

*Will Polluting Less  
Save You Money?*

**A Workbook  
for  
Total Cost Assessment**

P<sup>2</sup><sub>C</sub>

This handbook is intended for educational purposes. Additional copies may be obtained by contacting P<sub>2</sub>c at the address below.

First Printing 1994. Copyright 1995 Mitchell Kennedy & the Pollution Prevention Cooperative (P<sub>2</sub>c). The author reserves all rights. This document may not be reproduced, transmitted, sold, electronically stored without the consent of Pollution Prevention Cooperative. Contact the author at 67 Maplewood Avenue, West Hartford, CT 06119: 860-231-7151.

# Total Cost Handbook

## Table of Contents

|                                                          |    |
|----------------------------------------------------------|----|
| Forward .....                                            | 1  |
| Introduction .....                                       | 2  |
| Methodology .....                                        | 3  |
| Cost Categories .....                                    | 3  |
| Gathering Cost Data .....                                | 6  |
| Calculating Present Value .....                          | 7  |
| The Effects of Depreciation and Tax .....                | 7  |
| Use of TCA for Budgeting Projects .....                  | 9  |
| Example Calculation .....                                | 10 |
| Background .....                                         | 10 |
| Capital Costs .....                                      | 10 |
| Operating Cash Flows .....                               | 10 |
| Cash Flow Summary .....                                  | 13 |
| Equivalent Annual Annuity .....                          | 16 |
| Practice Exercises .....                                 | 18 |
| Exercise #1: Group Discussion<br>Identifying Costs ..... | 19 |
| Exercise #2: Case Study<br>Electroplating Analysis ..... | 21 |
| Teacher's Notes to Exercise #2 .....                     | 28 |

|                                          |    |
|------------------------------------------|----|
| Exercise #3: Case Study                  |    |
| Textile Dyeing Analysis . . . . .        | 29 |
| Exercise #4: Case Study                  |    |
| Spray Painting Analysis . . . . .        | 37 |
| Teachers Notes on Exercise #4 . . . . .  | 46 |
| Appendices . . . . .                     | 47 |
| A: Compound Interest Tables . . . . .    | 48 |
| B: Sources for Further Reading . . . . . | 49 |

# Forward

My goal in writing this book was to provide a practical, no-nonsense guide for understanding the most persuasive tool in business; the financial analysis. The popularity of it has given me the opportunity to add more examples and helpful notes.

The exercises herein are pulled from my experiences at over 200 industrial facilities and make use of actual financial data and projects from those industries. The names have been changed to protect the confidentiality. The case studies make up a portion of a more involved training workshop I conduct on Total Cost Assessment.

I hope through reading the text and following the examples you will be able to concretely demonstrate what is often known instinctively; that preventing pollution makes environmental and economic sense.

Mitchell L. Kennedy  
August, 1995

# Introduction

The physician's old adage "An ounce of prevention is worth a pound of cure" applies to today's environmental management issues just as it applies to keeping one's body healthy. Preventing pollution creates a cascade effect that relieves companies from other burdens connected with creating, treating and disposing of industrial wastes.

Current methods of financial assessment fail to capture the "preventative advantage" of many environmental projects and quantify it in economic terms. Whether it is an investment for a new industrial process or the building of a hydro-electric power dam the total costs associated with the development, installation and operation of the system are too often placed into overhead or disregarded. Yet, these forgotten costs ultimately make or break most prevention-oriented projects.

A new financial analysis method that can more fully track and allocate the forgotten costs shows that being green makes green (\$\$). When used to evaluate, justify or track pollution prevention progress Total Cost Assessment provides three important benefits:

1. Complete evaluation of options. Total Cost Assessments help select the most financially feasible alternative, taking into consideration costs that would normally be buried in the Overhead category.
2. Justification of project worth. The use of Total Cost Assessment creates solid data on short and long-term savings for comparison against competing projects.
3. Complete tracking of project success. Total Cost Assessment tracks savings attributable to a new project, providing proof of performance and building a record of success.

This handbook provides users with the tools to evaluate the financial feasibility of pollution prevention projects. The exercises are designed to teach skills in gathering data, performing the analysis, and considering intangible factors such as long-term liability.

# Methodology

The process used to determine total costs in this handbook uses terms and methods from the many existing cost accounting systems. Net Present Value and Equivalent Annual Annuity determine project feasibility in these examples. Assumptions made to simplify calculations are described below and in the text of the exercises.

## Cost Categories

Cost information is usually of two types: costs connected to the purchase of new equipment and day-to-day operation of the process or use of a chemical; and ancillary costs which are impacted by the process and chemical use, but not a part of production. Examples of the former would be chemical purchases and electrical energy use for a particular production process. Examples of the latter would be the impact the chemical has on insurance premiums, or the additional waste treatment needed.

This handbook avoids classifying costs into "direct" and "indirect", or "direct" and "hidden" costs. These categories are too broad to be used effectively in calculating project impacts. Most companies have their own specific cost categories, yet the majority do not proportion the costs to production or chemical usage.

Total Cost Assessment creates a fine-grained level of detail that allows costs of production to be attributed to individual chemical use or production processes. Because of this, the cost categories are often process or chemical specific, instead of department or function specific. For example the exercises in this book refer to labor connected to the maintenance of a specific process, not the maintenance of the facility.

## Terms and Definitions

This manual uses terms and methods commonly found in the financial analysis field to standardize methods, and limit the creation of new terms and potential for confusion. The terms used herein are briefly explained below in the order they appear.

## **Capital Costs**

All costs considered part of the implementation of a new project or system. These include research and design of the new system, obtaining necessary permits, changes to the production process or building, purchase of equipment, and disposal of the old process.

## **Discount Rate**

A company's Discount Rate (also called the Hurdle Rate) is the "interest rate" used in evaluating projects. It reflects the cost of borrowing money to finance the project and a subjective, perceived level of risk involved.

## **Operating Cash Flow**

All regularly occurring costs, or savings, associated with the operation and maintenance of the systems. These include chemical purchases, waste management, all fees and labor connected to regulatory compliance and annual permitting, system maintenance, production costs, and water, natural gas or steam, and electricity usage.

## **Incremental Cash Flow**

This term refers to the difference in operating costs between an old process and the new. Revenues from future systems are not estimated in this handbook, resulting in the use of this specific term.

## **Interest Expense**

Pollution prevention projects often require capital, either from reserve funds within the company or through a bank loan. In the second instance the interest on the loan must be included as a cost in evaluating the project. Interest on project loans has been omitted to retain a focus on the cost analysis process.

## **Opportunity Cost**

Internal financing of a pollution prevention project means a lost opportunity to invest those funds elsewhere. Logically, this lost opportunity represents an expense to be counted against the project. However, the opportunity is embodied within the many financial analysis tools such as Net Present Value. Comparing projects using these tools automatically considers the opportunity cost and no further treatment is necessary.



## **Depreciation**

The process of allocating the costs of a machine across its entire lifetime to represent the loss of value as a result of using the machine. This workbook uses straight line depreciation for all options.

## **Taxable Income, Income Tax, After Tax Cash Flow**

These terms are used to figure the effect of income tax on the savings resulting from the pollution prevention projects. Taxable Income is the operating cash flow minus the annual depreciation.

Income tax rates for corporations vary almost as much as personal income tax rates. For this analysis all projects were evaluated using an assumed 40% as the tax rate.

After Tax Cash Flow refers to the amount of profit remaining after taxes have been taken out.

## **Annuity**

An annuity is a fixed cash inflow or outflow occurring every year. Annual savings from a pollution prevention project are considered an annuity.

## **Present Value**

Present Value accounts for the effects of time on an investment opportunity. Present Values in this workbook were calculated using the interest tables found in Appendix A.

## **Equivalent Annual Annuity**

When two options have different lifetimes the Net Present Values can not be compared accurately. The Net Present Values can be normalized by dividing each by their respective compound interest factors. See page 15 for more detail.

# Gathering Cost Data

Locating cost data often involves interactions with the purchasing department, process or plant engineers, waste treatment operators, environmental health and safety staff and company management. Rarely are records available for every cost category. It would be up to the discretion of the researcher whether to estimate the number or leave it blank. Missing data emphasizes the need for accuracy in cost tracking.

Costs not specifically connected to process operation can be found through insurance premiums, labor rates, fees and taxes, and time required for compliance with applicable environmental regulations. Often times interviews with line operators or shop foremen are necessary to determine how long a particular process takes, and what other constraints are on the process. Worker attitude and need for re-training also figure into any pollution prevention project. The list below details some sources of cost information:

- |                                                 |                                       |
|-------------------------------------------------|---------------------------------------|
| • Vendors of new technologies                   | • Waste treatment guidelines          |
| • Federal and state chemical use fees, or taxes | • Employee labor rates                |
| • Utility usage                                 | • Insurance premiums                  |
| • Purchase orders                               | • Waste manifests and annual reports  |
| • Chemical inventories                          | • Federal and state emissions reports |
| • Maintenance records                           | • Chemical and equipment catalogs.    |

# Calculating Present Value

Calculating the present value of a project takes into consideration the time-value of money and potential long-term savings/costs. It more accurately reveals the financial worth of a project.

Calculations in this manual were performed using the compound interest table in Appendix A. Using this table, the After Tax Cash Flow can be multiplied by a single number to obtain a present value normally resulting from an iterative process. The interest tables are based on a common algorithm found in most financial analysis text books. For this project the algorithm was taken from "Engineering Economy" by G.J. Thesen and W.J. Fabrycky<sup>1</sup>.

The equation converts actual dollars of the past or future into an equivalent amount at time  $t=0$  (usually  $t=0$  is the present day). The equation is given as:

$$P = F \times \frac{1}{(1+i)^n}$$

Where **P** is the unknown current dollar amount (the Present Value), **F** is the known past or future amount (the annuity), **i** is the market interest rate, discount rate or inflation rate, and **n** is the number of years in the past or the future. The Present Value of the annuity is the summation of this calculation performed for each year of the projects life.

## The Effects of Depreciation and Tax

Most investments in manufacturing equipment, pollution control technologies and durable goods have a useful life. At the end of their useful life they may have a salvage value, or they may be completely

---

<sup>1</sup> Engineering Economy, by G. J. Thesen and W. J. Fabrycky, Prentice Hall Publishers, Englewood Cliffs, NJ 1984.

worthless. The Internal Revenue Service allows companies to depreciate the cost of their equipment over the lifetime of the equipment. There are limitations to the amount and time period for depreciation.

There are several common methods for depreciating capital equipment. The types of methods and differences between each are outlined below.

### **Straight Line Method**

The Straight Line depreciation model assumes the value of an asset decreases at a constant rate. It divides the total capital cost of the equipment by the expected life of the equipment. This method provides a quick number for use in additional calculations but does not have the same tax benefits of the other methods. The exercises in this handbook employ this method.

### **Declining Balance Method**

The Declining Balance method of depreciation assumes that an asset decreases in value faster in the latter portion of its service life. By this method a fixed percentage is multiplied by the book value of the asset at the beginning of the year to determine the depreciation charge for that year. The Double Declining balance method is a variation often used for income tax purposes where the maximum allowable depreciation rate is double the Straight Line rate.

### **Declining Balance Switching to Straight Line Depreciation**

Under pre-1981 federal tax law it is allowable to depreciate an asset over the early portion of its life using a Declining Balance and then switch to Straight Line for the remainder of the asset's life. The switch usually occurs at a point where the Straight Line amount exceeds the Declining Balance amount for the next year.

### **Accelerated Cost Recovery System (ACRS)**

The passage of the 1981 Economy Recovery Act established ACRS for the calculation of depreciable assets in service during and after 1981. The ACRS system structures all depreciable assets into one of four lifetimes of property (3, 5, 10, and 15 years). Depreciation rates are then prescribed by IRS tables. For example the rates on a 3 year property are 25% the first year, 38% the second year, and 37% the final year. ACRS assumes no salvage

value for the property at the end of it's lifetime. Any value recovered is subject to a tax liability.

Depreciation is not a true cash flow in that it transfers no revenue to the company. Depreciation is used to figure a tax decrease that in turn can be viewed as a cash flow. For example a company purchasing a \$7,000 piece of equipment that has a seven year lifetime could depreciate \$1,000 per year on the item. They do not actually receive \$1,000. The only real savings comes from the avoided income tax.

## **Use of TCA for Budgeting Projects**

A Total Cost Assessment provides detailed insight into the costs of production processes and pollution prevention projects. TCA can narrow the search for alternatives from the outset by working backwards from a set of final figures. For example, if a company knows a certain Return on Investment, or Hurdle Rate is required for a project to be acceptable to the corporate approval process, current operating costs can be used to determine a base price for equipment purchase or a maximum allowable expenditure on chemical purchases.

# Example Calculation

The following example analyzes total costs for replacing a trichloroethylene (TCE) vapor degreaser at a mid-sized screw machine shop. The numbers have been simplified to focus attention on the cost analysis process, but reflect real data of manufacturing practices. The example begins by locating data about costs of the current process. Shaded tables represent portions of the larger tables on pages 12 and 15. Standard accounting practices are employed to show costs within parentheses, (\$400), and savings without parentheses, \$400.

## Background

Parts are degreased in a 10-year old, hand-operated, vapor unit using TCE. The company switched from vapor degreasing to aqueous cleaning after exploring alternatives such as ultrasonics, large automated basket washers, drop-in replacements of hydrocarbon blends, and terpene based chemistries. The decision to use aqueous instead of an alternative solvent was primarily based on a desire to limit future liabilities.

## Capital Costs

The aqueous system was custom built for \$10,500 and incorporates air agitation and counter current rinsing. Additional changes to the processes or building were necessary including labor associated with disconnecting the old water line and connecting the new system (\$550). The old degreaser was cleaned and sold as scrap for \$50.

| Capital Costs           | TCE | Alkaline   |
|-------------------------|-----|------------|
| Equipment Purchases     | NA  | (\$10,500) |
| Disposal of Old Process | NA  | \$50       |
| Bldg / Process Changes  | NA  | (\$550)    |

## Operating Cash Flows.

The company's 1993 usage of TCE was 23,148 pounds. At current market prices for TCE the company spends \$25,000 to purchase the solvent. Current disposal costs are \$1,000 / year for seven drums.

| <b>Operating Cash Flows</b> | <b>TCE</b>        | <b>Alkaline</b> |
|-----------------------------|-------------------|-----------------|
| <b>Chemical Purchases</b>   | <b>(\$25,000)</b> | <b>(\$400)</b>  |
| <b>Waste Disposal</b>       | <b>(\$1,000)</b>  | <b>0</b>        |

Usage of TCE required the company to file SARA 313 form R and a state toxics use report. The state collected an annual toxics use fee of \$500. The associated paperwork takes 20 hours for both forms and another 5 hours for permits associated with chemical use.

|                              |                |          |
|------------------------------|----------------|----------|
| <b>Chemical Use Fees</b>     | <b>(\$500)</b> | <b>0</b> |
| <b>Filing Paperwork Time</b> | <b>(\$400)</b> | <b>0</b> |

The vapor degreaser required a complete clean out every six months, taking one worker 3.5 hours each time. Electricity usage could not be obtained as the degreaser was not metered separately, and specifications on the unit could not be found. The company's labor rate is \$20 per hour; cost of capital 10%.

The new aqueous cleaning system has a 10 year lifetime. Chemical usage for the new system averages one half gallon per week. Cost per gallon for the new chemical is slightly higher than TCE's current market price (\$14.00/gallon of new cleaner versus \$12.50 per gallon for TCE), but less is used and it lasts longer. The chemical is not used at levels that trigger regulatory thresholds for toxics use regulations.

The new unit requires monthly cleaning, taking one worker just over 2 hours to complete. Metal filings that accumulate at the bottom of the new cleaning tank are sold as scrap, but no cost data was available. In-line filters are changed every 6 months and discarded as solid waste.

The cleaning tank's rinses consume roughly \$10 / year of water. Compared to water used in other shop processes this is a nominal impact. The company heats both the old and new systems with in-plant steam. Cost differences for other utilities are considered marginal.

| <b>Capital Costs</b>          | <b>TCE<br/>degreaser</b> | <b>Alkaline<br/>wash</b> |  |  |
|-------------------------------|--------------------------|--------------------------|--|--|
| Equipment Purchase            | NA                       | \$10,550                 |  |  |
| Disposal of Old Process       | NA                       | + \$50                   |  |  |
| Research & Design             | NA                       | 0                        |  |  |
| Initial Permits               | NA                       | 0                        |  |  |
| Building / Process<br>Changes | NA                       | \$500                    |  |  |
| <b>Total Capital Costs</b>    | <b>NA</b>                | <b>\$11,000</b>          |  |  |

| <b>Operating Cash Flow</b>      |                | <b>TCE<br/>degreaser</b> | <b>Alkaline<br/>wash</b> | <b>Increm. C.F.</b> |  |
|---------------------------------|----------------|--------------------------|--------------------------|---------------------|--|
| Chemical Purchases              |                | (\$25,000)               | (\$400)                  | \$24,600            |  |
| Waste<br>Mgmt.                  | Chemicals      | 0                        | 0                        | 0                   |  |
|                                 | Testing        | 0                        | 0                        | 0                   |  |
|                                 | Disposal       | (\$1,000)                | 0                        | \$1,000             |  |
| Safety Training / Equip         |                | (\$20)                   | (\$20)                   | 0                   |  |
| Insurance                       |                | NA                       | no change                | 0                   |  |
| Chemical Use Fees               |                | (\$500)                  | 0                        | \$500               |  |
| Filing Paperwork time           |                | (\$400)                  | 0                        | \$400               |  |
| Annual Permitting               |                | (\$100)                  | 0                        | \$100               |  |
| Production<br>Costs             | %<br>Inc./Dec. | 0                        | 0                        | 0                   |  |
|                                 | \$ / yr.       | 0                        | 0                        | 0                   |  |
| Main-<br>tenance                | Time           | (\$140)                  | (\$480)                  | (\$400)             |  |
|                                 | Materials      | 0                        | 0                        | 0                   |  |
| Utilities                       | Water          | NA                       | (\$10)                   | (\$10)              |  |
|                                 | Electricity    | same                     | same                     | 0                   |  |
|                                 | Gas/Steam.     | same                     | same                     | 0                   |  |
| <b>Total Annual Oper. C. F.</b> |                | <b>(\$27,160)</b>        | <b>(\$910)</b>           | <b>\$26,250</b>     |  |



# Cash Flow Summary

Now that the cost data has been entered into the tables it can be totaled to find the Total Capital Costs and Total Annual Operating Costs. Calculating the present value begins with accounting for the effects of depreciation, and the tax savings from the use of depreciation.

## Find the Incremental Cash Flow

Subtract the total operating costs of the proposed project (the Alkaline Washer) from the annual operating costs of the TCE Vapor Degreaser.

| Cash Flow Summary     | TCE        | Alkaline |
|-----------------------|------------|----------|
| Total Operating Costs | (\$27,160) | (\$910)  |
| Incremental Cash Flow | NA         | \$25,250 |

## Figure the Taxable Income

Divide the total capital costs by the number of years of expected lifetime for the equipment. In this case divide \$11,000 by 10 years. The annual depreciation of the new equipment is \$1,100 per year. Subtract this from the Incremental Cash Flow.

|                |    |           |
|----------------|----|-----------|
| - Depreciation | NA | (\$1,100) |
| Taxable Income | NA | \$25,150  |

## Determine the After Tax Cash Flow

This example assumes a corporate tax rate of 40%. More accurate calculations could be made with an actual tax rate. Multiply the taxable income by the tax rate and subtract the income tax. Add the annual depreciation to the net income to determine the After Tax Cash Flow.

|                     |    |            |
|---------------------|----|------------|
| Income Tax (40%)    | NA | (\$10,060) |
| Net Income          | NA | \$15,090   |
| + Depreciation      | NA | \$1,100    |
| After Tax Cash Flow | NA | \$16,190   |

### Find the Net Present Value

Multiply the after tax cash flow by a present value factor. This factor is determined by the lifetime of the equipment and the company's discount rate. Compound interest tables in Appendix A provide a factor of 6.1446 for a 10 year lifetime at 10% discount rate. Subtract the Total Capital Costs from the Present Value to obtain the Net Present Value of the project.

|                        |    |            |
|------------------------|----|------------|
| Present Value (6.1446) | NA | \$99,481   |
| Total Capital Costs    | NA | (\$11,000) |
| Net Present Value      | NA | \$88,481   |

### Financial Viability

The table on page 12 shows the Annual Operating Cost for running the old degreaser are \$27,160. Total annual savings, after taxes, from the new system are \$16,190. The Net Present Value on this project is \$88,481.

The ratio of capital invested to that returned (cost-benefit ratio) can be found by dividing the Net Present Value by the total capital costs. For this example, the ratio is 8.0:1. This means the investment in an alternative to TCE is returns \$8 for every \$1 invested. Using a payback analysis yields a payback period of just over 8 months. The company saves \$1,400 per year on avoided paperwork and fees, yet has maintained regulatory compliance through eliminating regulated substances.

| <b>Cash Flow Summary</b> | <b>TCE<br/>degreaser</b> | <b>Alkaline<br/>wash</b> |  |  |
|--------------------------|--------------------------|--------------------------|--|--|
| Total Operating Costs    | (\$27,160)               | (\$910)                  |  |  |
| Incremental Cash Flow    | NA                       | \$26,250                 |  |  |
| - Depreciation           |                          | (\$1,100)                |  |  |
| Taxable Income           |                          | \$25,150                 |  |  |
| Income Tax (40%)         |                          | (\$10,060)               |  |  |
| Net Income               |                          | \$15,090                 |  |  |
| + Depreciation           |                          | \$1,100                  |  |  |
| After Tax Cash Flow      |                          | \$16,190                 |  |  |
| Present Value (6.1446)   |                          | \$99,481                 |  |  |
| Total Capital Cost       |                          | (\$11,000)               |  |  |
| Net Present Value        |                          | \$88,481                 |  |  |
| Cost - Benefit Ratio     |                          | 8.0                      |  |  |

# Equivalent Annual Annuity

In reality there is usually more than one solution to any problem, and all options will not have 10 year lifespans. When evaluating two or more projects each having a different lifetime, the Net Present Value calculations can not be compared directly. Accounting theory holds that the project with the shorter lifetime will allow the user to more quickly re-invest their money, thus creating an "opportunity cost" (See page 4). The Net Present Values have to be modified to account for the difference. One method to evaluate two options having different lifetimes is the Equivalent Annual Annuity (EAA).

The EAA approach consists of finding each option's Net Present Value and calculating an amount (an annuity) that provides equal annual payments over the project's life. This is done by dividing the Net Present Value by its present value factor (from appendix A- compound interest tables).

The resulting EAAs can be compared to one another, or divided by the discount rate to produce the Infinite Horizon Net Present Value. The Infinite Horizon NPV results from the assumption that each option would be continually replaced for an infinite number of times.

Consider two projects, one with a 4 year lifespan and a second with a 9 year lifespan, their respective NPVs might look like this:

|                           | 4 years  | 9 years |
|---------------------------|----------|---------|
| Net Present Values        | \$3,700  | \$4,200 |
| Equiv. Ann. Annuity       | \$1,168  | \$729   |
| Infinite Net Present Val. | \$11,683 | \$7,292 |

At first glance the 9 year project appears the most profitable. By considering the difference in lifetimes, and dividing the NPVs by their respective present value factors (Four years @ 10% = 3.1699, nine years @ 10% = 5.7590) the four year project becomes the most profitable. Further dividing the results by the discount rate (10%) yields their Infinite

## Horizon Net Present Values.

In order to analyze options of different lifetimes using the EAA, method several assumptions must be made. These are:

- The projects' equipment will be replaced with identical equipment at the end of each lifetime,
- Each replacement provides the same cash flows as its predecessor, i.e. no change in capital or operating costs.

Extending projects indefinitely into the future forces the use of assumptions that can not take all variables into account. Several potential weaknesses of comparing options of different lifetimes are:

- The effects of inflation are not considered,
- Replacements often employ new technology that change cash flows.

The researcher will want to document all assumptions made during their TCA analysis to build the most solid case possible for the pollution prevention project.

# Practice Exercises

The following exercises will help the reader become familiar with Total Cost Assessment techniques. The exercises are based upon pollution prevention projects at real manufacturing facilities, but simplified to focus attention on the assessment process. Answers are provided at the end of each exercise.

## **Instructor's Note:**

The exercises can be given as group activities with each member of the group playing a particular role in the assessment process. For example, information in exercise 2 is provided in categories based on factory staff that would be part of a pollution prevention team. Each person in a group could adopt the role of one of these team members for this exercise. Each team member has information necessary for an accurate assessment of the project, requiring all members to participate.

# **Exercise #1: Group Discussion**

## **Identifying Costs**

You are the pollution prevention team leader for a manufacturing plant. Your team has decided that replacing the current vapor degreaser with a new technology will be the next pollution prevention project.

- a) What basic cost categories would the team need to consider in an assessment of financial feasibility?
- b) Where would the team find cost data for these categories?
- c) What additional factors might influence the feasibility of this project?

# **Answer Key for Exercise 1**

- a) Chemical purchases; waste testing, treatment and disposal; worker health and safety training; insurance; chemical, water and sewer usage fees; interest on loans for the project; labor associated with maintenance and paperwork; production costs; utilities; research and design; initial and annual permits; disposal of old process; changes to the building or processes; retraining workers, potential loss of jobs, and purchase of the new equipment.
- b) The purchasing department; line workers; process engineers; accountants; vendors; E H & S staff; insurance agent; waste manifests; and product information.
- c) New permits for wastes associated with new process; taxes and fees associated with new chemicals; purchase costs of equipment and useful life of new technology; new or proposed legislation which would have a bearing on the new technology; and work health and safety issues surrounding the new technology.



## **Exercise #2: Case Study**

### **Electroplating Analysis**

Use the process and information developed in Exercise 1 and the following proposals, to assess the feasibility of the following pollution prevention project. Incorporate both quantitative and qualitative analyses. Use worksheets provided on the following pages. Answers can be found on pages 26 & 27.

- a) Use the provided role information to fill in the table of costs. Calculate capital costs for each alternative, the total operating cash flows and the incremental savings.
- b) Calculate the present value (PV), the net present value (NPV) and the ratio of benefits to costs. Is this alternative feasible?

## **Exercise #2: American Electro-Metals, Inc.**

American Electro-Metals, Inc. (AEM) is a mid-sized, privately owned, high-volume, electroplating job-shop. AEM plates a variety of finishes; nickel, bright brass, cadmium, and chromates. Most plating equipment is 10 - 20 years old. Recently, AEM's production manager has noticed the cyanide brass plating solution has been "growing". This growth has resulted in production down-time when the "extra" solution must be pumped out, placed in barrels, and the bath re-formulated. The surplus of dilute brass cyanide solution grows at a rate of 44 gallons per day. The company could be cited for "treating" hazardous waste illegally if they attempt to empty the barrels into their wastewater treatment system, even though they are permitted for treating cyanide rinsewaters. Currently the extra solution is hauled off-site as hazardous waste.

AEM's quality/environmental team has been instructed to find a way to decrease the costs associated with hauling the waste off-site. They think the cause of the problem is too much drag-in from previous tanks and too little drag out from the brass bath. Options considered were; hard-piping the cyanide tank to the treatment system and obtaining a permit modification to treat process solutions; low-temperature evaporation of the excess solutions and possible re-use; adding a second hoist to the plating line to decrease drag-in of other process solutions and rinsewaters. The team decided to evaluate adding the second hoist because of the potential benefits to product quality and increases in production capacity. The company's discount rate is 10%, with a 40% tax rate.

### **I. Adding a Second Hoist**

The group conducted a time-motion study of hoist dwell and travel patterns and concluded that extending dwell times could reduce solution losses from 20 - 35%. This translates directly to chemical savings (approximately 30% for chemicals used on this line) and reduced hazardous waste generation.

The group agreed that the new hoist would have automated indexing and computer timing features to control withdrawal rates from each tank and dwell time over the tanks, and would also be compatible with the existing hoist. Jessup Plating Equipment, Inc. provided AEM with electrical, space, and weight requirements for this second hoist. The proposal included labor for re-programming the first hoist, testing and fine tuning

both hoists to work in tandem. Conservatively, the hoist was given a 10 year lifetime. Additional information:

### Purchasing

- The cost estimate for the second hoist comes to \$35,000.
- Reductions in process chemical dragout achieved through slower withdrawal time and extended dwell time would decrease brass and other cyanide chemicals consumption by 30%.

### Environmental Management

- Waste treatment chemicals and disposal costs associated with the brass line would decrease 33% due to reductions of process chemical drag-in into running rinses.
- The costs for filling out manifests, test reports, conducting personnel training, or insurance would not be effected by this process change; therefore no costs were developed.

### Engineering

- Maintenance costs for this line would double with the addition of a second hoist.
- An estimated \$5,000 of building alterations to support the second hoist would be needed.
- For the initial project analysis the costs of production (increases or decreases) will not be considered.

### Manufacturing

- Adding a second hoist is expected to be less than twice the current electricity cost, as some savings would be accrued from the hoist not traveling as much ( $\$6,300 + 80\% = \$11,340$ ).
- The drag-out reductions would decrease water use, waste water flow discharge, sewer usage fees and water taxes charged to AEM. Conservatively, water usage and the associated sewer usage fee was given a 20% decrease to adjust for rate increases. Water tax was given a 10% decrease.

## Exercise #2 Worksheet

| Capital Costs              | Current Process | Second Host |  |  |
|----------------------------|-----------------|-------------|--|--|
| Equipment Purchase         | NA              |             |  |  |
| Disposal of Old Process    | NA              | 0           |  |  |
| Research & Design          | NA              | 0           |  |  |
| Initial Permits            | NA              | 0           |  |  |
| Building / Process Changes | NA              |             |  |  |
| Total Capital Costs        | NA              |             |  |  |

| Operating Cash Flow      |             | Current Process | Second Host |  |  |
|--------------------------|-------------|-----------------|-------------|--|--|
| Chemical Purchases       |             | (\$19,091)      |             |  |  |
| Waste Mgmt.              | Chemicals   | (\$13,473)      |             |  |  |
|                          | Testing     | N/A             |             |  |  |
|                          | Disposal    | (\$8,736)       |             |  |  |
| Safety Training / Equip  |             | N/A             |             |  |  |
| Insurance                |             | N/A             | NA          |  |  |
| Sewer Use Fees           |             | (\$545)         |             |  |  |
| Filing Papework time     |             | N/A             | N/A         |  |  |
| Water Tax                |             | (\$7,300)       |             |  |  |
| Production Costs         | % Inc./Dec. | (?)             | (?)         |  |  |
|                          | \$ / Yr.    | (?)             | (?)         |  |  |
| Maintenance              | Time        | (\$100)         |             |  |  |
|                          | Materials   | 0               | 0           |  |  |
| Utilities                | Water       | (\$3,800)       |             |  |  |
|                          | Electricity | (\$6,300)       |             |  |  |
|                          | Gas/Steam.  | 0               |             |  |  |
| Total Annual Oper. C. F. |             |                 |             |  |  |

**Exercise #2 Worksheet**

| Cash Flow Summary     | Current Process | Second Hoist |  |  |
|-----------------------|-----------------|--------------|--|--|
| Total Operating Costs |                 |              |  |  |
| Incremental Cash Flow |                 |              |  |  |
| - Depreciation        |                 |              |  |  |
| Taxable Income        |                 |              |  |  |
| Income Tax (40%)      |                 |              |  |  |
| Net Income            |                 |              |  |  |
| + Depreciation        |                 |              |  |  |
| After Tax Cash Flow   |                 |              |  |  |
| Present Value         |                 |              |  |  |
| Total Capital Cost    |                 |              |  |  |
| Net Present Value     |                 |              |  |  |
| Cost - Benefit Ratio  |                 |              |  |  |

### Answer Key for Exercise 2

| <b>Capital Costs</b>       | <b>Current Process</b> | <b>Second Hoist</b> |  |  |
|----------------------------|------------------------|---------------------|--|--|
| Equipment Purchase         | NA                     | (\$35,000)          |  |  |
| Disposal of Old Process    | NA                     | 0                   |  |  |
| Research & Design          | NA                     | 0                   |  |  |
| Initial Permits            | NA                     | 0                   |  |  |
| Building / ProcessChanges  | NA                     | (\$5,000)           |  |  |
| <b>Total Capital Costs</b> | <b>NA</b>              | <b>(\$40,000)</b>   |  |  |

| <b>Operating Cash Flow</b>      |             | <b>Current Process</b> | <b>Second Hoist</b> |  |  |
|---------------------------------|-------------|------------------------|---------------------|--|--|
| Chemical Purchases              |             | (\$19,091)             | (\$13,363)          |  |  |
| Waste Mgmt.                     | Chemicals   | (\$13,473)             | (\$9,027)           |  |  |
|                                 | Testing     | N/A                    | N/A                 |  |  |
|                                 | Disposal    | (\$8,736)              | (\$5,853)           |  |  |
| Safety Training / Equip         |             | N/A                    | N/A                 |  |  |
| Insurance                       |             | N/A                    | N/A                 |  |  |
| Sewer Use Fees                  |             | (\$545)                | (\$436)             |  |  |
| Filing Paperwork time           |             | N/A                    | N/A                 |  |  |
| Water Tax                       |             | (\$7,300)              | (\$6,570)           |  |  |
| Production Costs                | % Inc./Dec. | (?)                    | (?)                 |  |  |
|                                 | \$ / yr.    | (?)                    | (?)                 |  |  |
| Main-tenance                    | Time        | (\$100)                | (\$200)             |  |  |
|                                 | Materials   | 0                      | 0                   |  |  |
| Utilities                       | Water       | (\$3,800)              | (3,040)             |  |  |
|                                 | Electricity | (\$6,300)              | (\$11,340)          |  |  |
|                                 | Gas/Steam.  | 0                      | 0                   |  |  |
| <b>Total Annual Oper. C. F.</b> |             | <b>(\$59,345)</b>      | <b>(\$49,829)</b>   |  |  |

| <b>Cash Flow Summary</b> | <b>Current Process</b> | <b>Second Hoist</b> |  |  |
|--------------------------|------------------------|---------------------|--|--|
| Total Operating Costs    | (\$59,345)             | (\$49,829)          |  |  |
| Incremental Cash Flow    | NA                     | \$9,516             |  |  |
| - Depreciation           | NA                     | (\$4,000)           |  |  |
| Taxable Income           | NA                     | \$5,516             |  |  |
| Income Tax (40%)         | NA                     | (\$2,206)           |  |  |
| Net Income               | NA                     | \$3,310             |  |  |
| + Depreciation           | NA                     | \$4,000             |  |  |
| After Tax Cash Flow      | NA                     | \$7,310             |  |  |
| Present Value            | NA                     | \$44,917            |  |  |
| Total Capital Cost       | NA                     | (\$40,000)          |  |  |
| Net Present Value        | NA                     | \$4,917             |  |  |
| Cost - Benefit Ratio     | NA                     | 1.1                 |  |  |

### **Financial Feasibility**

This analysis uses a 10 year lifetime for the new hoist, depreciated on a straight line basis. The corporate tax rate was assumed to be 40%, and the "hurdle rate" for this investment was set at 10%. This results in a Net Present Value of \$4,917 over the project's 10 year life. That is, the project will pay for itself and yield a profit of \$4,917. Using only the costs listed above the project pays back in 4.2 years.

What would the revised Net Present Value be, given the following assumptions about the impacts on production costs?

- A unit cost to AEM's customer of \$18 per barrel of brass plated parts.
- An increase in production capacity from 7 barrels / hour to 12 barrels / hour.
- A 4,000 hour work year.

## Teacher's Notes to Exercise #2

- 1) The answer to "How much would production costs effect the analysis?" is: The Net Present Value would rise to \$1.3 million, and the project would pay for itself in 1.3 months.
  - Adding the second hoist could potentially double production capacity on the cyanide brass line.
- 2) What is a logical argument against including production costs?
  - You may have the production capacity to run twice as much product but you may not always have the demand.
- 2) What would the likely Net Present Values be for the other proposed projects (hard-piping waste solutions to the wastewater treatment system, and installing a low temperature evaporator)?
  - For the hard pipe option there would be lower capital costs than installing a second hoist, except for the permitting process. There would be fewer savings in operating costs, with the decrease in hazardous waste costs offset by the increased use of wastewater treatment chemicals and testing. Other impacts?
  - For the low temperature evaporator there would be the capital cost of equipment purchase and installation. Utilities use would increase (electricity), process chemical usage, and waste disposal costs would decrease. Other impacts?



## **Exercise #3: Case Study**

### **Textile Dyeing Analysis**

This exercise is similar to Exercise 2 and provides another real life scenario. Again, use the process and cost information to assess the feasibility of the following pollution prevention projects. Incorporate both quantitative and qualitative analyses. Use worksheets provided on the following pages. Answers can be found on pages 35 & 36.

- a) Use the provided role information to fill in the table. Calculate capital costs of each alternative, total operating costs, and incremental cash flow.
- b) Calculate the present value (PV), the net present value (NPV) for each alternative.
- c) Answer the following questions:
  - 1) At which points in the analysis does the attractiveness of the different options change?
  - 2) Which alternatives can be eliminated based on their net present value?

## **Exercise #3: Tightwove Fabrics, Inc.**

Tightwove Fabrics, Inc. is a small-sized, privately owned, textile dye shop providing dyed and finished fabrics to a variety of sportswear and garment companies. Most dyeing equipment is 20 - 30 years old. Tightwove is located within an urban center, has very little extra floor space and has never needed to treat it's waste water. The company has recently been fined for exceeding a new discharge limit for copper. The company is seeking a pollution prevention alternative to installing a wastewater treatment system.

The team has been instructed to look at technologies for reducing the copper in the waste water. Review of the processes, Material Safety Data Sheets, and dye bath recipes, revealed two options: find a substitute for the copper dyes, or improve the dye/fabric adhesion efficiency. The team located vendors of chemical dyes and dying technologies and received these proposals. The company's cost of capital is 17%.

### **I. The Blue Sky Dye proposal**

Blue Sky Chemical company provided the team with MSDSs and samples of copper-free dyes, as well as a list of references. The dyes have no copper based pigments, but use a zircon based pigment. The literature said the new pigment was extremely light and color fast. Color swatches included in the sales material compared favorably with the color hues used at Tightwove. A higher operating temperature and the need for a hot rinse would require some modifications to the existing dye jigs. The sales rep said the EPA has been so busy with solvents and CFCs that the evaluation of zircon's potential toxicity will take at least four to five years. Additional information:

#### **Purchasing**

- The Blue Sky chemicals are 11% more expensive.
- Modifications to the heating lines, and piping for new hot rinses will cost \$31,000.

#### **Environmental Management**

- The lack of effluent limits for zircon will decrease the need to install a waste water treatment system.

- The lack of toxicity information on this product raises concerns about worker acute exposure and chronic health effects.
- Blue Sky has a 7 year lifetime due to potential changes in regulations.

## Engineering

- Increased temperatures in the tanks and feed lines may fatigue an already well-used system, and could precipitate a rupture and spill.
- Maintenance costs will rise on the boiler that provides process heat (\$3,000 in labor and \$5,000 in parts).
- Other facilities using this chemical have found it difficult to reuse the rinse waters and maintain product quality.

## Manufacturing

- Processing time will decrease 5% due to shorter drying time and will save \$6,250.
- The dying process would remain unchanged, and not require retraining the workers.
- Water use will decrease by 5%.
- Natural gas costs would rise by \$2,000.

## II. The Speed Jet proposal

Speed Jet is a manufacturer of ultrasonic assisted dye jigs. The company claims their technology can achieve a 99.5% exhaustion and fixing of dye molecules to fabric, even after rinsing. Typically exhaustion and adhesion are anywhere from 80 - 90% in a beck type operation. The Speed Jet operation would require considerable modifications to the process line. The entire process is one long unit, complete with an infra-red drying system and recirculating rinse and filter system. The vendor claims product quality improves because the ultrasonics force the dye into the fibers, resulting in a richer hue. This process was given a 7 year lifespan. Additional information:

## Purchasing

- The machinery will cost \$257,000, and building alterations \$110,000.
- Tightwove can continue to use the existing dye, and would

actually use 40% less.

### Environmental Management

- There appears to be limited risk to workers from the self contained units.
- It will cost \$1,000 to dispose of the old system.

### Engineering

- Processing a variety of jobs with this unit may raise timing scheduling issues and require more careful monitoring of individual runs.
- Electrical use will rise to \$10,000 per year.

### Manufacturing

- The workers are concerned some will lose their jobs. There is skepticism that this technology can work. It looks too delicate.
- Maintenance on this system is estimated at \$1,000 per year in labor and \$767 in parts, and may require out-of-shop specialists.
- Production costs would decrease through faster processing time, providing a 6% annual cost savings.
- All heat for baths and drying is electrical, no steam is needed.
- Water use would decrease by 27% due to a more efficient system.

### Exercise #3 Worksheet

| Capital Costs              |  | Current Process | Blue Sky | Speed Jet |  |
|----------------------------|--|-----------------|----------|-----------|--|
| Equipment Purchase         |  | NA              |          |           |  |
| Disposal of Old Process    |  | NA              |          |           |  |
| Research & Design          |  | NA              | 0        | 0         |  |
| Initial Permits            |  | NA              | 0        | 0         |  |
| Building / Process Changes |  | NA              |          |           |  |
| Total Capital Costs        |  | NA              |          |           |  |

| Operating Cash Flow      |             | Current Process | Blue Sky  | Speed Jet |  |
|--------------------------|-------------|-----------------|-----------|-----------|--|
| Chemical Purchases       |             | (\$87,000)      |           |           |  |
| Waste Mgmt.              | Chemicals   | 0               | 0         | 0         |  |
|                          | Testing     | 0               | 0         | 0         |  |
|                          | Disposal    | 0               |           | 0         |  |
| Safety Training / Equip  |             | (\$25)          |           |           |  |
| Insurance                |             | NA              | NA        | NA        |  |
| Chemical Use Fees        |             | 0               | 0         | 0         |  |
| Filing Paperwork time    |             | (\$100)         | (\$100)   | (\$100)   |  |
| Annual Permitting        |             | (\$200)         | 0         | (\$100)   |  |
| Production Costs         | % Inc./Dec. | 0               | 5% ↓      | 6% ↓      |  |
|                          | \$ / yr.    | (\$125,000)     |           |           |  |
| Maintenance              | Time        | (\$1,000)       |           |           |  |
|                          | Materials   | 0               |           | 0         |  |
| Utilities                | Water       | (\$275,000)     |           |           |  |
|                          | Electricity | (\$2,000)       | (\$2,000) |           |  |
|                          | Gas/Steam.  | (\$14,000)      |           | (\$8,000) |  |
| Total Annual Oper. C. F. |             |                 |           |           |  |

**Exercise #3 Worksheet**

| Cash Flow Summary     | Current Process | Blue Sky | Speed Jet |  |
|-----------------------|-----------------|----------|-----------|--|
| Total Operating Costs |                 |          |           |  |
| Incremental Cash Flow |                 |          |           |  |
| - Depreciation        |                 |          |           |  |
| Taxable Income        |                 |          |           |  |
| Income Tax (40%)      |                 |          |           |  |
| Net Income            |                 |          |           |  |
| + Depreciation        |                 |          |           |  |
| After Tax Cash Flow   |                 |          |           |  |
| Present Value         |                 |          |           |  |
| Total Capital Cost    |                 |          |           |  |
| Net Present Value     |                 |          |           |  |
| Cost - Benefit Ratio  |                 |          |           |  |

**Answer Key for Exercise #3**

| <b>Capital Costs</b>       |  | <b>Current Process</b> | <b>Blue Sky</b> | <b>Speed Jet</b> |  |
|----------------------------|--|------------------------|-----------------|------------------|--|
| Equipment Purchase         |  | NA                     | 0               | (\$257,000)      |  |
| Disposal of Old Process    |  | NA                     | 0               | (\$1,000)        |  |
| Research & Design          |  | NA                     | 0               | 0                |  |
| Initial Permits            |  | NA                     | 0               | 0                |  |
| Building / Process Changes |  | NA                     | (\$31,000)      | (\$110,000)      |  |
| <b>Total Capital Costs</b> |  | NA                     | (\$31,000)      | (\$368,000)      |  |

| <b>Operating Cash Flow</b>      |             | <b>Current Process</b> | <b>Blue Sky</b> | <b>Speed Jet</b> |  |
|---------------------------------|-------------|------------------------|-----------------|------------------|--|
| Chemical Purchases              |             | (\$87,000)             | (\$96,570)      | (\$52,200)       |  |
| Waste Mgmt.                     | Chemicals   | 0                      | 0               | 0                |  |
|                                 | Testing     | 0                      | 0               | 0                |  |
|                                 | Disposal    | 0                      | 0               | 0                |  |
| Safety Training / Equip         |             | (\$25)                 | (\$25)          | (\$25)           |  |
| Insurance                       |             | NA                     | NA              | NA               |  |
| Chemical Use Fees               |             | 0                      | 0               | 0                |  |
| Filing Paperwork time           |             | (\$100)                | (\$100)         | (\$100)          |  |
| Annual Permitting               |             | (\$200)                | 0               | (\$100)          |  |
| Production Costs                | % Inc./Dec. | 0                      | 5% ↓            | 6% ↓             |  |
|                                 | \$ / yr.    | (\$125,000)            | (\$118,750)     | (\$117,500)      |  |
| Main-tenance                    | Time        | (\$1,000)              | (\$3,000)       | (\$1,000)        |  |
|                                 | Materials   | 0                      | (\$5,000)       | (\$767)          |  |
| Utilities                       | Water       | (\$275,000)            | (\$261,250)     | (\$200,750)      |  |
|                                 | Electricity | (\$2,000)              | (\$2,000)       | (\$10,000)       |  |
|                                 | Gas/Steam.  | (\$14,000)             | (\$16,000)      | (\$8,000)        |  |
| <b>Total Annual Oper. C. F.</b> |             | (\$504,325)            | (\$502,695)     | (\$390,442)      |  |

| <b>Cash Flow Summary</b> | <b>Current Process</b> | <b>Blue Sky</b> | <b>Speed Jet</b> |  |
|--------------------------|------------------------|-----------------|------------------|--|
| Total Operating Costs    | (\$504,325)            | (\$502,695)     | (\$390,442)      |  |
| Incremental Cash Flow    | NA                     | \$1,830         | \$113,883        |  |
| - Depreciation           | NA                     | (\$4,428)       | (\$52,571)       |  |
| Taxable Income           | NA                     | (\$2,798)       | \$61,312         |  |
| Income Tax (40%)         | NA                     | (\$1,119)       | (\$24,525)       |  |
| Net Income               | NA                     | (\$4,476)       | \$36,787         |  |
| + Depreciation           | NA                     | \$4,428         | \$52,571         |  |
| After Tax Cash Flow      | NA                     | (\$48)          | \$89,358         |  |
| Present Value            | NA                     | (\$188)         | \$350,500        |  |
| Total Capital Cost       | NA                     | (\$31,000)      | (\$368,000)      |  |
| Net Present Value        | NA                     | (\$31,188)      | (\$17,500)       |  |
| Cost - Benefit Ratio     | NA                     | 0               | 0.9              |  |

### **Financial Feasibility**

Neither option is financially feasible based upon their negative Net Present Values. Notice that the annual savings before taxes (Incremental Cash Flow) from the Speed Jet option are significant, but are off-set over the project's lifetime by the large capital cost. Also notice that even though the Blue Sky alternative saves \$1,600 per year, over the life of the project it will cost \$31,188.



## **Exercise #4: Case Study Spray Painting Analysis**

This exercise builds on the experience of Exercise 3 by introducing more complicating factors. Again, use the process and cost information to assess the feasibility of the following pollution prevention project. Incorporate both quantitative and qualitative analyses. Use worksheets provided on the following pages. Answers can be found on pages 44 & 45.

- a) Use the provided role information to fill in the table. Calculate capital costs of each alternative, total operating costs, and incremental cash flow.
- b) Calculate the present value (PV), the net present value (NPV) and the Equal Annual Annuity (EAA), for each alternative.
- c) Answer the following questions:
  - 1) At which points in the analysis does the attractiveness of the different options change?
  - 2) Which alternatives can be eliminated based on their net present value?
  - 3) What additional factors would effect the feasibility of these projects?

## Exercise #4: Magnatronix Corp.

Magnatronix Corp. produces spindle plates and shock casings from high carbon steel for use in the aerospace industry. The company's pollution prevention team has decided to focus on opportunities in the spindle and casing painting operation. The paints currently used have a high percentage of Methyl Ethyl Ketone (MEK) as a carrier base. Usage of these paints resulted in 114,352 pounds of MEK stack emissions, and 12,864 pounds of MEK containing paint waste shipped off-site. Annual costs are \$81,750 for paint purchases and \$8,400 for disposal. After researching the available alternatives, vendors of alternative painting equipment were asked to make presentations to the P2 group. The company's discount rate is 10%.

### I. The Bright Boy alternative.

Bright Boy Chemical Company proposed switching to a reformulated water base coating using a newly developed carrier called Oxy-2-Butadiene, trade named MIRAGLO. This new chemical is not on EPA lists nor is it taxed under the Montreal Protocol for CFC Phaseouts. Bright Boy claims the chemical is self-cleaning, decreasing the amount of down time for clearing clogged paint delivery hoses. Paint equipment upgrades such as High Volume Low Pressure paint guns, a new water wall to catch paint over spray, new mixing equipment, and sparkless pumps, and fittings would make MIRAGLO an easy and painless switch from MEK. MIRAGLO requires no down time for fine tuning the system, nor extra drying time. Further more, the system requires minimal retraining of workers, and can use the existing ventilation system. The vendor says this will have a lifetime of at least 4 years.

The Bright Boy sales rep. gave the team the MSDS for MIRAGLO and a list of companies currently using his product. Each team member has looked the information over and has some information on this option.

#### Purchasing

- System changes would cost \$2,700 and \$37,200 in equipment purchases.
- MIRAGLO paint is 40% cheaper than MEK (\$49,050).
- Despite vendor's claims, all MEK must be removed from the system, the lines cleaned and the waste MEK disposed of. This results in an additional \$5,000 initial cost.

## Environmental Management

- MIRAGLO has a low VOC content allowing it to be discharged to drain rather than drummed as a hazardous waste.
- Water use would increase to \$1,500 per year; placing the facility in a significant discharger category.
- Waste MIRAGLO would need to be treated by the factory's pre-treatment system, treatment chemicals cost = \$3,000/year and, testing = \$1,800 / year.
- There is evidence that Oxy-2-Butadiene causes mutations in laboratory animals.

## Engineering

- Change over would require new water discharge permit and one-time permit fee of \$500.
- Electricity use would drop to \$3,520.

## Manufacturing

- Production costs would increase by 5%, due to smaller delivery lines & fittings. This would cost the company \$15,000 per year in lost production time compared to current practices.
- Maintenance costs would be around \$100 per year.

## II. The PC-Tech Alternative.

The P2 team also interviewed Powder Coating Technologists, Inc. (PC-Tech), manufacturer of PCT, an electrostatic powder coating process. The sales representative for PCT said her product meets all Mil-Spec coating requirements without risks to workers. PC-Tech manufactures a whole line of chemicals and powder coating machines and will assist in custom designing a system. The sales rep also said PCT generates no hazardous waste. The vendor says this project could easily have a 7 year lifetime. Again, each team member had something to offer about this proposal:

## Purchasing

- PCT chemical purchase costs would be \$42,100 per year.
- The system would cost \$150,000.

## Environmental Management

- The over-sprayed powders can be sifted and added back into the supply hoppers, eliminating hazardous waste disposal.
- Associated training costs = \$20 per year.

## Engineering

- The PCT system requires more floor space due to the conveyORIZED design, with ultrasonics and a hot air dryer at the end, meaning \$15,800 in changes.
- Production costs would increase by 7% because of the extra steps involved in preparing parts.

## Manufacturing

- Maintenance costs would be around \$200 per year.
- Electricity use would double to \$8,000.

## III. The Rön-Jen Alternative.

The final option evaluated by the Magnatronic team involved, Rönhauser-Jennings, a manufacturer of new high-tech alloys and machining technologies. Rön-Jen demonstrated the use of a new metal alloy that could replace the high carbon steel. This alloy does not corrode, has a higher tensile strength than steel while being lighter per cubic foot.

If Magnatronic installed a computerized machining cell that utilizes lasers for cutting and polishing, the need to clean and paint parts would be eliminated. The new system could be designed to perform the lathe work, cutting, drilling, and welding operations. Additionally, the laser's precision finish was more durable than the paint. The vendors say the machine has at least a 10 year lifetime.

## Purchasing

- Cost of design and purchase of new machinery = \$228,000.
- The new alloy eliminates the painting process, saving \$81,750 in chemical purchases; but is 8% more expensive than high carbon steel, resulting in \$24,700 per year in materials costs (place in chemical category).

## Environmental Management

- No hazardous wastes are generated.
- Built in safety lockouts assures worker health and safety.

## Engineering

- The unit requires rearranging the floor layout and building a new room. Alterations would cost \$152,000.
- Electricity costs would rise to \$6,500 per year.

## Manufacturing

- Eliminating the need to clean and paint parts would decrease production costs by 35%, saving \$105,000 per year over current costs.
- Maintenance on new system would be \$350 per year.
- Electricity usage would increase to \$6,500 per year

## Exercise #4 Worksheet

| <b>Capital Costs</b>          | <b>MEK<br/>Spray</b> | <b>MIRAGLO<br/>Water</b> | <b>PCT<br/>Powder</b> | <b>Rön-Jen<br/>Alloy</b> |
|-------------------------------|----------------------|--------------------------|-----------------------|--------------------------|
| Equipment Purchase            | NA                   |                          |                       |                          |
| Disposal of Old Process       | NA                   |                          | (\$5,000)             | (\$5,000)                |
| Research & Design             | NA                   |                          |                       |                          |
| Initial Permits               | NA                   |                          |                       |                          |
| Building / Process<br>Changes | NA                   |                          |                       |                          |
| <b>Total Capital Costs</b>    | <b>NA</b>            |                          |                       |                          |

| <b>Operating Cash Flow</b>      | <b>MEK<br/>Spray</b> | <b>MIRAGLO<br/>Water</b> | <b>PCT<br/>Powder</b> | <b>Rön-Jen<br/>Alloy</b> |
|---------------------------------|----------------------|--------------------------|-----------------------|--------------------------|
| Chemical Purchases              |                      |                          |                       |                          |
| Waste<br>Mgmt.                  | Chemicals            |                          |                       |                          |
|                                 | Testing              | (\$1,000)                |                       |                          |
|                                 | Disposal             |                          |                       |                          |
| Safety Training / Equip         | (\$40)               | (\$20)                   |                       |                          |
| Insurance                       | (\$10,000)           | (\$14,000)               | (\$2,000)             | 0                        |
| Chemical Use Fees               |                      |                          |                       |                          |
| Filing Paperwork time           | (\$500)              |                          |                       |                          |
| Annual Permitting               | (\$300)              | (\$150)                  | 0                     | 0                        |
| Production<br>Costs             | % Inc./Dec.          |                          |                       |                          |
|                                 | \$ / yr.             | (\$300,000)              |                       |                          |
| Main-<br>tenance                | Time                 | (\$250)                  |                       |                          |
|                                 | Materials            | (\$75)                   |                       |                          |
| Utilities                       | Water                | NA                       |                       |                          |
|                                 | Electricity          | (\$4,175)                |                       |                          |
|                                 | Gas/Steam.           |                          |                       |                          |
| <b>Total Annual Oper. C. F.</b> |                      |                          |                       |                          |

| <b>Cash Flow Summary</b>  | <b>MEK<br/>Spray</b> | <b>MIRAGLO<br/>Water</b> | <b>PCT<br/>Powder</b> | <b>Rön-Jen<br/>Alloy</b> |
|---------------------------|----------------------|--------------------------|-----------------------|--------------------------|
| Total Operating Costs     |                      |                          |                       |                          |
| Incremental Cash Flow     |                      |                          |                       |                          |
| - Depreciation            |                      |                          |                       |                          |
| Taxable Income            |                      |                          |                       |                          |
| Income Tax (40%)          |                      |                          |                       |                          |
| Net Income                |                      |                          |                       |                          |
| + Depreciation            |                      |                          |                       |                          |
| After Tax Cash Flow       |                      |                          |                       |                          |
| Present Value             |                      |                          |                       |                          |
| Total Capital Cost        |                      |                          |                       |                          |
| Net Present Value         |                      |                          |                       |                          |
| Equivalent Annual Annuity |                      |                          |                       |                          |
| Infinite Horizon NPV      |                      |                          |                       |                          |

Answer Key for Exercise 4

| Capital Costs                 |  | MEK<br>Spray | MIRAGLO<br>Water | PCT<br>Powder | Rön-Jen<br>Alloy |
|-------------------------------|--|--------------|------------------|---------------|------------------|
| Equipment Purchase            |  | NA           | (\$37,200)       | (\$150,000)   | \$228,000)       |
| Disposal of Old Process       |  | NA           | (\$5,000)        | (\$5,000)     | (\$5,000)        |
| Research & Design             |  | NA           | 0                | 0             | 0                |
| Initial Permits               |  | NA           | (\$500)          | 0             | 0                |
| Building / Process<br>Changes |  | NA           | (\$2,700)        | (\$15,800)    | \$152,000)       |
| Total Capital Costs           |  | NA           | (\$45,400)       | (\$170,800)   | \$385,000)       |

| Operating Cash Flow      |             | MEK<br>Spray | MIRAGLO<br>Water | PCT<br>Powder | Rön-Jen<br>Alloy |
|--------------------------|-------------|--------------|------------------|---------------|------------------|
| Chemical Purchases       |             | (\$81,750)   | (\$49,050)       | (\$42,100)    | (\$24,700)       |
| Waste<br>Mgmt.           | Chemicals   | 0            | (\$3,000)        | 0             | 0                |
|                          | Testing     | (\$1,000)    | (\$1,800)        | 0             | 0                |
|                          | Disposal    | (\$8,400)    | 0                | 0             | 0                |
| Safety Training / Equip  |             | (\$40)       | (\$20)           | (\$20)        | (\$20)           |
| Insurance                |             | (\$10,000)   | (\$14,000)       | (\$2,000)     | 0                |
| Chemical Use Fees        |             | 0            | 0                | 0             | 0                |
| Filing Paperwork time    |             | (\$500)      | 0                | 0             | 0                |
| Annual Permitting        |             | (\$300)      | (\$150)          | 0             | 0                |
| Production<br>Costs      | % Inc./Dec. | 0            | 5% ↑             | 7% ↑          | 35% ↓            |
|                          | \$ / yr.    | (\$300,000)  | (\$315,000)      | (\$321,000)   | \$195,000)       |
| Main-<br>tenance         | Time        | (\$250)      | (\$100)          | (\$200)       | (\$350)          |
|                          | Materials   | (\$75)       | 0                | 0             | 0                |
| Utilities                | Water       | NA           | (\$1,500)        | 0             | 0                |
|                          | Electricity | (\$4,175)    | (\$3,520)        | (\$8,000)     | (\$6,500)        |
|                          | Gas/Steam.  | NA           | 0                | 0             | 0                |
| Total Annual Oper. C. F. |             | (\$406,490)  | (\$388,140)      | (\$373,320)   | \$226,570)       |



| <b>Cash Flow Summary</b> | <b>MEK<br/>Spray</b> | <b>MIRAGLO<br/>Water</b> | <b>PCT<br/>Powder</b> | <b>Rön-Jen<br/>Alloy</b> |
|--------------------------|----------------------|--------------------------|-----------------------|--------------------------|
| Total Operating Costs    | (\$406,490)          | (\$388,140)              | (\$373,320)           | \$226,570)               |
| Incremental Cash Flow    | NA                   | \$18,350                 | \$33,170              | \$179,920                |
| - Depreciation           | NA                   | (\$11,350)               | (\$24,400)            | (\$38,500)               |
| Taxable Income           | NA                   | \$7,000                  | \$8,770               | \$141,420                |
| Income Tax (40%)         | NA                   | (\$2,800)                | (\$3,508)             | (\$55,568)               |
| Net Income               | NA                   | \$4,200                  | \$5,262               | \$84,852                 |
| + Depreciation           | NA                   | \$11,350                 | \$24,400              | \$38,500                 |
| After Tax Cash Flow      | NA                   | \$15,550                 | \$29,662              | \$123,352                |
| Present Value            | NA                   | \$49,133                 | \$144,406             | \$757,948                |
| Total Capital Cost       | NA                   | (\$45,400)               | (\$170,800)           | \$385,000)               |
| Net Present Value        | NA                   | \$3,733                  | (\$26,393)            | \$372,948                |
| Equal Annual Annuity     | NA                   | \$1,177                  | (\$5,421)             | \$60,695                 |
| Infinite Horizon NPV     | NA                   | \$11,770                 | (\$54,210)            | \$606,950                |

### **Financial Feasibility**

The three proposals have significantly different Capital Costs and different lifetimes. If the decision were made solely on purchase cost, MIRAGLO would win. Net Present Value can not be used for comparison in this case because of the different lifetimes of each project.

This requires the use of the Equal Annual Annuity method to accurately compare their profitability. The EAA is calculated by dividing each project's Net Present Value by the corresponding Present Value Factor in Appendix A. For example MIRAGLO's Net Present Value is \$3,733, the Present Value Factor for this 4 year project at 10% cost of capital is 3.1699. Dividing the NPV by this factor yields an Equal Annual Annuity of \$1,177 per year for the life of the project. If this project were replaced every four years with an identical system, forever, the Infinite Horizon NPV would be \$1,177 divided by the cost of capital (10%). Based upon the EAA method, the Rön-Jen Alternative looks most profitable.

## Teachers Notes on Exercise #4

If you choose to walk through the exercise, note the following points:

- Which alternative looks the most promising based solely upon Equipment purchase costs?  
(One might choose this option if no other analysis is done - MIRAGLO).
- Which alternative looks the best after annual savings have been calculated?  
(Again one might conclude that is the right choice if no further analysis is done (MIRAGLO)).
- Which are still feasible projects after the Net Present Value Calculations?  
(Now how do we choose between two alternatives? MIRAGLO & Rön-Jen)
- Which one is the best considering the information provided?  
(Rön-Jen - What considerations might change this? [layoffs of workers, ability to raise capital]).
- Notice the inconsistent electrical use cost data. This often occurs in analyses.
- Notice the \$5,000 to clean out the lines and get rid of the extra MEK, even with MIRAGLOs drop in replacement.
- MIRAGLO causes mutations in rats; what are the tradeoffs of using a new chemical?
- Notice the lack of information in some instances. How can this be corrected? Is this a problem? Will it significantly impact the analysis?

# **Appendices**

**A. Compound Interest Tables**

**B. Sources for Further Reading**

Present Value of an Annuity of \$1 for  $n$  Periods:

$$\left[ \sum_{t=1}^n \frac{1}{(1+k)^t} \right]$$

| number of<br>payments | 1%      | 3%      | 5%      | 6%      | 7%      | 8%      | 9%      | 10%    | 11%    | 12%    | 13%    | 14%    | 15%    | 16%    | 17%    | 18%    | 19%    |
|-----------------------|---------|---------|---------|---------|---------|---------|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| 1                     | 0.9901  | 0.9709  | 0.9524  | 0.9434  | 0.9346  | 0.9259  | 0.9174  | 0.9091 | 0.9009 | 0.8929 | 0.8850 | 0.8772 | 0.8696 | 0.8621 | 0.8547 | 0.8475 | 0.8403 |
| 2                     | 1.9704  | 1.9135  | 1.8594  | 1.8334  | 1.8080  | 1.7833  | 1.7591  | 1.7355 | 1.7125 | 1.6901 | 1.6681 | 1.6467 | 1.6257 | 1.6052 | 1.5852 | 1.5656 | 1.5465 |
| 3                     | 2.9410  | 2.8286  | 2.7232  | 2.6730  | 2.6243  | 2.5771  | 2.5313  | 2.4869 | 2.4437 | 2.4018 | 2.3612 | 2.3216 | 2.2832 | 2.2459 | 2.2096 | 2.1743 | 2.1399 |
| 4                     | 3.9020  | 3.7171  | 3.5460  | 3.4651  | 3.3872  | 3.3121  | 3.2397  | 3.1699 | 3.1024 | 3.0373 | 2.9745 | 2.9137 | 2.8550 | 2.7982 | 2.7432 | 2.6901 | 2.6386 |
| 5                     | 4.8534  | 4.5797  | 4.3295  | 4.2124  | 4.1002  | 3.9927  | 3.8897  | 3.7908 | 3.6959 | 3.6048 | 3.5172 | 3.4331 | 3.3522 | 3.2743 | 3.1993 | 3.1272 | 3.0576 |
| 6                     | 5.7955  | 5.4172  | 5.0757  | 4.9173  | 4.7665  | 4.6229  | 4.4859  | 4.3553 | 4.2305 | 4.1114 | 3.9976 | 3.8887 | 3.7845 | 3.6847 | 3.5892 | 3.4976 | 3.4098 |
| 7                     | 6.7282  | 6.2303  | 5.7864  | 5.5824  | 5.3893  | 5.2064  | 5.0330  | 4.8684 | 4.7122 | 4.5638 | 4.4226 | 4.2883 | 4.1604 | 4.0386 | 3.9224 | 3.8115 | 3.7057 |
| 8                     | 7.6517  | 7.0197  | 6.4632  | 6.2098  | 5.9713  | 5.7466  | 5.5348  | 5.3349 | 5.1461 | 4.9676 | 4.7988 | 4.6389 | 4.4873 | 4.3436 | 4.2072 | 4.0776 | 3.9544 |
| 9                     | 8.5660  | 7.7861  | 7.1078  | 6.8017  | 6.5152  | 6.2469  | 5.9952  | 5.7590 | 5.5370 | 5.3282 | 5.1317 | 4.9464 | 4.7716 | 4.6065 | 4.4506 | 4.3030 | 4.1633 |
| 10                    | 9.4713  | 8.5302  | 7.7217  | 7.3601  | 7.0236  | 6.7101  | 6.4177  | 6.1446 | 5.8992 | 5.6502 | 5.4262 | 5.2161 | 5.0188 | 4.8332 | 4.6586 | 4.4941 | 4.3389 |
| 11                    | 10.3676 | 9.2526  | 8.3064  | 7.8869  | 7.4987  | 7.1390  | 6.8052  | 6.4951 | 6.2065 | 5.9377 | 5.6869 | 5.4527 | 5.2337 | 5.0286 | 4.8364 | 4.6560 | 4.4865 |
| 12                    | 11.2551 | 9.9540  | 8.8633  | 8.3838  | 7.9427  | 7.5361  | 7.1607  | 6.8137 | 6.4924 | 6.1944 | 5.9176 | 5.6603 | 5.4206 | 5.1971 | 4.9884 | 4.7932 | 4.6105 |
| 13                    | 12.1337 | 10.6350 | 9.3936  | 8.8527  | 8.3577  | 7.9038  | 7.4869  | 7.1034 | 6.7499 | 6.4235 | 6.1218 | 5.8424 | 5.5831 | 5.3423 | 5.1183 | 4.9095 | 4.7147 |
| 14                    | 13.0037 | 11.2961 | 9.8986  | 9.2950  | 8.7455  | 8.2442  | 7.7862  | 7.3667 | 6.9819 | 6.6282 | 6.3025 | 6.0021 | 5.7245 | 5.4675 | 5.2293 | 5.0081 | 4.8023 |
| 15                    | 13.8651 | 11.9379 | 10.3797 | 9.7122  | 9.1079  | 8.5595  | 8.0607  | 7.6061 | 7.1909 | 6.8109 | 6.4624 | 6.1422 | 5.8474 | 5.5755 | 5.3242 | 5.0916 | 4.8759 |
| 16                    | 14.7179 | 12.5611 | 10.8378 | 10.1059 | 9.4466  | 8.8514  | 8.3126  | 7.8237 | 7.3792 | 6.9740 | 6.6039 | 6.2651 | 5.9542 | 5.6685 | 5.4053 | 5.1624 | 4.9377 |
| 17                    | 15.5623 | 13.1661 | 11.2741 | 10.4773 | 9.7632  | 9.1216  | 8.5436  | 8.0216 | 7.5488 | 7.2497 | 6.7291 | 6.4674 | 6.0472 | 5.1280 | 5.4746 | 5.2223 | 4.9897 |
| 18                    | 16.3983 | 13.7535 | 11.6896 | 10.8276 | 10.0591 | 9.3719  | 8.7556  | 8.2014 | 7.7016 | 7.1196 | 6.8399 | 6.3729 | 6.1280 | 5.7487 | 5.5339 | 5.2732 | 5.0333 |
| 19                    | 17.2260 | 14.3238 | 12.0853 | 11.1581 | 10.3356 | 9.6036  | 8.9501  | 8.3649 | 7.8393 | 7.3658 | 6.9380 | 6.5504 | 6.1982 | 5.8775 | 5.5845 | 5.3162 | 5.0700 |
| 20                    | 18.0456 | 14.8775 | 12.4622 | 11.4699 | 10.5940 | 9.8181  | 9.1285  | 8.5136 | 7.9633 | 7.4694 | 7.0248 | 6.6231 | 6.2593 | 5.9288 | 5.6278 | 5.3527 | 5.1009 |
| 25                    | 22.0232 | 17.4131 | 14.0939 | 12.7834 | 11.6536 | 10.6748 | 9.8226  | 9.0770 | 8.4217 | 7.8431 | 7.3300 | 6.8729 | 6.4641 | 6.0971 | 5.7662 | 5.4669 | 5.1951 |
| 30                    | 25.8077 | 19.6004 | 15.3725 | 13.7648 | 12.4090 | 11.2578 | 10.2737 | 9.4269 | 8.6938 | 8.0552 | 7.4957 | 7.0027 | 6.5660 | 6.1772 | 5.8294 | 5.5168 | 5.2347 |
| 40                    | 32.8347 | 23.1148 | 17.1591 | 15.0463 | 13.3317 | 11.9246 | 10.7574 | 9.7791 | 8.9511 | 8.2438 | 7.6344 | 7.1050 | 6.6418 | 6.2335 | 5.8713 | 5.5482 | 5.2582 |
| 50                    | 39.1961 | 25.7298 | 18.2559 | 15.7619 | 13.8007 | 12.2335 | 10.9617 | 9.9148 | 9.0417 | 8.3045 | 7.6752 | 7.1327 | 6.6605 | 6.2463 | 5.8801 | 5.5541 | 5.2623 |
| 60                    | 44.9550 | 27.6756 | 18.9293 | 16.1614 | 14.0392 | 12.3766 | 11.0480 | 9.9672 | 9.0892 | 8.3240 | 7.6873 | 7.1401 | 6.6651 | 6.2492 | 5.8819 | 5.5553 | 5.2630 |



---

## Appendix B: Sources for Further Reading

- "The Cost of Changing: A Total Cost Analysis of Solvent Alternatives"; Mitchell Kennedy, for the Massachusetts Toxics Use Reduction Institute, Lowell, MA. 1993.
- "Costing and Financial Analysis of Pollution Prevention Projects: A Training Packet"; Northeast Waste Management Officials Association, Boston, MA. 1994.
- "Engineering Economy"; G.J. Thiesen & W.J. Fabrycky; Prentice Hall Publishers, Englewood, NJ. 1984.
- "A Primer for Financial Analysis of Pollution Prevention Projects"; US EPA Office of Research and Development, Washington, DC. 1993.
- "Activity Based Costing / Activity Based Management: The Next Frontier"; NCMS, Ann Arbor, MI. 1993.
- "Total Cost Assessment: Accelerating Industrial Pollution Prevention through Innovative Project Financial Analysis"; US EPA Doc #741/R-92/002, May 1992.



## More?

If you would like to know more about Total Cost Assessment and other pollution prevention tools we would be glad to assist you. Please contact P<sup>2</sup>c at the number below for more information on workshop and training programs. (860) 231-7151