pounds = 780lbs.

Cost of new ethyl acetate = $ 0.61 per pound

Weekly cost to purchase ethyl acetate = $ 0.61/lb.x 780lbs. = ... $ 475.80

Disposal Costs:

Evaporation/dragout losses = 5%

Current weekly disposal volume = total purchased volume 5% = (.95)(780 lbs.) = 740lbs.

Disposal cost of spent ethyl acetate = $ 0.28 per pound

Weekly cost to dispose of ethyl acetate = $ 0.28/lb.x740lbs. = ... $ 207.20

Total current weekly cost for ethyl acetate = ... $ 683.00

Proposed Method: Purchase/Recover in house/make up as required. Purchase of solvent still with permit recovery of approximately 75% ethyl acetate, disposal of balance as still bottoms.

Purchase costs:

Purchase costs of new ethyl acetate per week = .25 x 780 lbs/week x $ 0.58/lbs. = 195 lbs. @ $0.58 = ... $ 113.10

Disposal Costs:

Disposal volume of still bottoms = .25 x 740 lbs/week = 185 lbs/week

Disposal cost of still bottoms estimated @ $1.28 per pound (Note:Disposal cost of still bottoms significantly higher as recyclable product has been largely removed).

Weekly disposal cost of still bottoms = 185 lbs x $ 1.28/lb. = ... $ 237.18

Total weekly cost for ethyl acetate
with still recovery = ... $ 350.28

Estimated weekly savings:
Weekly cost - old method .... $ 683.00
Weekly cost with still .... $ 350.28
Weekly savings: .... $ 332.72

Still Cost:
Still and peripheral equipment: .... $ 14,000

Installation cost (In-house labor and
materials, not capitalized): .... $ 2,000

Total estimated cost: .... $ 16,000

Payback Analysis:
$16,000 total cost/$333 savings per week
= 48 week payback
or 11 month payback

Notes:
- Still can be operated at no additional labor cost

- Utility costs for operation are estimated at:
--15 gals recovered per 8 hours of operation
--100 gallons/15 gallons/8 hours x 53 hours per week
--Power requirements = 4 KW
--Weekly power consumption = 212 KW-hours
--Operating cost = 212 KW-hours per week x
$ 0.02/KW-hour= .... $ 4.25

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Once all of the items have been listed, cash flows filled in, and present values calculated, the sum of all these PVs is the Net Present Value. The decision rule for NPV is very simple: if the NPV is greater than zero, the project is economically feasible.

In terms of filling in cash flows, one must remember to project estimated cash flows over the economic lifetime of the project. In other words, if the economic lifetime is five years, then items such as labor savings and/or maintenance costs should be estimated over five years. Second, the costs that should be included in the analysis are those that are directly tied to the possession of the equipment. Third, sunk costs should be ignored in this analysis. "Sunk costs" are those costs that have already been paid or committed; this analysis is concerned with incremental, or differently costs, or those that are affected by the implementation of the project. Likewise, costs that are the same for all the alternatives are ignored.

Keep in mind that this analysis is only half the entire picture. This quantitative analysis only indicates the economic attractiveness of a project, and does not account for all the qualitative issues involved in the purchase. For example, worker safety, compliance, market share, and potential liability are a few of the possible qualitative issues. In some cases, the qualitative aspects override the quantitative aspects. For example, the net present value of a particular project might be negative, indicating that the initial capital outlay exceeds the projected inflows. However, in the interests of reducing potential liability resulting from the current operations, the project is implemented on qualitative grounds.

LIGHTOLIER, INC.

FALL RIVER DIVISION

Costing and Financial Analysis of
Pollution Prevention Projects

July 1991
Marlene R. Wittman

Printed on recycled paper

I. EXECUTIVE SUMMARY

The Aluminum Processing Company (APC), a subsidiary of Lightolier, Inc., manufactures aluminum reflectors for Lightolier's track and recessed lighting product lines. Based in Fall River, Massachusetts, APC had recently embarked upon a program of pollution prevention techniques in its manufacturing processes. Lightolier, Inc., headquartered in Secaucus, New Jersey, had drafted a corporate environmental statement which provides the overall guidance for its subsidiaries and employees. Corporate headquarters maintains a policy whereby each subsidiary has the responsibility to translate this statement into action in the maintenance of environmentally sound manufacturing operations.

At APC, Michael Cahill of the Manufacturing Engineering Department provides the direction for environmental projects; he often works in conjunction with Don Williams, an engineer from Lightolier - Genlyte headquarters. APC's current pollution prevention techniques include capital budgeting expenditures for two vapor degreaser replacements, and an oil substitution in the manufacturing process. Future environmental plans include the transition to a closed loop system in the next few years, and the change of its reporting status from a large quantity generator to a small quantity generator by 1992.

The acquisition of the new degreasers involved an analysis of the financial ramifications of the expenditure, and approvals from several management layers. The justification for the expenditure included a quantitative evaluation of the costs and savings from the project, in addition to consideration of qualitative factors. Costing and financial analysis of Lightolier's initial capital investment in the degreaser yielded a positive net present value exceeding $90,000 over the project's economic lifetime. Based upon the financial and qualitative aspects of the project, corporate headquarters approved the project.

II. COMPANY BACKGROUND

The Aluminum Processing Company facilities are situated in a Fall River industrial park in southern Massachusetts. APC has occupied the site - 400,000 square feet of industrial space in four buildings - for approximately 18 years. APC's sales revenues were approximately $110 million in 1990.

APC is a plant of approximately 500 workers, 450 of which are on the shop floor; the plant operates two shifts per day. The facility is a union shop (International Brotherhood of Electrical Workers - IBEW) and shop employees work according to piece rate incentives; in this particular facility, 100 pieces per hour is standard. From an accounting standpoint, APC utilizes a standard costing system and schedules production runs with MRP II, or a Material Requirements Planning system.[1] APC produces thousands of reflector products, and most differ only in terms of type of finish, or degree of reflectivity.

While the Fall River facility manufactures the reflectors for Lightolier's track and recessed product lines, its Connecticut facility manufactures the company's fluorescent product lines. Prior to Lightolier's corporate restructuring program in 1989, the Edison facility produced outdoor lighting and track lighting; when the Edison plant was closed down, APC picked up the production of Edison's track and recessed product lines. Lightolier operates additional plants on the West Coast and in Mexico.

III. CAPITAL BUDGETING PROCESS

The capital budgeting approval procedure at Lightolier is very formal: it begins with the originator's development of the project parameters and requirements, a request for proposal (RFP), and the in-house Project Appropriation Request Form (PAR). The justification process includes its review by several levels at the plant and at corporate headquarters, in addition to a sign-off from each of these layers of the organization (*See* Exhibit I, the organizational chart for the APC facility). Generally, expenditures require operational and divisional approvals (in this case, from APC) and Genlyte Group corporate approvals (from headquarters in New Jersey).

The PAR is Lightolier's standardized project justification form for capital expenditures. The form includes financial analyses for the projects' cash inflows and outflows, a qualitative assessment as to the project's benefits, and a vendor spreadsheet. Project funds are disbursed after the PAR has been reviewed and approved by each of the corporate levels.

IV. THE MANUFACTURING PROCESS

The manufacture of aluminum reflectors involves the following processes: 1. thin sheet aluminum is cut to a particular diameter, depending upon the model type of reflector; 2. the sheets are passed on to the Hydroform machine, where it is pressed into the reflector shape by

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[1] An MRP system is a computerized planning and control system for manufacturing operations; a Type II MRP system is an information system used to plan and control inventories and capacities in manufacturing companies. The Type II system has a feedback loop between the orders launched and the master production schedule to adjust for capacity availability. As a result, this type of MRP system is often called a closed-loop system because it controls both inventories and capacity. (Schroeder, Operations Management. Second Edition. New York: McGraw-Hill Publishing Company, 1985).

a form-covered baffle (the reflectors acquire a thin coating of oil in the Hydroform); 3. the newly-formed reflectors are loaded into the baskets of the vapor degreaser, where they are washed, drained, rinsed, and drained a second time; 4. the reflectors are then buffed and finished for high reflectivity; 5. reflector models requiring a metal plating process are sent to the plating baths; reflector models requiring a paint finish are sent, via two conveyor belts, to the paint spray booths and baking ovens; 6. reflectors are carefully packaged to preserve the high grade finish and either delivered to the end-user or placed into on-site inventory. (*See* Exhibit II for the facility's process flow diagram).

V. THE POLLUTION PREVENTION PROJECT

The manufacturing process outlined above involves pollutants at two points. First, the vapor degreasers utilize trichlorethylene (TCE), a Form R substance; second, the paint spray booths release toxic air emissions, thereby creating uncomfortable breathing conditions for the employees in the area. Cahill chose to tackle both of these problems simultaneously by recommending the replacement of one degreaser with an aqueous solution model, the replacement of another degreaser with a combination degreaser/electrostatic powder coater unit, and the substitution of the oil in the Hydroform with a non petroleum-based oil. The project, conceived and initiated in the summer of 1989, involved two equipment replacements and a process change.

In 1990, the plant used 73.5 tons of TCE. Less than 7.30 tons of spent TCE was removed and recycled by the vendor. The vendor credited APC for this recycled amount. With the replacement of two of the degreasers, TCE usage for 1991 is estimated to be approximately 15 tons, an 80 percent usage reduction. Cahill estimates zero use for 1992.

The catalyst for a replacement of this magnitude was the age and poor condition of the degreasers; all three degreasers were in the 20-25 year old range, and one had been brought from APC's previous facility during the move to its present site in 1973. The choice, as perceived by Cahill, was to continue to maintain these machines and replace them in five years, or to replace all three machines immediately. The former option was untenable because of the amount of downtime and inefficiency caused by frequent repairs. Moreover, plant management wished to minimize employees' contact with the chlorinated solvent. (Lightolier's corporate environmental policy involves a toxics use reduction to four percent of current use by 1996; the incentive underlying this goal is concern with worker safety).

Cahill, with the guidance and suggestion of Don Williams in the Secaucus office of Lightolier, drafted the requirements for a replacement degreaser. Cahill and Williams, in effect, developed a set of blueprints for the physical dimensions of the proposed unit, in addition to operational requirements. (*See* Exhibit III). After refining the systems requirements and consulting with industry contacts as to reliable vendors, they sent requests for proposals (RFPs) to sixteen vendors of aqueous products. (*See* Exhibit IV).

While waiting for vendors to respond to the RFPs, a plan was devised to phase in the new degreasers while the old ones were still operating in order to prevent disruption in production. One aqueous degreaser would be installed, immediately replacing one old degreaser; the remaining two old machines would operate below capacity; for example, the new degreaser would run for 13 hours per day, and the two old machines would run for 8 hours per day. The powder coater/degreaser would then be installed, and the second old degreaser would be taken off the line and dismantled. The end result would be the operation of two new degreasers and one old degreaser in parallel for six months to assess capacity and efficiency. In tandem with this phased-in replacement, the oil used in the Hydroform would be replaced with a less costly non-petroleum lubricant.

VI. ECONOMIC JUSTIFICATION OF THE PROJECT

Cahill received twelve proposals from vendors, ranging from $81,735 to $147,000 in base cost (excluding installation, permitting and other peripherals). Cahill then reviewed the specifics of each proposal and laid them out in spreadsheet format for analysis and evaluation. (*See* Exhibit V for this spreadsheet analysis). During the fall of 1989 and early 1990, Cahill continued to receive bids and evaluate proposals. He recommended the purchase of one model and prepared documentation to satisfy management's justification requirements for this expenditure.

The decision as to choice of model and vendor rested with Cahill; he decided, on the basis of technical merits, options, design, electricity and water usage, to chose the proposal in the $117, 500 range. In February 1990, he filled out the PAR for capital budgeting approval. The PAR form included a brief narrative of the project, the amount requested for approval, the payout period, rate of return, and summary description of project benefits.

The financial analysis section of the PAR included an income statement analysis, an investment and cash flow analysis, and a breakdown of the project expenditures. Cahill's vendor spreadsheet served as an exhibit to the justification package. (*See* Exhibit VI for a copy of the PAR package).

Cahill's completed PAR stated that although the accounting rate of return was not immediately favorable, the ongoing efficient operation of the plant would be threatened if the equipment were not replaced. Moreover, even though the facility was currently in compliance, the plant should plan for TURA (Toxics Use Reduction Act) requirements, which mandate that companies plan for reductions in the use of chlorinated solvents. The equipment replacement looked extremely favorable if the costs of purchasing the TCE and disposing of it as a hazardous substance were included in the justification:

> "This appropriation request is sorely needed to replace an old decrepit solvent vapor degreasing machine. The direct return on investment is not to current standards, however, it is only prudent business-wise to replace this machine as quickly as possible for a number of reasons:
>
> (1) The existing machine may literally breakdown completely and make production schedules impossible. . . .
> (3) The hazard of spills requiring the evacuation of the entire factory will be eliminated.
> (4) The basic costs of the solvents and the expensive disposition of the spent solvent chemical.
>
> The three-stage washer specified has all the capacity required for the future "work-cell" relayout of the APC factory. This in-process cleaning center will include a self-contained wastewater treatment system so that all surplus water can be drained directly into the sewer system, not through the existing near-to-capacity waste treatment plant at APC. Approval time for this PAR is of the essence since this machine must be installed during the early July plant shutdown to avoid costly and troublesome problems."

Therefore, Cahill used a number of convincing arguments for the implementation of this project, ranging from the expected cost reductions to the environmental and safety concerns of the facility.

VII. FINANCIAL ANALYSIS

Cahill's financial analyses were very thorough, accounting for cash inflows and outflows for the entire 10-year life of the project (ie., expected economic lifetime of the project). (*See* Exhibit VI). The first analysis projected the estimated cost of the current solvent, the cost of disposing of the spent solvent, the project depreciation (ten year straight line method), and the cost of the new non-toxic, biodegradable detergent. Both the current solvent and the substituted detergent costs were adjusted for inflation. The two expected cash flows from the installation - project depreciation and detergent chemical cost - were subtracted from the two costs of operating the current degreasers- solvent cost and spent solvent disposal - for a before-tax net savings:

Example from the PAR - First Year 1990

Col.1 Cost of Solvent	*Col 2.* Disposal of Spent Solvent	*Col.3* Depreciation	*Col. 4* Detergent Cost	*Col.5* EBIT*	*Col.6* Net Profit
$31,104	$3,120	$13,467	$10,500	$10,257	$6,257

Column 5 = (Column 1 + Column 2) - (Column 3 + Column 4)
Column 6 = Column 5 - Taxes, or Net Profit = EBIT - Taxes
Example: $10,257 x 39% tax rate = $4,000
$10,257 - $4,000 = $6,257

* EBIT = Earnings Before Interest and Taxes

The total net profit from the project over the next ten years was an after-tax amount (the corporate tax rate used here was 39 percent). The total net profit, calculated in this accounting manner, totaled $99,873 over the lifetime of the project.

This approach took into account the more obvious costs and savings from the installation, such as purchase and disposal costs of TCE, purchase costs of the detergent, and project depreciation. The narrative expanded upon additional savings resulting from the project, but these were not included in the cash flow projection. These savings included the following items:

> i) ". . . it is fair to say that a cost avoidance of $20,000 maintenance cost per year could be claimed for this project.
>
> ii) The machine manufacturer has quoted $25,000 for parts only to renovate the existing machine for the long term. Labor associated with these parts will bring a total repair cost of about $40,000.
>
> iii) Should the current machine fail, a major costly production disruption would result. Approximately 4.4 million parts are processed through this washing system per year. These parts represent 40 percent of all degreased parts and most of these cannot be processed through existing systems." (*See* Exhibit VI, PAR, p. 2)

This type of financial analysis is fairly common in companies requiring a standard justification form. The analyses project only verifiable cash inflows and outflows over the lifetime of the project, and estimate a simple accounting rate of return based upon the initial expenditure and project depreciation. The usual, obvious costs and savings are listed on an annual basis, while the less obvious are mentioned in the narrative sections of the form. This form also categorizes the nature of the capital budgeting request, such as cost reduction, replacement, safety, or environmental. This type of analysis does not take into account the time value of money, or the hidden and/or intangible costs and savings associated with the project.

The Lightolier PAR was signed off by a number of management layers, including operational approvals by the engineering manager, the controller, the Quality Control (QC) manager, the general manager, and Vice President - Operations at APC. Corporate approval included sign-offs by the Vice President - Finance, and President of APC. Genlyte corporate approval included sign-offs by the Vice President - Finance, and the President at headquarters in New Jersey. This particular capital budgeting expenditure was approved rather quickly: there was only a two day delay between APC and Genlyte corporate sign-offs.

VIII. DISCOUNTED CASH FLOW PROJECT ANALYSIS

In his discussions with the casewriters, Cahill described this capital budgeting procedure and the steps he took to produce the justification package. After they had reviewed Cahill's analysis of the more obvious costs and savings from the installation of this equipment, the casewriters evaluated the project's hidden costs and savings. These less obvious costs and savings, although rough estimates, were projected over the lifetime of the project and adjusted for inflation. These hidden costs included the following:

i). **Maintenance Costs** - Cahill's department estimated that the maintenance on the old machine amounted to $20,000 per year. The replacement of this machine eliminated the need for this expenditure over the lifetime of the project.

ii). **Labor Costs - Spill/Leak Incident Reporting** - Cahill calculated that approximately 40-50 hours per year were spent on incident reporting (ie., phoning to the appropriate environmental agency and completing the related documentation). Most of these incidents were related in some way to the existence of TCE on the premises. The replacement of the degreaser eliminated the use of TCE and the labor hours spent in incident reporting. To calculate the savings associated with this project, the engineering wage rate ($30 per hour) was multiplied by 45 hours (the mean of 40 and 50), adjusted for inflation, and projected over 10 years.

iii) **Labor Costs - Monitoring/Manifesting** - Cahill estimated that 10 percent of his work week was devoted to TCE monitoring and manifesting activities. This 10 percent represented his time spent monitoring the two vapor degreasers and manifesting TCE shipments. To calculate this figure, the engineering wage rate ($30/hour) was multiplied by four hours per week and then by 50 weeks to obtain the total annual labor costs saved by the project.

iv). **Labor Costs - Right to Know Training** - Both application engineers spent a total of 70-80 hours per year for two Right to Know training sessions for the entire facility. Forty percent of the questions, concerns, and training exercises related to workers' handling of TCE. To calculate this figure, the engineering wage rate ($30/hour) was multiplied by 75 hours (the mean of 70 and 80 hours) and then by 40 percent to obtain the total labor costs saved if TCE is eliminated from the facility.

v). **Labor Costs - Labelling** - The manufacturing engineering department spent approximately 150 hours per year labelling the incoming and outgoing TCE. Again, the labor savings was calculated by multiplying the engineering wage rate ($30/hour) by 150 hours.

Cahill and the casewriters discussed other costs and savings which were not as readily quantifiable or which did not noticeably change with the implementation of the pollution prevention project:

i). **Downtime Costs** - In the event of a facility-wide evacuation, or in the event of a fire caused by TCE, the plant would experience an expensive downtime. This could be estimated by the probability of the event occurring and the potential sales losses from late deliveries to customers.

ii). **Protective Equipment** - Gloves and glasses are normally used on other lines and for other processes in the plant, so this cost would not change with the elimination of TCE use.

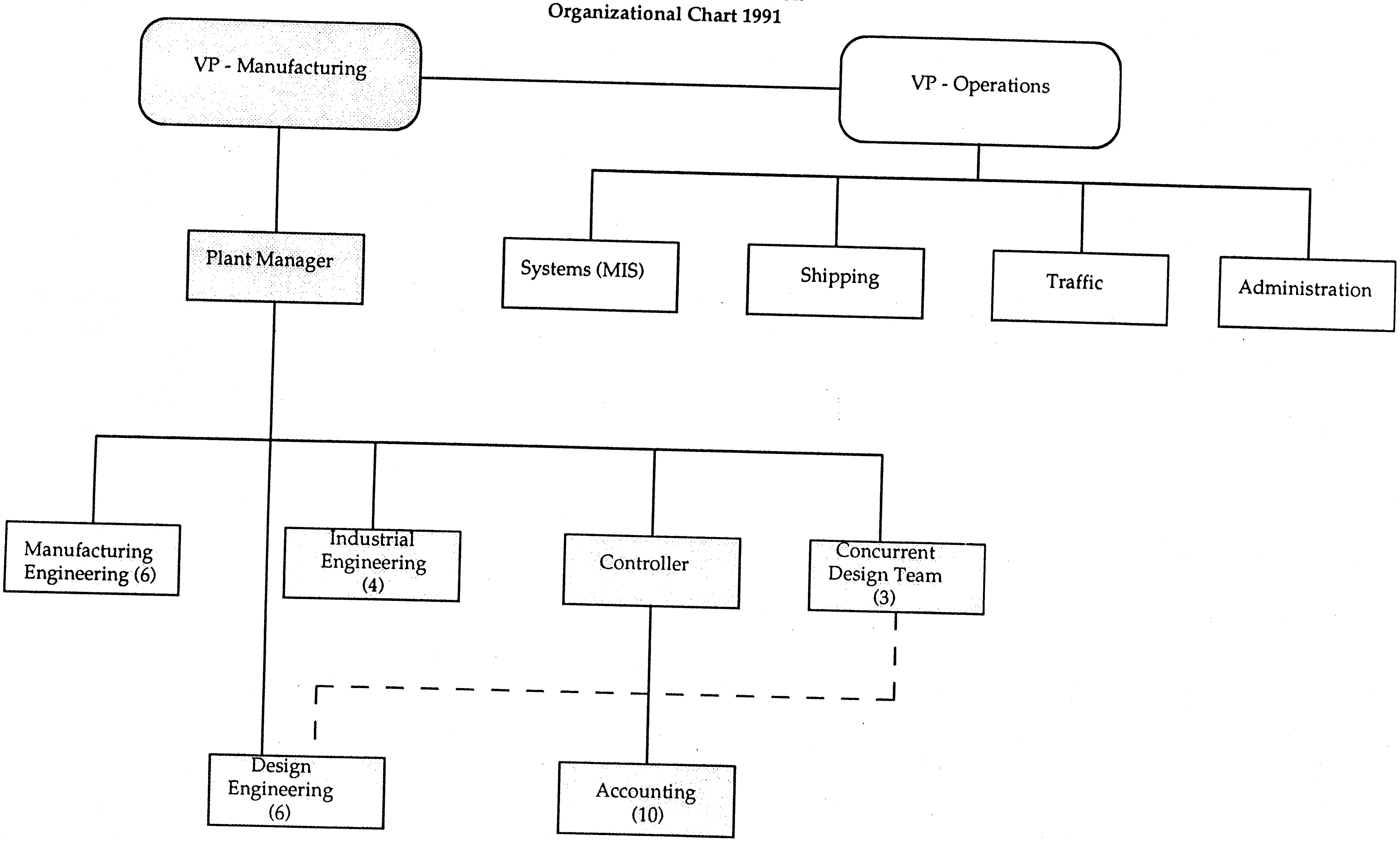
iii). **Permitting and Fees**- The labor costs associated with TCE permitting would not change significantly with the project because of the volume of required reporting for other substances used in the plant. The TURA fees associated with TCE would be reduced once the plant's TCE usage falls below 10,000 pounds annually. Since Cahill estimated that the plant would use approximately 15 tons (30,000 lbs.) of TCE in 1991, the plant would have to pay the $1100 fee for 1991. However, in 1992, the plant would have zero TCE usage, thereby saving the estimated TURA fee.

iv). **Research and Development Costs (R&D)** - The chemical company supplying the new detergent recommended an appropriate cleaning solvent for the aqueous degreaser, and lubricant substitution for the Hydroform. This R&D cost was borne by the chemical company, and not by APC. This saving, therefore, cannot be included in the analysis; if, at some future point, APC makes a further process change and invests time and materials in R&D, then this cost must be accounted for in the project evaluation.

The casewriters consolidated these hidden and usual costs into a spreadsheet and evaluated them in terms of a discounted cash flow model. (*See* Exhibit VII). Estimated costs and savings were projected over the 10 year economic lifetime of the project in before- and after-tax cash flow format. The corporate tax rate used was 39 percent, and APC's cost of capital was estimated at 15 percent.

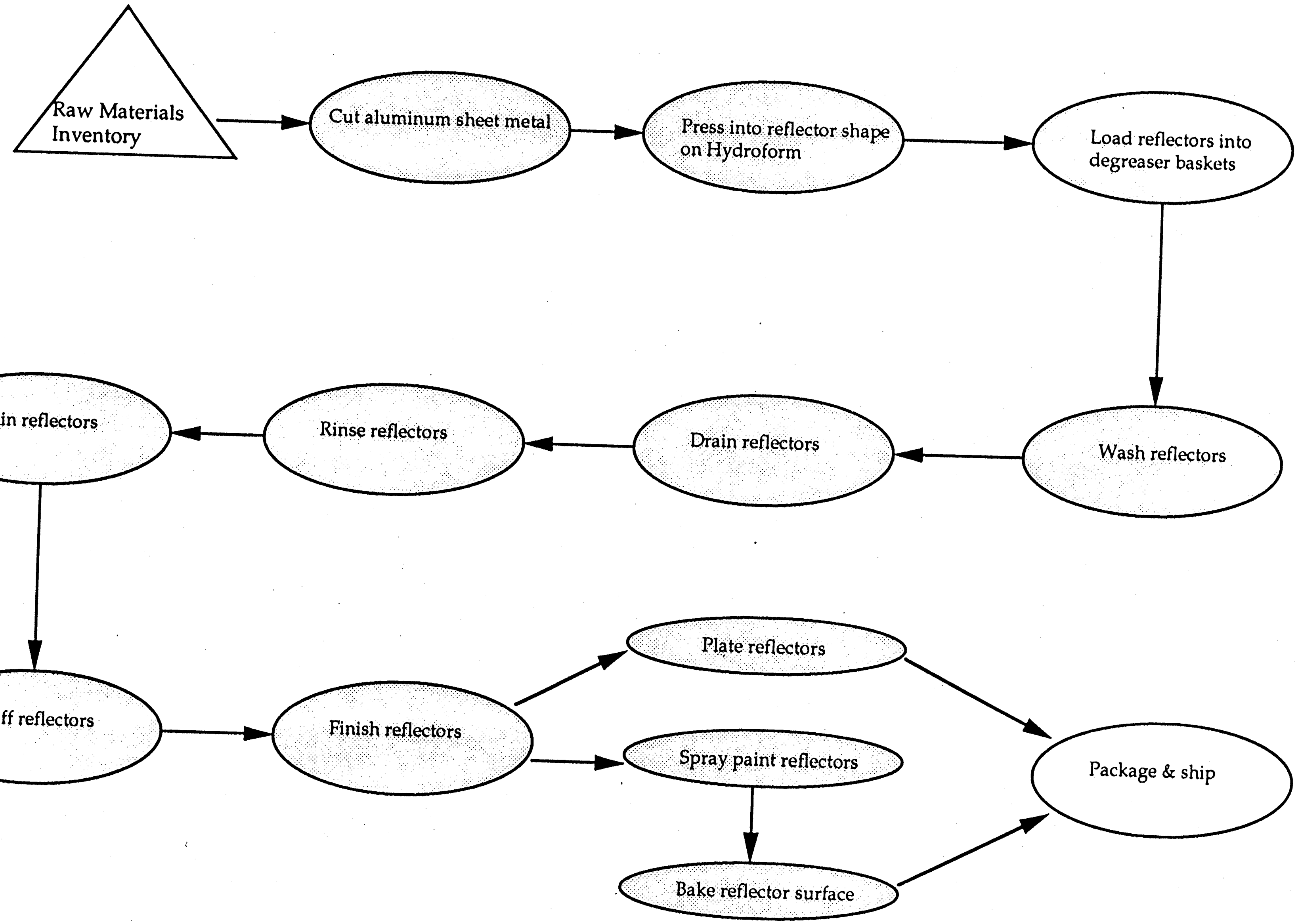
This project, inclusive of the usual and hidden costs, yielded an extremely favorable (ie., positive) net present value of approximately $93,000. The discounted cash flow analysis rendered a much more accurate view of the project than Cahill's accounting rate of return analysis because it included tax and inflation effects, and the time value of money. Consequently, this financial analysis demonstrated that this project, on its cost merits alone, added value to the company.

Exhibit I
Aluminum Processing Company
(APC)
Lightolier - Fall River Division
Organizational Chart 1991



Lightolier - Fall River Division
Process Flow Diagram
Manufacture of Aluminum Reflectors for Lighting Systems

Exhibit II



Aluminum Processing

DIVISION OF

LIGHTOLIER, INC.

May 18, 1989

Enclosed please find a copy of a layout of a proposed washer for our aluminum processing plant in Fall River, Massachusetts. This machine will replace a vapor degreasing machine in serious disrepair and it is felt to be an urgent project.

The need is for an in-process cleaning only. An absolute clean part, as required for subsequent finishing, is not needed for this application. Also, an absolutely dry part also is not needed.

We will appreciate your comments and a costed proposal along with delivery. Please address your proposal to Mr. Michael Cahill, Manufacturing Engineer at APC with a copy to myself. Either Michael or myself can answer whatever questions you may have.

Thank You,

Don Williams

Donald F. Williams
Corporate Operations Engineer

DFW/tar
cc: M. Cahill
R. Hacking
enc.

SIX THIRTY-ONE AIRPORT ROAD, FALL RIVER, MASSACHUSETTS 02720. TEL. 617-679-8131

Exhibit VII

Exhibit VII
Lightolier, Inc.
Fall River Division

Discounted Cash Flow Project Analysis
Capital Budgeting for Pollution Prevention Equipment
(ReplacementAqueous Degreaser Purchased1990)

Item	Year(s)	BTCF*	ATCF**	Present Value Factor 15% Cost of Capital	Present Value Total for Cost Category
Purchase Aqueous Degreaser	0	($155,365)	($155,365)	1	($155,365)
Depreciation (Ten Year Straight Line, No Salvage Value)	1 - 10	$13,467	$5,252	Various	$26,359
Changes in Operations (TCE Solvent Costs) (5% annual inflation)	1 - 10	$31,104	$18,973	Various	$113,299
Spent Solvent Disposal Savings (5% annual inflation)	1 - 10	$3,120	$1,903	0.8696	$11,369
Detergent Chemical Costs (Derived from Costs Provided by Parker Chemical Company - includes 5% annual inflation)	1 - 10	($10,500)	($6,405)	Various	($38,267)

Exhibit VII

Item	Year(s)	BTCF*	ATCF**	Present Value Factor 15% Cost of Capital	Present Value Total for Cost Category
Maintenance Costs Saved ($20,000/yr., 5% annual inflation)	1 - 10	$20,000	$12,200	Various	$72,879
Repair Costs Saved ($25,000 materials + $15,000 labor = $40,000)	1	$40,000	$24,400	0.8696	$21,218
Labor Costs Saved Spill/Leak Incident Reporting (45 hrs/year x $30/hour; 5% annual inflation)	1 - 10	$1,350	$824	Various	$4,919
Labor Costs Saved Monitoring/Manifesting (4 hrs/week x 50 weeks x $30/hr; 5% annual inflation)	1 - 10	$6,000	$3,660	Various	$21,862
Training Costs Saved Right to Know Training (40% of sessions x 75 hrs/yr x $30/hr; 5% annual inflation)	1 - 10	$900	$549	Various	$3,279

Exhibit VII

Item	Year(s)	BTCF*	ATCF**	Present Value Factor 15% Cost of Capital	Present Value Total for Cost Category
Labor Costs Saved Labelling @ 150 hrs/year ($30/hr x 150 hrs/yr)	1 - 10	$4,500	$2,745	Various	$16,397
Maintenance Costs **Aqueous Degreaser** ($2000 per year, inclusive of labor and parts; 5% annual inflation)	1 - 10	($2,000)	($1,220)	Various	($7,287)
TURA Fees Saved (5% annual inflation)	1 2 - 10	($1,100) $1,155	($671) $705	0.8692 Various	($583) $3,425
				Net Present Value	**$93,504**

* BTCF = Before Tax Cash Flow
** ATCF = After Tax Cash Flow
Lightolier's corporate tax rate is 39%.