A COMPARISON OF
REVERSE VENDING MACHINE ALTERNATIVES

by

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(ABSTRACT)

The purpose of this report is to demonstrate the use of the Life-Cycle Cost Analysis technique and the Analytic Hierarchy Process technique as decision tools for determining the most economical choice of three Reverse Vending machine alternatives.

The report compares costs associated with production and construction, operation and maintenance, disposal, and metal income. Difficult to quantify factors, such as, ease of use, appearance, and accessibility were also investigated. Each technique yielded a different recommendation.

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INTRODUCTION

BACKGROUND

Aluminum, being the second most common metal employed by man, has posed a significant waste disposal problem. The recycling of aluminum is a concern of the environmentalist as well as the resource conservationist. By recycling aluminum, 95% of the energy required to make aluminum from bauxite is saved. The concept of recycling aluminum is not new. Reynolds Metals Company (RMC) began recycling scrap from fabricating operations over forty years ago. In addition to reducing the amount of energy consumed, recycling also saves valuable natural resources and reduces the burden on our landfills [1].

One form of aluminum scrap is the used beverage can (UBC). In 1968, RMC opened a collection center that offered to pay any individual for aluminum cans and other clean household aluminum. Since 1968, RMC has paid recyclers more than $1 billion. In 1989, various can reclamation programs harvested 765,671 metric tons of metal [2].

Aluminum recyclers, wanting to increase the volume of aluminum cans recycled, expressed the desire for an automated machine. If a machine could be developed to buy cans back from

the public on a 24-hour basis, the volume of recycled cans would increase.

As a result of the desire for such a machine, the development of 'Reverse Vending' was born. Reverse vending refers to a machine that accepts a commodity (aluminum cans) and pays the customer money in return. A number of machines appeared on the market in the late 1970s. None of the available machines satisfied the quality standards that RMC wanted in a machine. (See Appendix A for a listing of desired Machine Parameters.)

In 1981, RMC started the development of their first prototype reverse vending machine. The project was referred to as P-I. The purpose of the project was to design and build an advanced reverse vending machine capable of purchasing used beverage cans (UBCs) from the public.

After the completion of the P-I machine, it became apparent that modifications to the original design would be required to make the machine more reliable. The desire was to have a machine that would experience less than one breakdown per 3,000 pounds of UBCs collected. A new prototype was designed and was called P-II.

The new P-II machine was developed and tested. Additional engineering established a variety of cost-saving measures. With these measures incorporated into the design,

the estimate of the initial cost of the machine was still higher than the desired $30,000 limit.

A machine that had an initial price less than $30,000 and met the original specifications was still needed. As a result, the P-III project was started. The P-III was a re-engineering of the P-II prototype. The P-III machine incorporated the basics of the processing system from the P-II machine and also used lower cost materials. The P-III came close to meeting the desired price criteria and also fulfilled the original specifications.

RMC continued to search the market for feasible reverse vending machines. A reverse vending machine was found that appeared to meet the RMC specifications. A unit was purchased and placed in operation. It was referred to as the PP, or purchased prototype. Field testing of the PP machine revealed that it did not meet all of the originally established specifications. However, it was felt that the trade-offs in operating performance justified the initial cost savings.

As a result of the tests being performed on the PP test unit, RMC now questioned if some of the stringent requirements that were originally established, and by which all the RMC prototype machines were designed and fabricated, were actually required.

OBJECTIVE

The objective of this report is to demonstrate the use of Life-Cycle Cost analysis, as well as the Analytic Hierarchy Process, as decision tools to compare alternate systems. The two different techniques will be used to evaluate the following three possible reverse vending machine alternatives:

1. PP design: does not fulfill the original specifications, but the initial cost savings, availability of machines, and the known expectancies make it a viable alternative.

2. P-II design: fulfills all of the original specifications and uses ideal equipment and materials in its design. The desired initial price criteria is exceeded.

3. P-III design: fulfills all of the original specifications, but uses lower-cost materials.

DEFINITION OF NEED

In an effort to reduce the cost to produce aluminum, Reynolds Metals Company (RMC) has a desire to increase the volume of recycled used beverage cans (UBCs). The cost savings can be used to increase RMC's profit margin, produce lower cost products thus capturing more of the consumer market, conserve natural resources, conserve energy use, contribute to the reduction of the landfill burden, and promote the image of RMC as an environmentally concerned organization with an emphasis on recycling.

A network of 'Reverse Vending' machines nationwide would assist with the collection of UBCs from the general public. A test project has been awarded a budget of $1,500,000 for the initial purchase of the machines. A number of machines will be placed in service and used as a basis for proving the feasibility of expanding nationwide.

The machines are expected to generate an additional volume of 10,000,000 pounds of UBCs per year. The existing RMC-manned collection center network will be used to support machine placement and service. The initial price of each macine are desired to be less than $30,000. Using a design-to-cost criteria, a module of 50 machines or less would be required. (See Appendix A for further listings of Machine Parameters and Appendix B for Project Assumptions).

CHAPTER II

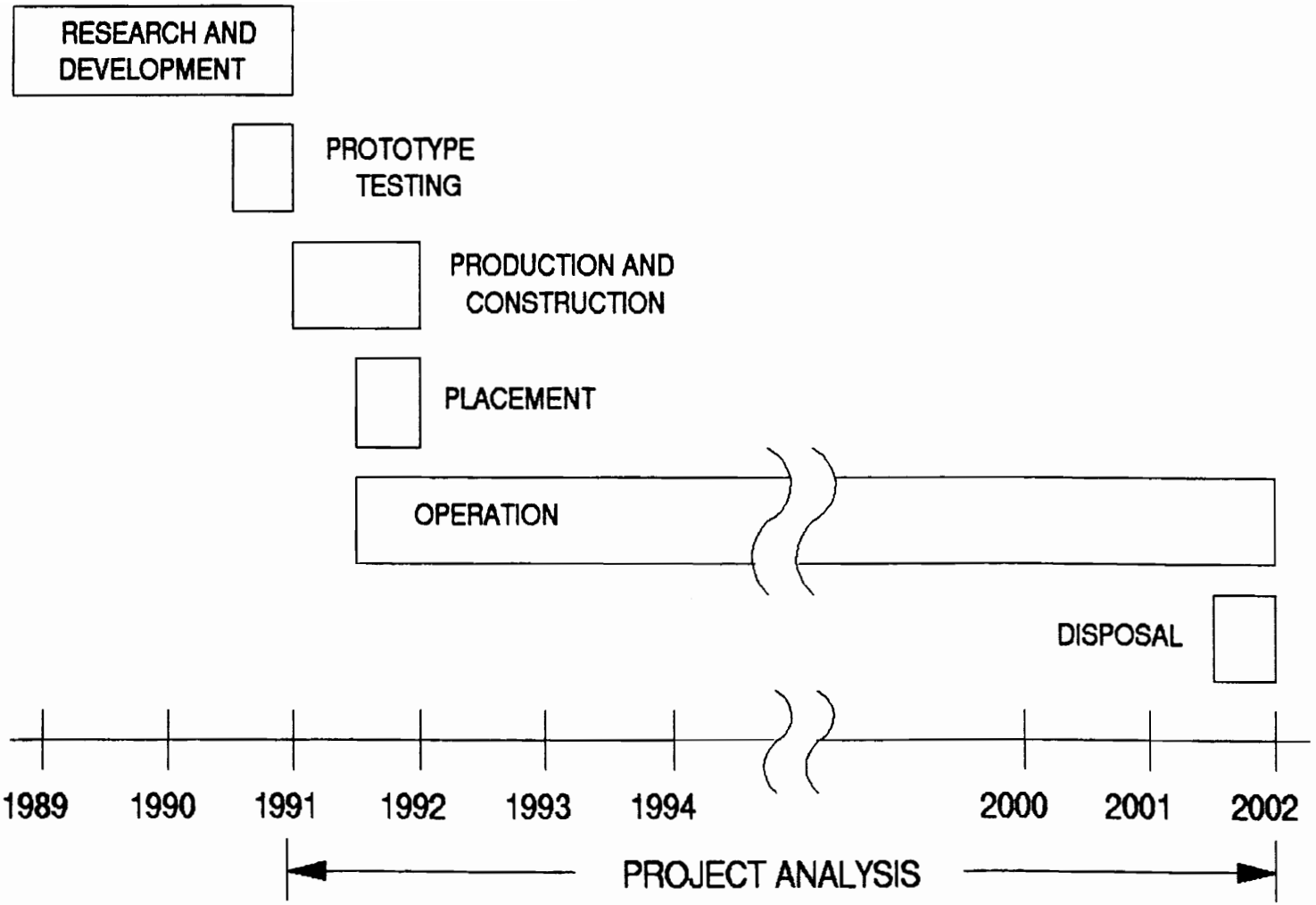
THE LIFE-CYCLE COST APPROACH

CALCULATION OF LIFE-CYCLE COST ELEMENTS

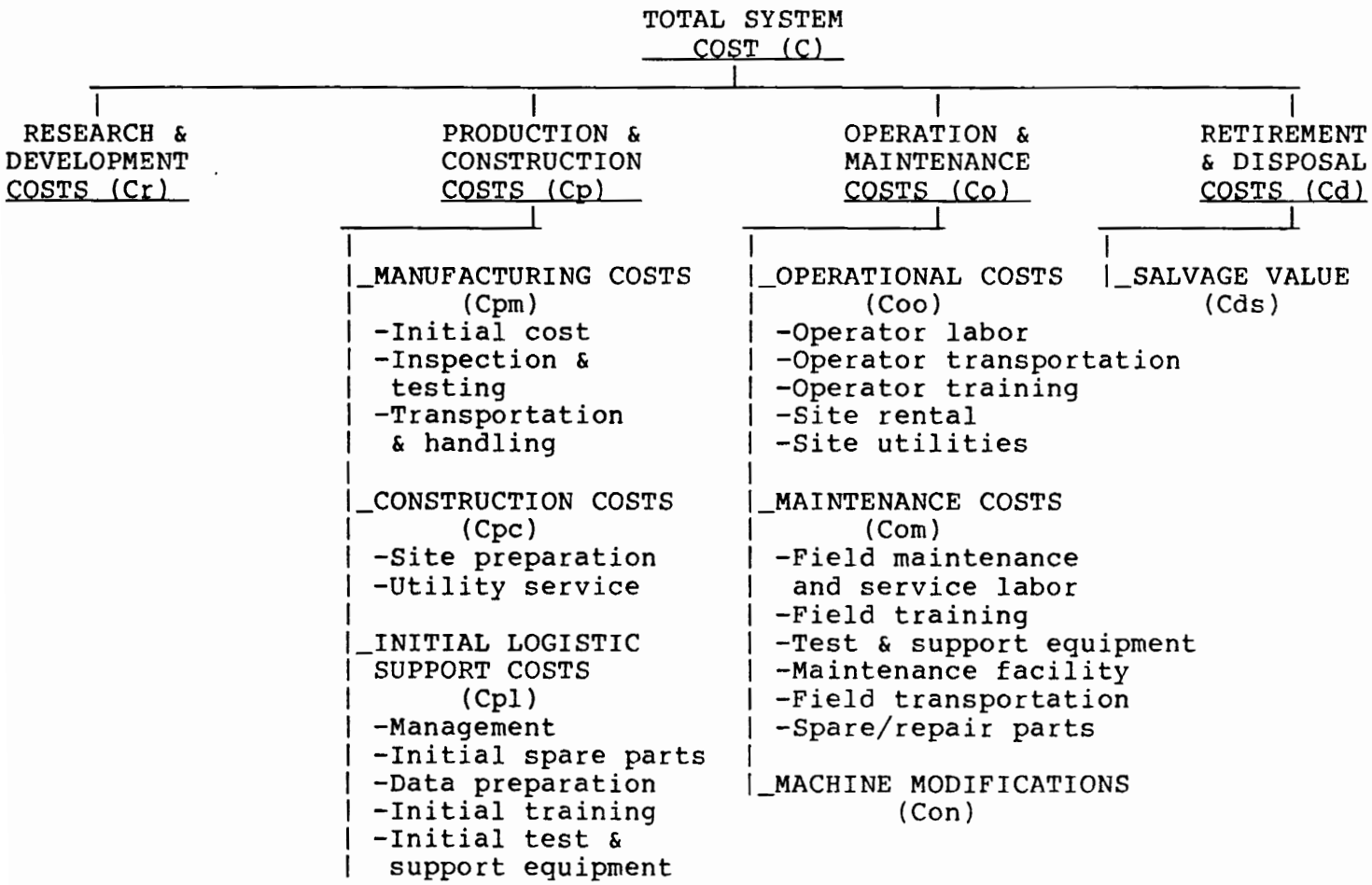
There are always some assumptions that must be made during the analysis of a project. The results of this report represent only one possible scenario. The logic of the application of the two techniques would be applicable to other scenarios as well.

Life-cycle costs (LCC) refer to the costs encountered during the six phases of a project. The phases include concept, preliminary design, detail design, production and construction, system utilization, and system retirement. Figure 2-1 illustrates the project schedule, with respect to the system life cycle process.

A Life-Cycle Cost analysis is the analytical analysis of the expected costs of a project. One advantage of the life-cycle cost analysis technique is that it is iterative in nature and may be applied to any phase or phases of the system life cycle. The analysis of this project will begin with the production and construction phase.



PROJECT SCHEDULE
FIGURE 2-1



COST BREAKDOWN STRUCTURE

Figure 2-2

All of the expected costs categories can be displayed in a Cost Breakdown Structure as shown in Figure 2-2 [3]. The total system cost equation for the system is:

TOTAL SYSTEM COST (C) =

RESEARCH AND DEVELOPMENT (Cr)

+ PRODUCTION AND CONSTRUCTION (Cp)

+ OPERATION AND MAINTENANCE (Co)

+ DISPOSAL (Cd)

$C = Cr + Cp + Co + Cd$

RESEARCH AND DEVELOPMENT COSTS

Three machines are being evaluated to determine which machine RMC should purchase for a 50-machine test module. One machine was developed by an outside vendor. The other two machines were developed by RMC and incurred research and development costs. The analysis is taking place once the machines have already been developed and tested as units. As a result, the Research and Development Costs (Cr) are considered as sunk costs. The costs, although different for each machine, have already been spent.

PRODUCTION AND CONSTRUCTION COST

The analysis is being performed from Reynolds Metals Company's viewpoint. The production and construction costs

to be considered are those that would have an impact on the decision of which machine RMC should select. Table 2-1 is a summary of the production and construction costs expected for the three different machine alternatives.

Production and Construction Costs (Cp) include Manufacturing Costs (Cpm), Construction Costs (Cpc), and Initial Logistic Support Costs (Cpl).

$$Cp = Cpm + Cpc + Cpl$$

Manufacturing Costs (Cpm) include all nonrecurring manufacturing costs (Cpn) and recurring manufacturing costs (Cpr) associated with the production and testing of the 50 machines.

$$Cpm = Cpn + Cpr$$

Since all three machines are to be manufactured by an outside fabricator, at the fabricator's facility, the fixed nonrecurring manufacturing costs (Cpn) are included in the price of the machine. This would include such costs as manufacturing management, manufacturing engineering, initial tooling and factory test equipment. The fabricator has included these overhead expenses in the selling price of the machine.

Factors contributing to the recurring manufacturing costs

(Cpr) are the production cost (Cprp), the testing cost (Cprt), and shipment cost (Cprs) of each unit once fabrication is completed. The selling price of each of the three different machines will be used as the production cost (Cprp) of the machines.

$$Cpr = Cprp + Cprt + Cprs$$

The selling prices of the machines are $17,500 for the PP model, $30,000 for the P-II model, and $26,500 for the P-III model. These prices are based on vendor quotations.

An acceptance test of each machine will occur at the vendor's facility prior to shipment. Testing costs (Cprt) will include the cost of one man traveling to the vendor's location and testing the units. Five units will take five days to test at an expense of $1,500 per week for any of the three machines. The inspector will make five trips to the vendor's location and test the machines in lots of ten.

The manufacturing rate for the PP machine would be three units per week. The P-II and P-III machines could be manufactured only at a rate of two units per week due to their more complex design.

The purchase price is F.O.B. vendor's shop. As a result, the shipment cost (Cprs) includes the initial transportation and handling cost. The location of the potential vendors

varies for the different machines.

The PP machine has the highest transportation cost due to a greater travel distance. The P-II and P-III will cost approximately the same to transport. Due to the smaller size of the PP machine, the handling costs are lower than for the P-II and P-III machines. Summing the average transportation and handling cost results in an approximate equivalent expense of $1,200 per machine.

Construction Costs (Cpc) include all initial acquisition costs associated with facilities and utilities for manufacturing, testing, and maintaining the units. The initial manufacturing, testing, and utility facility costs have already been realized by the fabricator. Any recurring facility or utility cost incurred by the vendor will be included in the initial price of the machines by the vendor as overhead expenses.

Construction costs (Cpc) to consider are the initial site preparation costs (Cpcs) and utility service costs (Cpcu) for each machine.

$$Cpc = Cpcs + Cpcu$$

The estimated cost for site preparation and utilities per machine is $4,000 for the PP machine and $5,000 for either the P-II or the P-III machine. These values are based on the respective test unit placement costs. The costs have been

adjusted to account for a quantity of 50 machines.

Initial Logistic Support Costs (Cpl) include the costs associated with obtaining the initial spare parts and training equipment.

$$Cpl = Cpls + Cpli + Cpld + Cplt + Cplx$$

The PP test unit experienced 8 breakdowns, operated 1,008 hours, and processed 90,894 pounds of UBCs during the test year. The P-II machine experienced 9 breakdowns, operated 685 hours, and processed 131,967 pounds of UBCs during the test year. The P-III machine had 14 breakdowns, operated 544 hours, and processed 102,616 pounds of UBCs during the year. The failure rate (FR) for each machine is as follows:

PP FR = 8 breakdowns/1008 hours = .00794 bds/hr

P-II FR = 9 breakdowns/685 hours = .01314 bds/hr

P-III FR = 14 breakdowns/544 hours = .02574 bds/hr

Each machine consists of approximately 10 sub-assemblies. Each sub-assembly is made up of hundreds of components. An analysis of the required spare component parts is beyond the scope of this report. Based on the failure rate experienced during the test year, vendor recommendation, and experience, an estimate of the required number of spare sub-assemblies will be calculated.

The cost for the recommended spare parts, the calculation

for the required quantity, and an explanation of the procedure is detailed in Appendix K. A 90% probability of having a spare sub-assembly available, a 30-day restocking cycle, and a quantity of 50 machines were used in the calculations. A series logic flow was used when designing the machines. As a result, the sub-assemblies were put together in a series formation.

The spare parts, as well as the maintenance facility repair shop, will be housed in an existing RMC collection center. The initial spare parts cost (Cpls), for a module of 50 machines, is estimated at $57,496 for the PP, $143,937 for the P-II, and $73,266 for the P-III.

The initial inventory management costs (Cpli) includes catalogs, listings, and codes for spare parts entering the inventory. Since the PP machine would be purchased from an outside vendor, this cost is included in the selling cost of the machine. The P-II and P-III were designed by RMC, but would be built by an outside fabricator. It is estimated that the inventory management cost (Cpli) for the two Reynolds machines will be approximately $20 per machine.

The technical data preparation cost (Cpld) includes the cost for the development of operating, maintenance, and test manuals. Again, this cost is included in the original cost of the PP machine. It is estimated that it would take a

process engineer and a secretary one month to perform the task for either the P-II or the P-III machine.

Process Engineer = $40,000/yr x 1yr/12mo
x 1.27% (fringes)
= $4,233/mo

Secretary = $8.50/hr x 173 hrs/mo x 1.27% (fringes)
= $1,868/mo

Cpld = ($4,233/mo + $1,868/mo) x 1 mo = $6,101

Training will take place at the site of a newly placed machine. The initial training and training equipment costs (Cplt) include a technician traveling to the site and spending one week training the maintenance person as well as the collection center manager. The cost will be the same for any of the three machines - approximately $1,500 for the week. No special training equipment will be required.

The initial test cost (Cplx) includes all initial test and support equipment. The only test equipment required is the hand-held test device that comes with each machine. The cost of the hand-held has been included in the initial cost of the machine. Support equipment includes the tools required by the maintenance personnel. The initial costs are approximately $575. These costs will be the same for all three alternatives.

Table 2-1

PRODUCTION AND CONSTRUCTION COSTS PER MODULE *
(Constant Dollars)

COST CATEGORY		PP	P-II	P-III
Production & construction cost				
a. Selling price of machine	Cpri	$875,000	$1,500,000	$1,325,000
b. Initial testing	Cprt	$15,000	$15,000	$15,000
c. Initial shipment	Cprs	$60,000	$60,000	$60,000
d. Initial construction	Cpc	$200,000	$250,000	$250,000
e. Initial spare parts	Cpls	$57,496	$143,937	$73,266
f. Initial inventory mgmt.	Cpli	$0	$1,000	$1,000
g. Initial data preparation	Cpld	$0	$6,101	$6,101
h. Initial training	Cplt	$1,500	$1,500	$1,500
i. Initial test equipment	Cplx	$575	$575	$575
	TOTAL	$1,209,571	$1,978,113	$1,732,442

* Module consists of 50 machines.

OPERATION AND MAINTENANCE COST

All operating (Coo) and maintenance (Com) costs required to keep the machines functioning throughout each machine's life-cycle are contributors to the operation and maintenance costs (Co). Also included are all equipment modification costs (Con).

$$Co = Coo + Com + Con$$

All expenses due to the actual operation of the machines are included in the operating cost (Coo). The cost of operating labor (Cool), recurring operator training (Coop), operator transportation (Coot), site rental (Coor), and site utilities (Coou) are included in the operating cost (Coo).

$$Coo = Cool + Coop + Coot + Coor + Coou$$

All three possible machines are automated, free-standing machines, such that there are no on-site operator expenses. Two collection people will be required to recover the collected UBCs from the machines and transport them to the collection center. See Appendix B for details of the labor costs. These costs are equivalent for any of the three machine alternatives.

Cool = 2 x $8.50/hr x 240 hrs/mo x 1.27% (fringes)

Cool = $5,182/mo ($62,179/yr)

It is assumed that one of the two collection people will leave per year due to attrition. The remaining collection person will be responsible for training the replacement. One week will be required to show the new person the route and methods required to unload the machines. Two person-weeks will be consumed in the process. These costs are equivalent for any of the three machine alternatives.

2 x $8.50/hr x 40 hr/wk = $680/turnover

1 turnover/yr x $680/turnover = $680/yr

Coop = $680/yr

The required transportation costs (Coot) by the collection personnel are included in the operating cost (Coo). All transportation vehicles will be leased. The maintenance and insurance of the vehicles will be included in the lease.

Each collection person will require a tractor and trailer rig. A total of six trailers will be required, three trailers per collection person. The three trailers will be rotated between collection, ready to unload, and being unloaded. The collection person will unload four to five machines a day. An average of 100 miles, six days a week, will be traveled by the collection person. The costs are equivalent for any of the three machine alternatives.

Tractors: Lease = 2 x $3,500/mo x 12 mo/yr = [$84,000/yr]

Travel = 2 x 100 mi/day x 6 days/wk = 1200 mi/wk

1200 mi/wk x $.40/mi = $480/wk

$480/wk x 52 wk/yr = [$24,960/yr]

Trailers: Lease = 2 x 3 x $600/mo x 12 mo/yr = [$43,200/yr]

Travel = 2 x 3 x 100 mi/day x 2 days/wk

= 1200 mi/wk

1200 mi/wk x $.10/mi = $120/wk

$120/wk x 52 wk/yr = [$6,240/yr]

Coot = $84,000/yr + $24,960/yr + $43,200/yr + $6,240/yr

Coot = $158,400/yr

The monthly rent (Coor) for the selected sites and the monthly utilities (Coou) for each machine are included in the operating costs (Coo). The rent for each site is $300/mo for each machine. This is the highest price that RMC is willing to pay. This cost is equivalent for any of the three machine alternatives.

Coor = $300/machine/mo x 50 machines

= $15,000/mo [$180,000/yr]

The utility costs are different for each machine due to design and usage differences. The average utility cost for the PP test unit was $225/mo. The P-II and P-III have a 40%

higher power consumption rate due to their more complex designs. The PP test machine was used 1008 hours and processed 90,894 pounds of UBCs during the test year. The P-II and P-III machines were used 685 and 544 hours and processed 131,967 and 102,616 pounds of UBCs respectively during the test year. The differential in use is assumed to be due to customer preference.

PP Coou = $225/mo/machine x 50 machines

= $11,250/mo = [$135,000/yr]

P-II Coou = ($225/mo x 1.40 x 90,894/131,967)/ machine x 50 machines

= $10,848/mo = [$130,176/yr]

P-III Coou = ($225/mo x 1.40 x 90,894/102,616)/ machine x 50 machines

= $13,951/mo = [$167,412/yr]

Maintenance costs (Com) include labor (Comm), training (Comp), recurring spare parts (Comx), recurring tools and test equipment (Coms), transportation (Comt), and facilities (Comf) costs.

Com = Comm + Comp +Comx + Coms + Comt + Comf

Maintenance labor will include one maintenance person (Commc) and two cleaning people (Commp). These expenses are included in the labor costs (Comm).

Comm = Commc + Commp

The maintenance person will be hired from an outside firm to perform corrective maintenance functions. The maintenance person will work only when corrective maintenance is required. The average corrective downtime was 8 hours per failure. The maintenance company charges $55.00/hr for a serviceman's time.

PP Commc = 8 bd/yr x 8 hrs/bd x $55.00/hr = $3,520/yr

P-II Commc = 9 bd/yr x 8 hrs/bd x $55.00/hr = $3,960/yr

P-III Commc = 14 bd/yr x 8 hrs/bd x $55.00/hr = $6,160/yr

The two cleaning people will perform only preventive maintenance functions. These functions will be the same for all three possible machines.

2 Cleaning people:

2 x $8.50/hr x 240 hrs/mo x 1.27% (fringes)

= $5,182/mo [$62,184/yr]

PP Comm = $3,520/yr + $62,184/yr = $65,704/yr

P-II Comm = $3,960/yr + $62,184/yr = $66,144/yr

P-III Comm = $6,160/yr + $62,184/yr = $68,344/yr

Recurring training costs (Comp) include the cost of training replacement cleaning and maintenance personnel. It is assumed that one of the two cleaning people will leave per year due to attrition. The replacement cleaning person

will be trained by the remaining cleaning person. It is assumed that it will take approximately one week to train the new person. Two person-weeks are assumed to be the expense of training the new personnel.

(2 x $8.50/hr x 40 hr/wk)/turnover

= $680/turnover.

1 turnover/yr x $680/turnover

= $680/yr.

Since the maintenance person is hired from a firm that specializes in corrective maintenance repair, replacement training will not be required.

The recurring training costs (Comp) are assumed to be equivalent for any of the three machine alternatives.

Comp = $680/yr

The cost of spare/repair parts (Csd) kept at the collection center, as well as the cost of consumables (Csc) used by the cleaning and maintenance crews, are included in the replenishment spare parts cost (Comx).

Comx = Csd + Csc

The cost of required assemblies are detailed in Appendix K. The cost of consumables(Csc) was an average $50/mo for each of the test machines.

Csc = $50/machine/mo x 12 mo/yr x 50 machines/module

= $30,000/yr per module

The assumed cost of spare parts (Comx) for the respective module of machines will be:

PP Comx = $57,496/yr + $30,000/yr = $87,496/yr

P-II Comx = $143,937/yr + $30,000/yr = $173,937/yr

P-III Comx = $73,266/yr + $30,000/yr = $103,266/yr

The recurring costs for tools and test equipment (Coms), including maintenance of test equipment, is assumed to be $300/yr for each of the three different alternatives.

The required transportation costs (Comt) by the maintenance and cleaning personnel are included in the maintenance cost (Com). All transportation vehicles will be leased. The maintenance and insurance of the vehicles will be included in the lease.

The cleaning crew will require the use of a van. The van will travel an average of 100 miles per day, six days a week. The cleaning crew will service five machines a day.

Van: Lease = $300/mo x 12 mo/yr = [$3,600/yr]

Travel = 100 mi/day x 6 days/wk = 600 mi/wk

600 mi/wk x $.25/mi = $150/wk

$150/wk x 52 wk/yr = [$7,800/yr]

Comt = $3,600/yr + $7,800 = $11,400/yr

The maintenance person will be hired from an outside firm that specializes in maintenance repair. The repair person will be called to repair particular machines as required. The corrective maintenance company will supply their own vehicle.

The maintenance facility will be installed in an existing RMC collection center facility. The initial maintenance facility expense has already been realized. The monthly rental of the space allocated for the maintenance facility is included in maintenance facility cost (Comf). The maintenance facility will house the spare parts and test equipment required for routine maintenance. This area accounts for 5% of the existing facility. The rent for the complete facility is $4,000 per month. The utilities average $500 per month. This results in a monthly cost of :

Comf = (5% x $4,000/mo) + (%5 x $500/mo)

= $225/mo = [$2,700/yr]

Table 2-2

RECURRING OPERATION & MAINTENANCE COSTS PER MODULE *
(CONSTANT DOLLARS PER YEAR)

COST CATEGORY		PP	P-II	P-III
Operation & maintenance cost (Co)				
a. Operator labor	Cool	$62,179	$62,179	$62,179
b. Op. replacement training	Coop	$680	$680	$680
c. Operator transportation	Coot	$158,400	$158,400	$158,000
d. Site rental	Coor	$180,000	$180,000	$180,000
e. Site utility	Coou	$135,000	$130,176	$167,412
f. Maintenance labor	Comm	$65,704	$66,144	$68,344
g. Mt. replacement training	Comp	$680	$680	$680
h. Spare/repair parts	Comx	$87,496	$173,937	$103,266
i. Tools & test equipment	Coms	$300	$300	$300
j. Maintenance transportation	Comt	$11,400	$11,400	$11,400
k. Maintenance facility	Comf	$2,700	$2,700	$2,700
	TOTAL	$704,539	$786,596	$755,361

All three prototype machines have been tested in the field for the last year. All machine modifications have been incorporated into the prototypes and have also been field tested. It is assumed that no further equipment modifications will be required.

Table 2-2 contains a summary of the expected recurring operation and maintenance costs for the three different machine alternatives.

DISPOSAL COSTS

The expected life span for the PP machine is seven years based on expert opinion. The P-II and P-III are expected to have the same life of eleven years. This also is based on expert opinion. (See Appendix F for further detail.) At the end of a machine's respective life, the machine will be sold. It is assumed that the PP machines could be sold for a minimum of $1,000 each. It is also assumed that the P-II and P-III machines could be sold for a minimum of $2,000 and $1,500 per machine respectively. The dismantling and removal costs will be the responsibility of the buyer. The disposal documentation costs will be nominal and equivalent for any of the three alternatives.

For this project, retirement and disposal cost (Cd) will

be equivalent to the salvage value (Cs).

$$Cd = Cs$$

PP Cs = $1,000/machine

P-II Cs = $2,000/machine

P-III Cs = $1,500/machine

METAL INCOME

The quality of the metal collected by the three different machines varies. The P-II and the P-III machine have features that enable the machine to detect desirable material from undesirable. The desirable material is paid for and the undesirable is rejected and sent to the trash. The majority of these same features which increase the cost of the P-II and P-III machines do not exist on the PP machine. As a result, the PP machine is prone to buying material of a poorer quality than the P-II and P-III machine. For the purpose of this report, the material collected and paid for from the PP machine averages 10% contamination. The material collected from the P-II and P-III machines averages only 1% contamination.

The revenue generated from the metal collected by the machines is considered a savings (Sm). The intracorporate transfer price paid for the metal is $.225/lb. The average

price per pound paid to the customer for the metal is $.45/lb. The revenue generated is $.225/lb. The yearly income per respective machine is:

PP Savings = 90,894 lbs/machine x 90% x $.225/lb
x 50 machines/module = $920,302/module

P-II Savings = 131,967 lbs/machine x 99% x $.225/lb
x 50 machines/module = $1,469,782/module

P-III Savings = 102,616 lbs/machine x 99% x $.225/lb
x 50 machines/module = $1,142,886/module

LIFE-CYCLE COST ANALYSIS

The P-II and P-III machines both are assumed to have a life expectancy of eleven years. The life-cycle cost analysis will be based on an eleven-year life. The PP machine is assumed to have a seven-year life. The ability to repeat the existing life-cycle costs of the PP machine will be assumed. A second module of 50 machines will be purchased during the seventh year and will replace the units in the field. The salvage cost of the second module of machines will be prorated. At the end of the eleventh year, the second module of PP machines will have used four years of its expected seven year life. The expected salvage value (Cd) at the end of year four would be:

$$PP \quad Cd\{4\} = \frac{[(\$17,500 - \$1,000) \times 4yr]}{7\ yr} = \$9,430$$

The money required for the initial purchase of the machines must be requested and committed by the end of 1990. The contract for the machines will be let January 1, 1991. The selected vendor will require one month for preparation to begin fabrication. All of the potential machines can be fabricated and placed within the first calendar year. Six months of operation and maintenance costs will be assumed for the first and last calendar year. Four months of metal income will be assumed for the first year.

All of the expected costs are summed for each incremental

year and displayed in Table 2-3. Constant dollars are used to display today's dollar values. Table 2-4 is an incremental display of the annual costs, inflated, to obtain actual dollars, also known as inflated dollars. An inflation rate of 6% is used [5].

$$\text{Actual Dollars} = (1 + f)^{n} * (\text{Constant Dollars})$$

Table 2-5 is an incremental display of the present value of the actual costs using a discount rate of 10%. The inflated costs are discounted to 1990 present values [12].

$$\text{Present Value} = F * \frac{1}{(1 + i)^{n}}$$

Graphic displays of the three different rates for the three different machines are shown in Figures 2-3, 2-4, and 2-5.

A summary of the Life-Cycle Costs are compiled in Table 2-6. The analysis indicates that the present value of the P-II machine has the greatest savings. Desiring to obtain the greatest savings, the P-II machine would be favored. A graphic display of the comparison of the present values, or discounted cost profiles, for the three different machines is shown in Figure 2-6. The cost profile also indicates that the P-II machine has the highest savings value.

Refer to Appendix E for the additional spreadsheets used to compile the Incremental Cost/(Savings) and Life-Cycle Cost Summary tables.

Table 2-3

INCREMENTAL COST/(SAVINGS) TABLE BY CATEGORY [1]
(CONSTANT DOLLARS)

Cost Category	Alternative	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Total
1. Production and Construction costs (Cp)	PP	$875,000	$334,571							$950,000					$2,159,571
	P-II	$1,500,000	$478,113												$1,978,113
	P-III	$1,325,000	$407,442												$1,732,442
2. Oper. & Maintenance (Co)	PP		$352,270	$704,539	$704,539	$704,539	$704,539	$704,539	$704,539	$704,539	$704,539	$704,539	$704,539	$352,270	$7,749,930
	P-II		$393,298	$786,596	$786,596	$786,596	$786,596	$786,596	$786,596	$786,596	$786,596	$786,596	$786,596	$393,298	$8,652,556
	P-III		$377,681	$755,361	$755,361	$755,361	$755,361	$755,361	$755,361	$755,361	$755,361	$755,361	$755,361	$377,681	$8,308,972
3. Disposal (Cd)	PP									($50,000)				($471,500)	($521,500)
	P-II													($100,000)	($100,000)
	P-III													($75,000)	($75,000)
Costs total (C)	PP	$875,000	$686,841	$704,539	$704,539	$704,539	$704,539	$704,539	$704,539	$1,604,539	$704,539	$704,539	$704,539	($119,230)	$9,388,001
	P-II	$1,500,000	$871,411	$786,596	$786,596	$786,596	$786,596	$786,596	$786,596	$786,596	$786,596	$786,596	$786,596	$293,298	$10,530,669
	P-III	$1,325,000	$785,123	$755,361	$755,361	$755,361	$755,361	$755,361	$755,361	$755,361	$755,361	$755,361	$755,361	$302,681	$9,966,414
4. Metal income (Sa)	PP		($306,767)	($920,302)	($920,302)	($920,302)	($920,302)	($920,302)	($920,302)	($920,302)	($920,302)	($920,302)	($920,302)	($460,151)	($9,969,938)
	P-II		($489,927)	($1,469,782)	($1,469,782)	($1,469,782)	($1,469,782)	($1,469,782)	($1,469,782)	($1,469,782)	($1,469,782)	($1,469,782)	($1,469,782)	($734,891)	($15,922,638)
	P-III		($380,962)	($1,142,886)	($1,142,886)	($1,142,886)	($1,142,886)	($1,142,886)	($1,142,886)	($1,142,886)	($1,142,886)	($1,142,886)	($1,142,886)	($571,443)	($12,381,265)
Grand total	PP	$875,000	$380,074	($215,763)	($215,763)	($215,763)	($215,763)	($215,763)	($215,763)	$684,237	($215,763)	($215,763)	($215,763)	($579,381)	($581,937)
	P-II	$1,500,000	$381,484	($683,186)	($683,186)	($683,186)	($683,186)	($683,186)	($683,186)	($683,186)	($683,186)	($683,186)	($683,186)	($441,593)	($5,391,969)
	P-III	$1,325,000	$404,161	($387,525)	($387,525)	($387,525)	($387,525)	($387,525)	($387,525)	($387,525)	($387,525)	($387,525)	($387,525)	($268,762)	($2,414,851)

1. For a module of 50 machines.

Table 2--4

INCREMENTAL COST/(SAVINGS) TABLE BY CATEGORY [1]
(INFLATED DOLLARS) 2

Cost Category	Alternative	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Total
1. Production and Construction costs (Cp)	PP	$875,000	$354,646							$1,514,156					$2,743,802
	P-II	$1,500,000	$506,800												$2,006,800
	P-III	$1,325,000	$431,889												$1,756,889
2. Oper. & Maintenance (Co)	PP		$373,405	$791,620	$839,118	$889,464	$942,832	$999,402	$1,059,365	$1,122,928	$1,190,305	$1,261,722	$1,337,425	$708,837	$11,516,423
	P-II		$416,895	$883,819	$936,850	$993,058	$1,052,644	$1,115,802	$1,182,748	$1,253,715	$1,328,938	$1,408,674	$1,493,193	$791,393	$12,857,729
	P-III		$400,340	$848,724	$899,647	$953,626	$1,010,843	$1,071,494	$1,135,784	$1,203,931	$1,276,167	$1,352,737	$1,433,901	$759,968	$12,347,160
3. Disposal (Cd)	PP									($79,692)				($948,751)	($1,028,443)
	P-II													($201,220)	($201,220)
	P-III													($150,915)	($150,915)
Costs total (C)	PP	$875,000	$728,051	$791,620	$839,118	$889,464	$942,832	$999,402	$1,059,365	$2,557,392	$1,190,305	$1,261,722	$1,337,425	($239,914)	$13,231,782
	P-II	$1,500,000	$923,695	$883,819	$936,850	$993,058	$1,052,644	$1,115,802	$1,182,748	$1,253,715	$1,328,938	$1,408,674	$1,493,193	$590,173	$14,663,309
	P-III	$1,325,000	$832,229	$848,724	$899,647	$953,626	$1,010,843	$1,071,494	$1,135,784	$1,203,931	$1,276,167	$1,352,737	$1,433,901	$609,053	$13,953,134
4. Metal income (Sm)	PP		($325,173)	($1,034,051)	($1,096,094)	($1,161,860)	($1,231,572)	($1,305,466)	($1,383,794)	($1,466,822)	($1,554,831)	($1,648,121)	($1,747,008)	($925,914)	($14,080,706)
	P-II		($519,323)	($1,651,447)	($1,750,534)	($1,855,566)	($1,966,900)	($2,084,914)	($2,210,009)	($2,342,609)	($2,483,166)	($2,632,156)	($2,790,085)	($1,478,745)	($23,765,454)
	P-III		($403,820)	($1,284,147)	($1,361,196)	($1,442,867)	($1,529,439)	($1,621,206)	($1,718,478)	($1,821,587)	($1,930,882)	($2,046,735)	($2,169,539)	($1,149,856)	($18,479,752)
Grand total	PP	$875,000	$402,878	($242,431)	($256,976)	($272,396)	($288,740)	($306,064)	($324,429)	$1,090,570	($364,526)	($386,399)	($409,583)	($1,165,828)	($1,648,924)
	P-II	$1,500,000	$404,372	($767,628)	($813,684)	($862,508)	($914,256)	($969,112)	($1,027,261)	($1,088,894)	($1,154,228)	($1,223,482)	($1,296,892)	($888,572)	($9,102,145)
	P-III	$1,325,000	$428,409	($435,423)	($461,549)	($489,241)	($518,596)	($549,712)	($582,694)	($617,656)	($654,715)	($693,998)	($735,638)	($540,803)	($4,526,618)

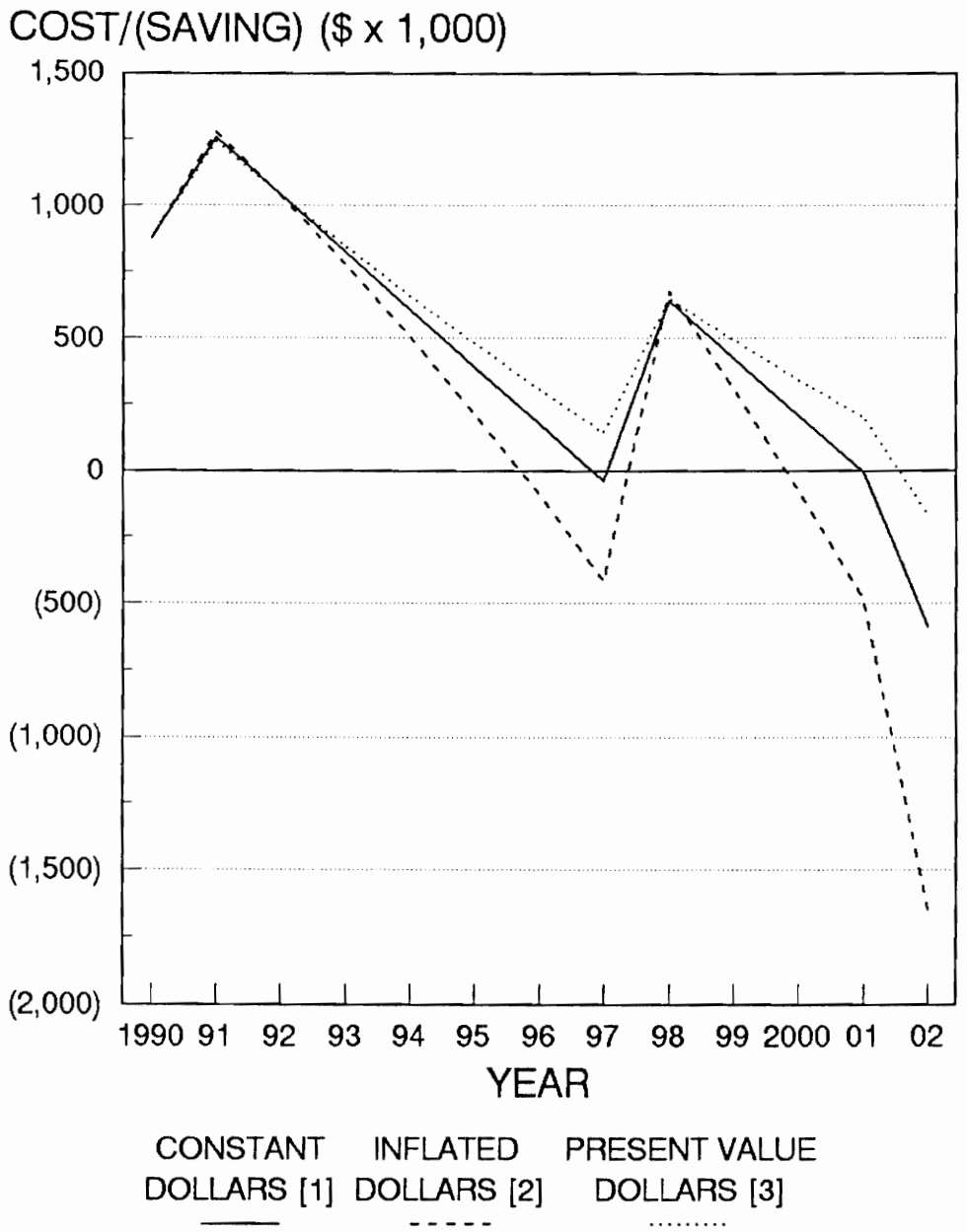
1. For a module of 50 machines.
2. An inflation rate of 6% was used; Inflated dollars = $(1 + f)^n$ * Constant dollars

Table 2-5

INCREMENTAL COST/(SAVINGS) TABLE BY CATEGORY [1]
(PRESENT VALUE DOLLARS) 2

Cost Category	Alternative	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Total
1. Production and Construction costs (Cp)	PP	$875,000	$322,405							$706,365					$1,903,770
	P-II	$1,500,000	$460,728												$1,960,728
	P-III	$1,325,000	$392,627												$1,717,627
2. Oper. & Maintenance (Co)	PP		$339,458	$654,230	$630,442	$607,516	$585,425	$564,137	$543,619	$523,855	$504,804	$486,448	$468,758	$225,856	$6,134,548
	P-II		$378,995	$730,428	$703,869	$678,272	$653,609	$629,841	$606,935	$584,867	$563,599	$543,105	$523,353	$252,162	$6,849,035
	P-III		$363,945	$701,423	$675,917	$651,338	$627,655	$604,830	$582,835	$561,645	$541,220	$521,538	$502,572	$242,148	$6,577,066
3. Disposal (Cd)	PP									($37,177)				($302,301)	($339,478)
	P-II													($64,115)	($64,115)
	P-III													($48,086)	($48,086)
Costs total (C)	PP	$875,000	$661,863	$654,230	$630,442	$607,516	$585,425	$564,137	$543,619	$1,193,043	$504,804	$486,448	$468,758	($76,445)	$7,698,840
	P-II	$1,500,000	$839,723	$730,428	$703,869	$678,272	$653,609	$629,841	$606,935	$584,867	$563,599	$543,105	$523,353	$188,047	$8,745,648
	P-III	$1,325,000	$756,572	$701,423	$675,917	$651,338	$627,655	$604,830	$582,835	$561,645	$541,220	$521,538	$502,572	$194,062	$8,246,607
4. Metal income (Sa)	PP		($295,612)	($854,588)	($823,512)	($793,566)	($764,709)	($736,902)	($710,105)	($684,283)	($659,400)	($635,422)	($612,316)	($295,025)	($7,865,440)
	P-II		($472,112)	($1,364,832)	($1,315,202)	($1,267,377)	($1,221,290)	($1,176,880)	($1,134,084)	($1,092,844)	($1,053,105)	($1,014,810)	($977,908)	($471,174)	($12,561,618)
	P-III		($367,109)	($1,061,279)	($1,022,687)	($985,498)	($949,661)	($915,129)	($881,851)	($849,784)	($818,882)	($789,105)	($760,410)	($366,380)	($9,767,775)
Grand total	PP	$875,000	$366,251	($200,358)	($193,070)	($186,050)	($179,284)	($172,765)	($166,486)	$508,760	($154,596)	($148,974)	($143,558)	($371,470)	($166,600)
	P-II	$1,500,000	$367,611	($634,404)	($611,333)	($589,105)	($567,681)	($547,039)	($527,149)	($507,977)	($489,506)	($471,705)	($454,555)	($283,127)	($3,815,970)
	P-III	$1,325,000	$389,463	($359,856)	($346,770)	($334,160)	($322,006)	($310,299)	($299,016)	($288,139)	($277,662)	($267,567)	($257,838)	($172,318)	($1,521,168)

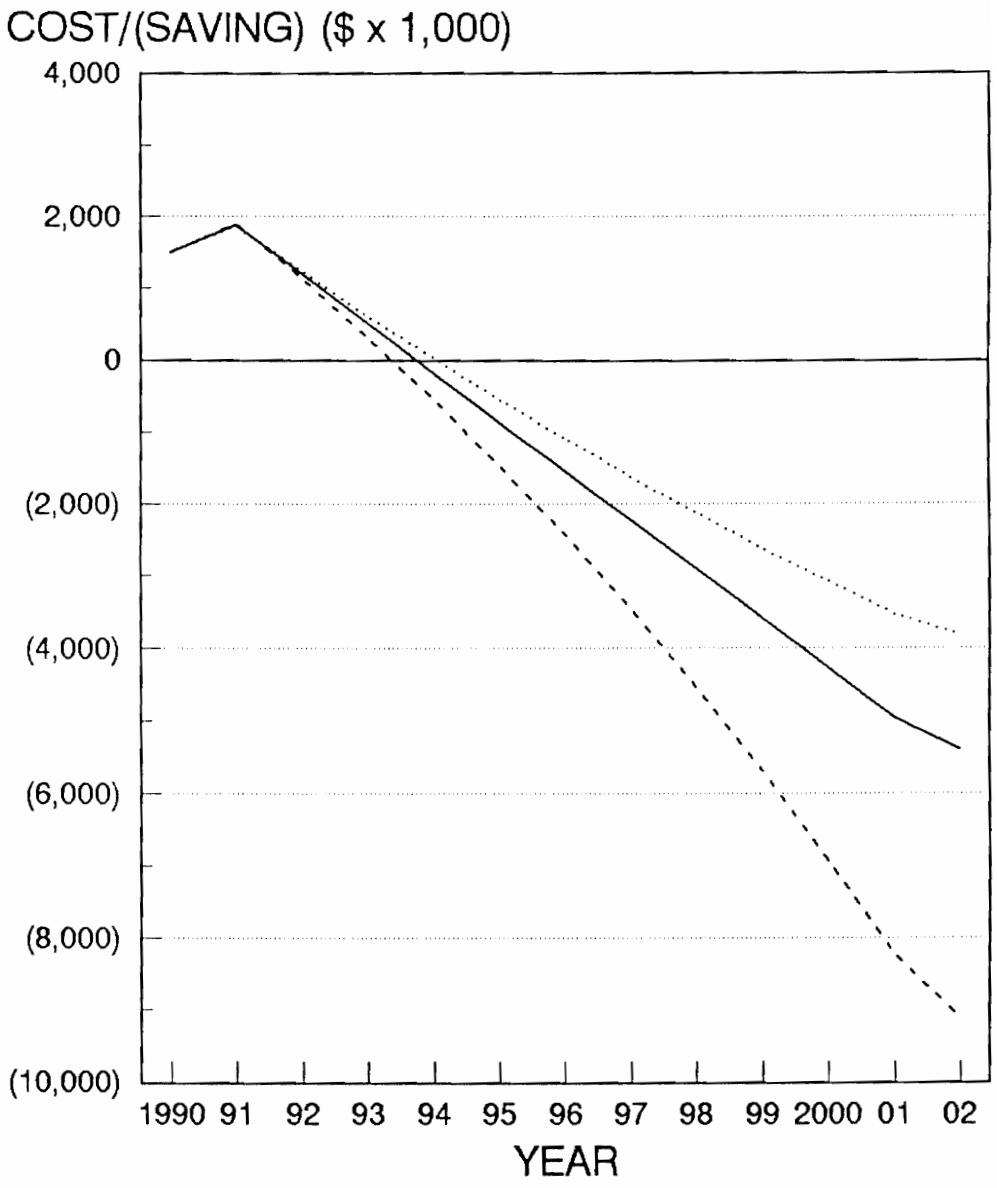
1. For a module of 50 machines.
2. A discount rate of 10% was used; Present value dollars = Inflated dollars * $\frac{1}{(1+i)^n}$



[1] CONSTANT DOLLARS
[2] 6% INFLATION RATE
[3] 10% DISCOUNT RATE

PP Machine Cost/Saving Profiles

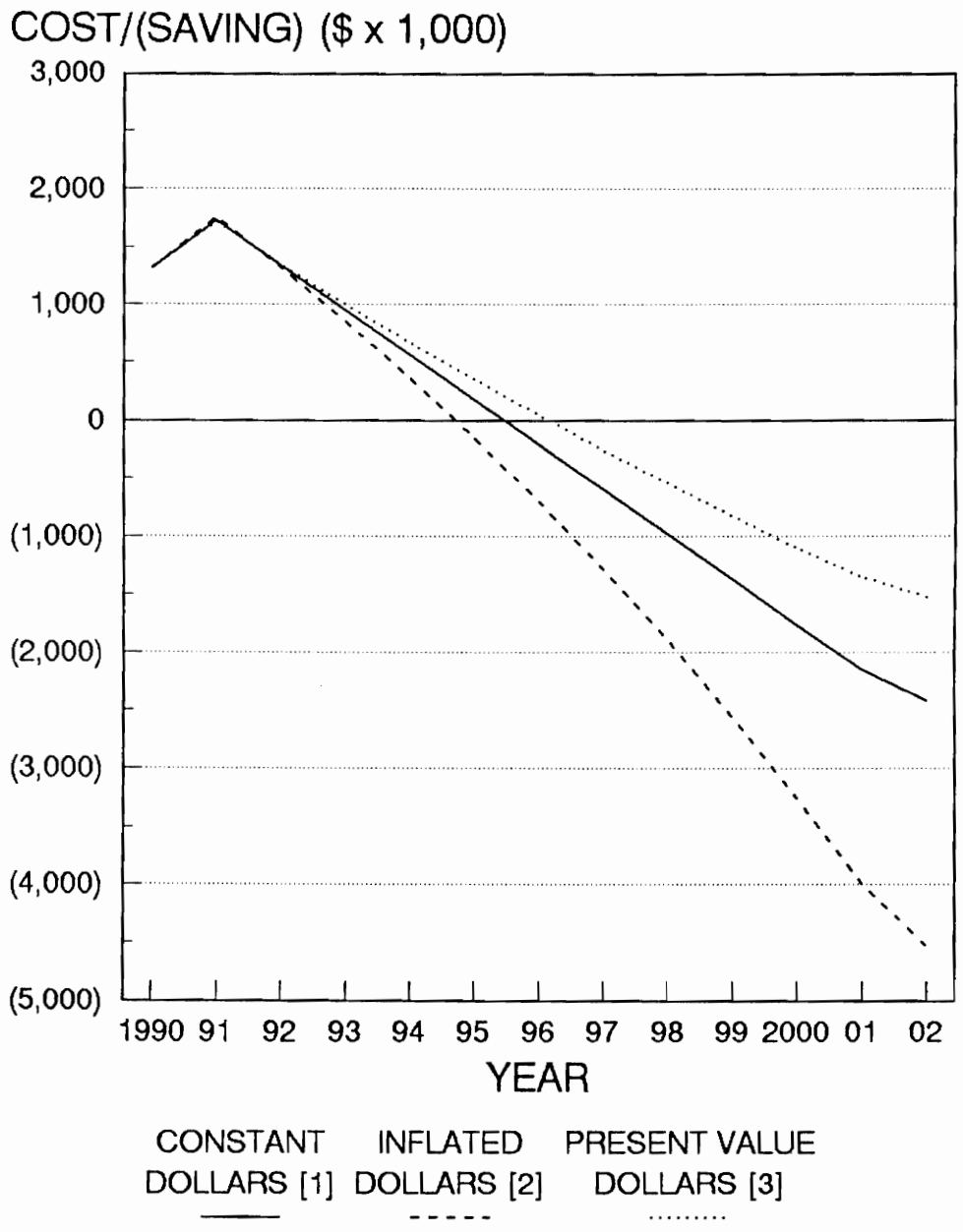
Figure 2-3



[1] CONSTANT DOLLARS
[2] 6% INFLATION RATE
[3] 10% DISCOUNT RATE

P-II Machine Cost/Saving Profiles

Figure 2-4



[1] CONSTANT DOLLARS
[2] 6% INFLATION RATE
[3] 10% DISCOUNT RATE

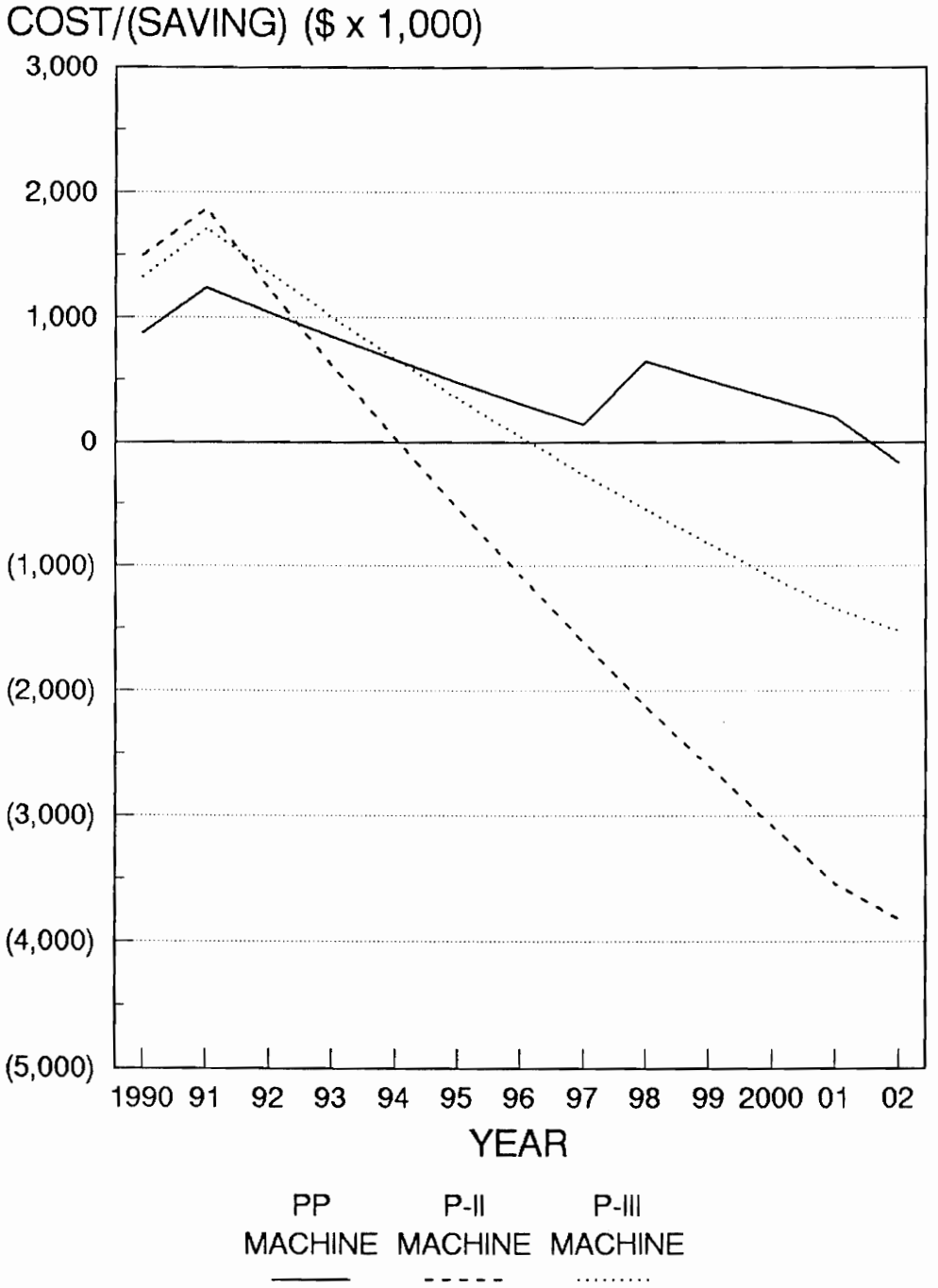
P-III Machine Cost/Saving Profiles

Figure 2-5

Table 2-6

LIFE-CYCLE COST SUMMARY
(1990 PV DOLLARS)

Cost Category	PP Cost ($)	Contribution (%)	P-II Cost ($)	Contribution (%)	P-III Cost ($)	Contribution (%)
1. Investment cost (Ci)	$1,903,770	24.7	$1,960,728	22.4	$1,717,627	20.8
a. Manufacturing (Cir)	$1,653,638	21.5	$1,572,273	18.0	$1,397,273	16.9
a-1. Initial cost (Ciri)	$1,525,599	19.8	$1,500,000	17.2	$1,325,000	16.1
a-2. Testing (Cirt)	$25,608	0.3	$14,455	0.2	$14,455	0.2
a-3. Transportation (Cirs)	$102,431	1.3	$57,818	0.7	$57,818	0.7
b. Construction (Cic)	$192,727	2.5	$240,909	2.8	$240,909	2.9
c. Initial logistic (Cil)	$57,405	0.7	$147,546	1.7	$79,445	1.0
c-1. Int. spare parts (Cils)	$55,405	0.7	$138,703	1.6	$70,602	0.9
c-2. Inventory mgmt. (Cili)	$0	0.0	$964	0.0	$964	0.0
c-3. Data preparation (Cild)	$0	0.0	$5,879	0.1	$5,879	0.1
c-4. Initial training (Cilt)	$1,445	0.0	$1,445	0.0	$1,445	0.0
c-5. Initial test eq. (Cilx)	$555	0.0	$555	0.0	$555	0.0
2. Oper. & Maintenance (Co)	$6,134,548	79.7	$6,849,035	78.3	$6,577,066	79.8
a. Operational costs (Coo)	$4,669,305	60.6	$4,627,304	52.9	$4,951,525	60.0
a-1. Operator labor (Co)	$541,404	7.0	$541,404	6.2	$541,405	6.6
a-2. Replacement training (Coop)	$5,920	0.1	$5,920	0.1	$5,919	0.1
a-3. Transportation (Coot)	$1,379,217	17.9	$1,379,217	15.8	$1,379,219	16.7
a-4. Rent (Coor)	$1,567,295	20.4	$1,567,295	17.9	$1,567,295	19.0
a-5. Utilities (Coou)	$1,175,469	15.3	$1,133,468	13.0	$1,457,687	17.7
b. Maintenance costs (Com)	$1,465,243	19.0	$2,221,731	25.4	$1,625,541	19.7
b-1. Labor (Comm)	$572,097	7.4	$575,928	6.6	$595,083	7.2
b-2. Replacement training (Comp)	$5,920	0.1	$5,920	0.1	$5,919	0.1
b-3. Recurring spares (Comx)	$761,846	9.9	$1,514,503	17.3	$899,156	10.9
b-4. Tools (Coms)	$2,611	0.0	$2,611	0.0	$2,612	0.0
b-5. Transportation (Comt)	$99,262	1.3	$99,262	1.1	$99,262	1.2
b-6. Facility (Comf)	$23,507	0.3	$23,507	0.3	$23,509	0.3
3. Disposal (Cd)	($339,478)	-4.4	($64,115)	-0.7	($48,086)	-0.6
Cost Total (C)	$7,698,840	100.0	$8,745,648	100.0	$8,246,607	100.0
4. Metal income (Cm)	($7,865,440)		($12,561,618)		($9,767,775)	
Grand total (C)	($166,600)		($3,815,970)		($1,521,168)	



Comparison Of The Present Value Profiles

Figure 2-6

SENSITIVITY ANALYSIS

The individual parameters that contribute more than 10% to the total cost of the machines are initial cost, operator transportation, site rental, site utilities, and recurring spare parts. Although these are significant factors, their significance is far outweighed by metal income. (Refer to Table 2-6.)

Metal income is a function of quantity and quality of metal collected. The quantity of metal collected by the three different machines was different during the one-year test period. It was assumed that the difference was due to customer preference. The quantity of metal collected also affects the operating utilities costs.

The present value cost/(savings) of the three different machines, as the quantity of metal is varied, is displayed in Figure 2-7. The percent contamination is constant at the previously assumed values. It is interesting to note that if all three machines could collect the same quantity of metal, the P-III machine would consistently have the highest present value savings. Under constant quantity of metal conditions, the P-III machine would be favored.

Metal income is also a function of the quality of the metal collected. The values used for the quality of metal collected were based on the one-year test results of the three

different machines. The P-II and P-III machines already achieve a level of 99% clean metal. The metal collected from the PP machine contained 10% contaminants, or 90% clean metal.

A graphic display of the present value cost/(savings) of the machines as the quality of metal is improved from ten to one percent contamination is shown in Figure 2-8. A constant quantity of 90,894 lbs/yr of metal collected is assumed for the PP machine. The P-II and P-III machine present value cost/(savings) are displayed at their respective quantity levels. It can be seen that the P-II machine is the favored machine since it has the highest present value savings.

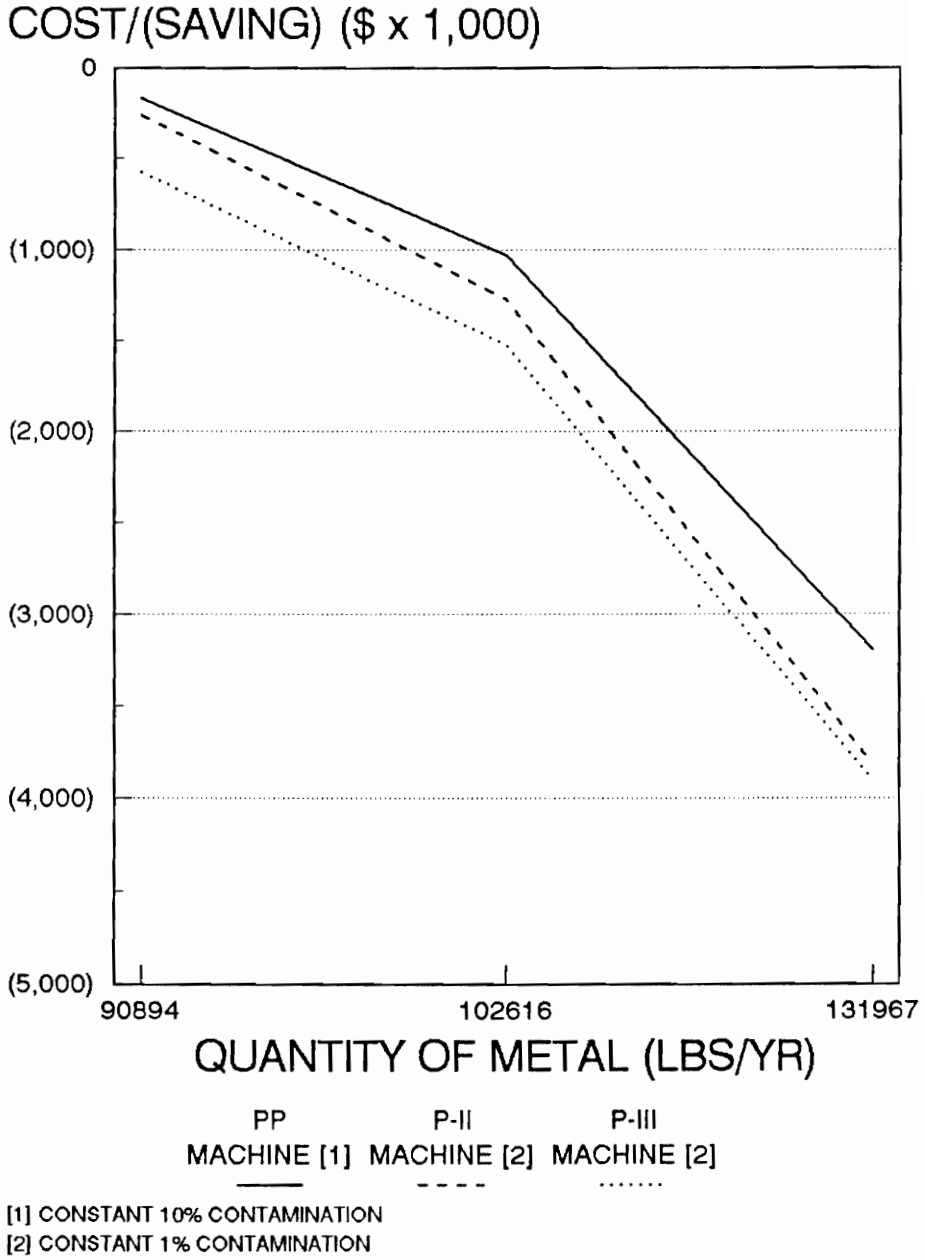
It is feasible that the quantity as well as the quality of the metal collected by the PP machine could improve at the same time. As an example, if the reliability of the PP machine could be improved, the mean pounds between failures (MPBF) would increase. In other words, if the machine functions were improved, the availability of the machine would be increased. The quantity as well as the quality of the collected metal should improve with the improved machine functions.

The present value cost/(savings) of the machines as the quantity as well as the quality of the metal collected is improved is displayed in Figure 2-9. If the PP machine could operate at the level of the P-II machine, it would be the

favored machine. If the P-III machine could operate at the same level as the P-II machine, it would also be favored over the P-II machine. This is indicated by the greater present value savings of the PP and P-III machines.

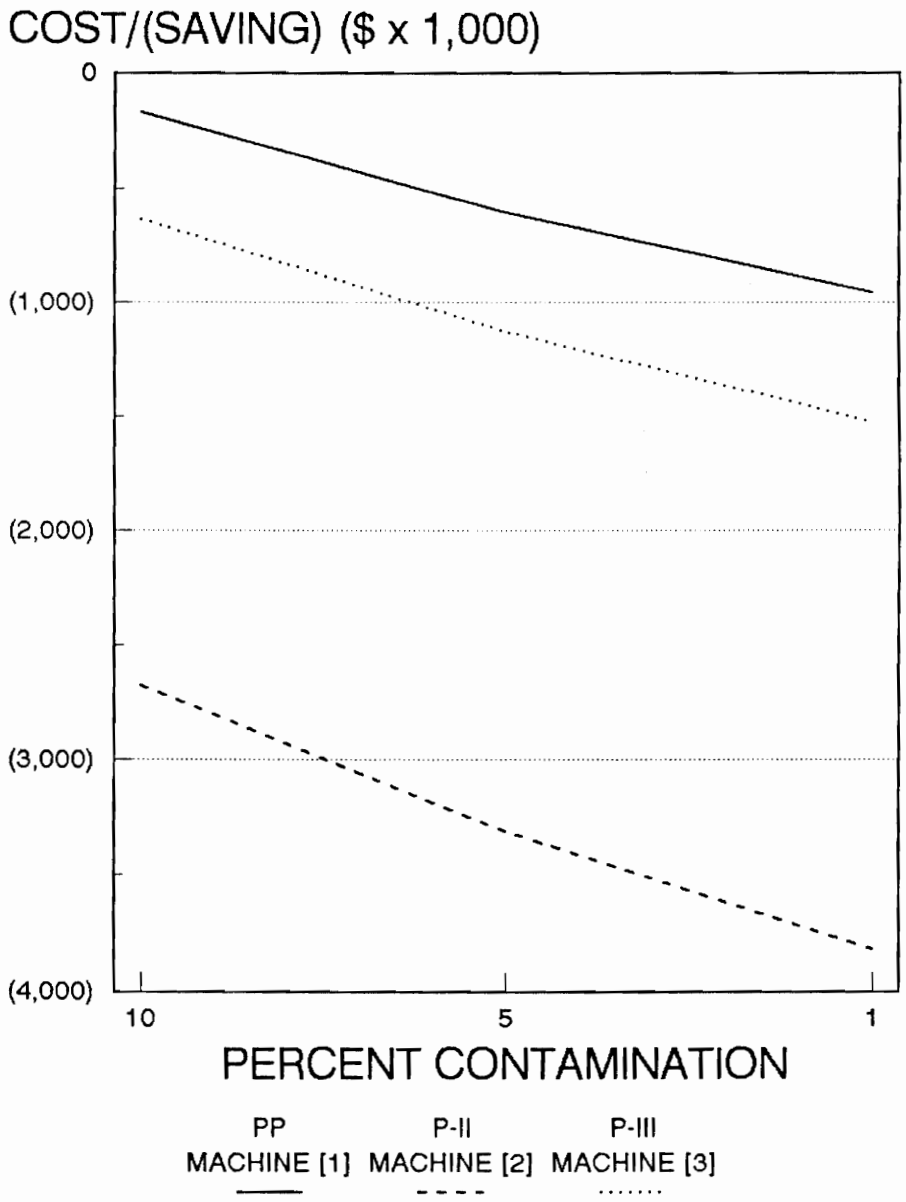
The PP machine would have to improve in both quantity as well as in quality of metal collected. The preference between the P-II and P-III machine when they are both able to collect at the 131,967 lbs/yr level is nearly equivalent. By the indications of the graphs in Figure 2-7, the P-II machine would soon be the preferred machine in the future when their collection levels increase.

Since the P-II machine has proven its capabilities to collect a high quality metal, at the highest volumes so far, it remains the preferred machine. It is suggested that a new evaluation be done near the end of the life cycle of the selected machine. The design of the PP machine may have improved by that time to make it the favored machine. See Appendix F for the spreadsheets used to generate the values for the sensitivity analysis.



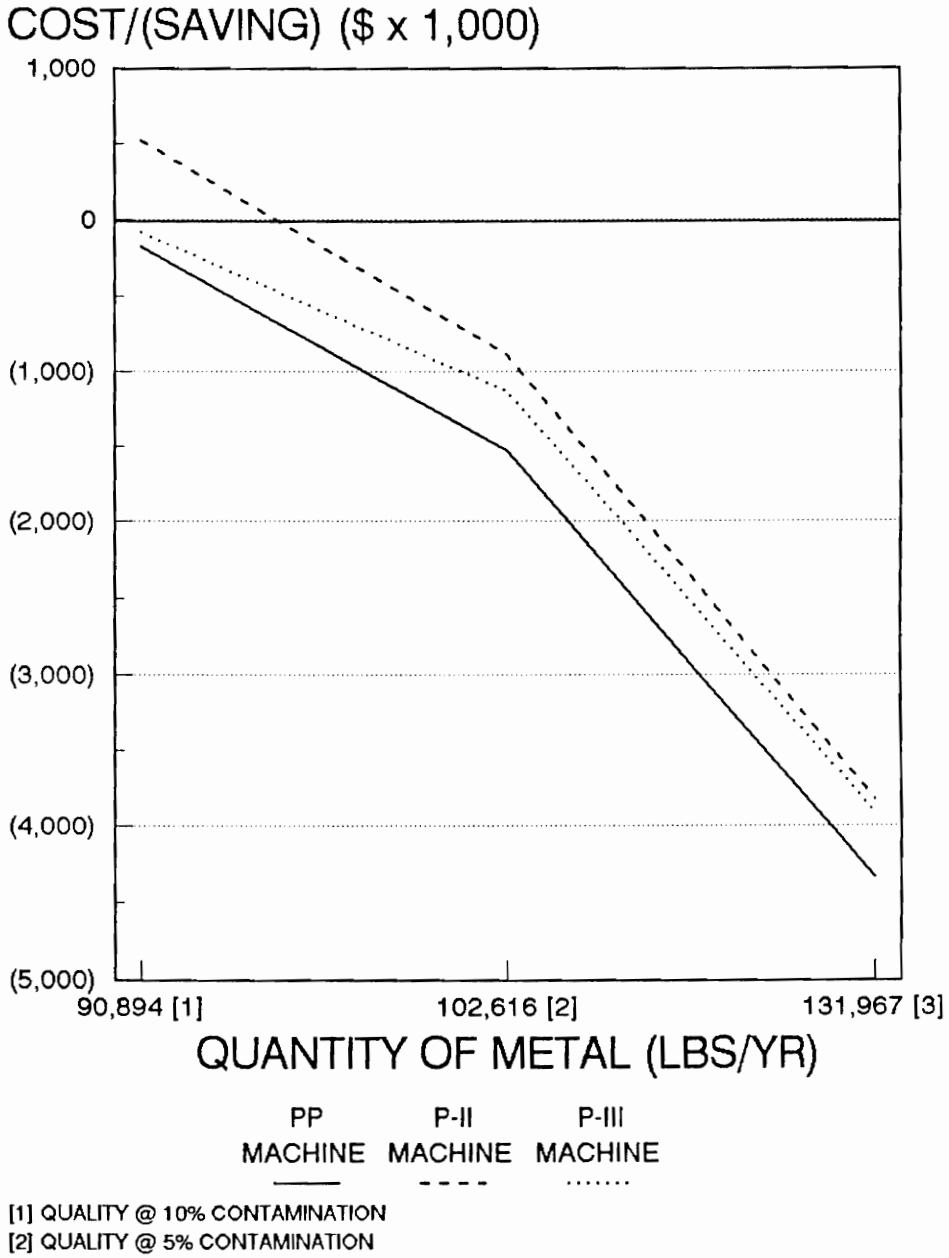
PV Profiles As Quantity Of Metal Varied

Figure 2-7



PV Profiles As Quality Of Metal Varied

Figure 2-8



PV Profiles As Quantity and Quality

Of Metal Varied.

Figure 2-9

Chapter III

ANALYTIC HIERARCHY APPROACH

The Analytic Hierarchy Process (AHP), is a decision tool that enables the analysis of complex, multiattribute problems. The process provides a method for quantifying elements that are difficult to quantify. Thomas Saaty is credited with the development of the process [6]. By using pairwise comparisons of the attributes and alternatives, priority weights can be established for each element of the hierarchy [7].

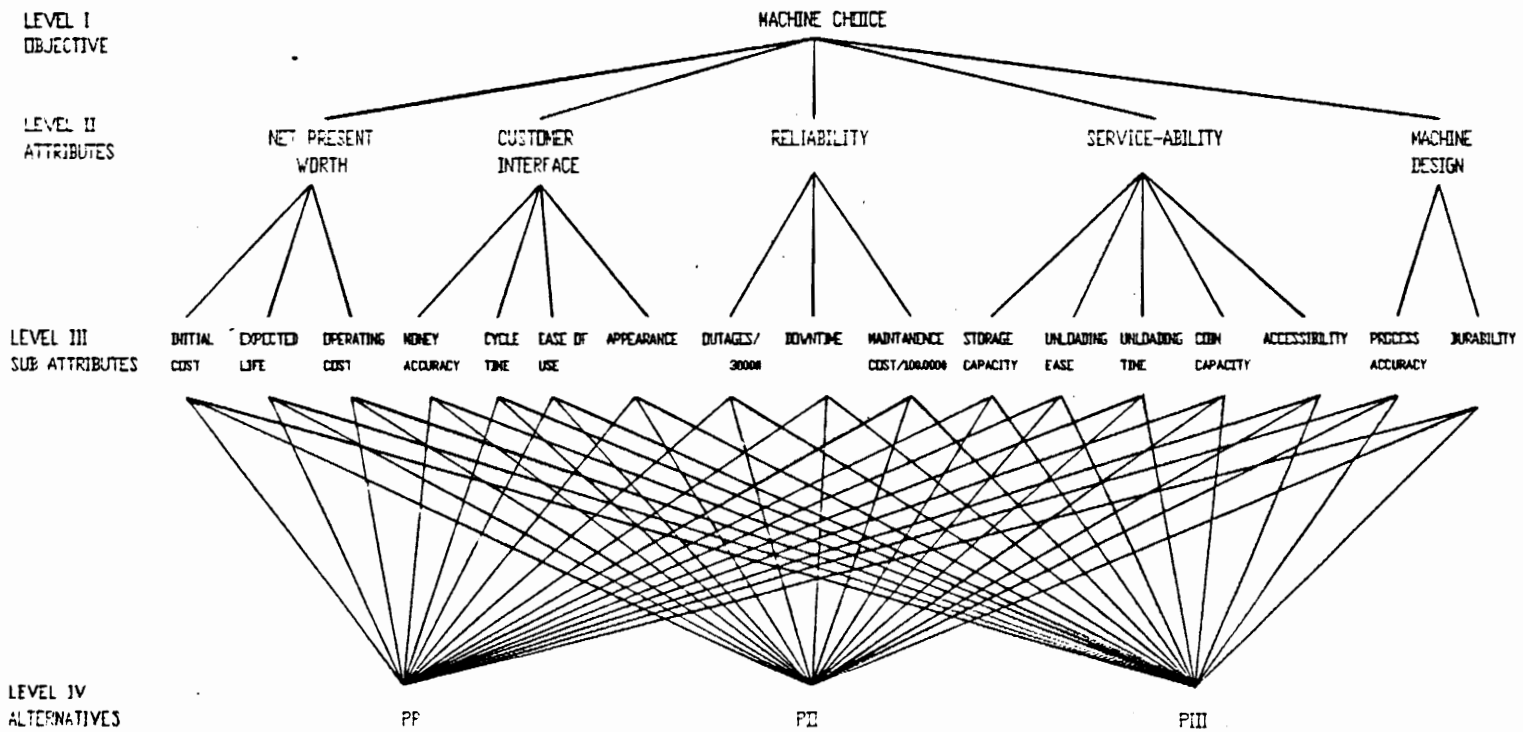
A survey was made of ten experts to determine what they considered the most important characteristics of a Reverse Vending machine. (See Appendix G for details.) Based upon the results of the survey, the four-level Decision Hierarchy Structure was developed as shown in Figure 3-1. A questionnaire was generated based upon the hierarchy structure. The same questionnaire was used to facilitate preference comparisons. (See Appendix H.) The results of the questionnaires were averaged and are displayed in Appendix I.

The following basic information was supplied with the questionnaire:

	PP	P-II	P-III
Initial cost:	$17,500	$30,000	$26,500
Failure rate (bd/yr):	8	9	14
Expected life:	7 yrs	11 yrs	11 yrs
Repair costs/breakdown:	$6.50	$6.50	$6.50
Money accuracy:	Fair	Good	Good
Cycle time (min/cycle):	3	2	2
Ease of use:	Fair	Good	Good
Storage capacity (lbs):	2,000	4,000	3,000
Unloading ease:	Poor	Excellent	Fair
Coin capacity:	$1,000	$1,500	$1,500
Durability:	Poor	Excellent	Fair

1. Note: 'Money Accuracy' and 'Ease Of Use' ratings were based on customer surveys.
2. Note: 'Unloading Ease' ratings were based on collection person's expert opinion.

DECISION HIERARCHY



Analytic Hierarchy Structure

Figure 3-1

From the preference comparisons, priority weights for the attributes as well as the alternatives were generated [8]. An example of the calculation of the priority weights follows:

Alternatives:

Matrix of level IV paired comparisons:

With respect to: Expected life.

	PP	P-II	P-III
PP	1.000	1.373	0.756
P-II	0.728	1.000	1.003
P-III	1.323	0.997	1.000
Totals	3.051	3.370	2.759

Normalizing the above matrix and averaging the rows in the following matrix results in an approximation of the normalized eigenvector of the matrix. Following is an example of the procedure:

Normalized matrix of level IV paired comparisons:

With respect to: Expected life.

	PP	P-II	P-III	Row Sum	Avg
PP:	0.328	0.407	0.274	1.009	0.336
P-II	0.239	0.297	0.364	0.899	0.300
P-III	0.434	0.296	0.362	1.092	0.364
Totals	1.000	1.000	1.000		1.000

The averages in the previous matrix are the priority weights of the three alternatives with respect to expected life. The consistency of the results are verified by the calculation of the consistency ratio (C.R.). If the calculated consistency ratio is greater than 0.10, intransitivities or inconsistencies in the stated degree of preferences are likely. Following is an example of the calculation of the consistency ratio (C.R.):

1.000	1.373	0.756		0.336		1.023
0.728	1.000	1.003	x	0.300	=	0.910
1.323	0.997	1.000		0.364		1.108

$$D = \frac{1.023}{0.336} \quad \frac{0.910}{0.300} \quad \frac{1.108}{0.364} = 3.04,\ 3.04,\ 3.04$$

$$\text{Lambda max} = \frac{3.04 + 3.04 + 3.04}{3} = 3.04$$

For any given square matrix of size N (number of rows) the

$$\text{consistency index (C.I.)} = \frac{\text{Lambda max} - N}{N - 1}$$

$$\text{For the above matrix (C.I.)} = \frac{3.04 - 3}{3 - 1} = 0.02$$

Based on work done by Saaty, random indexes (R.I.) for various matrix sizes are as follows:

N	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

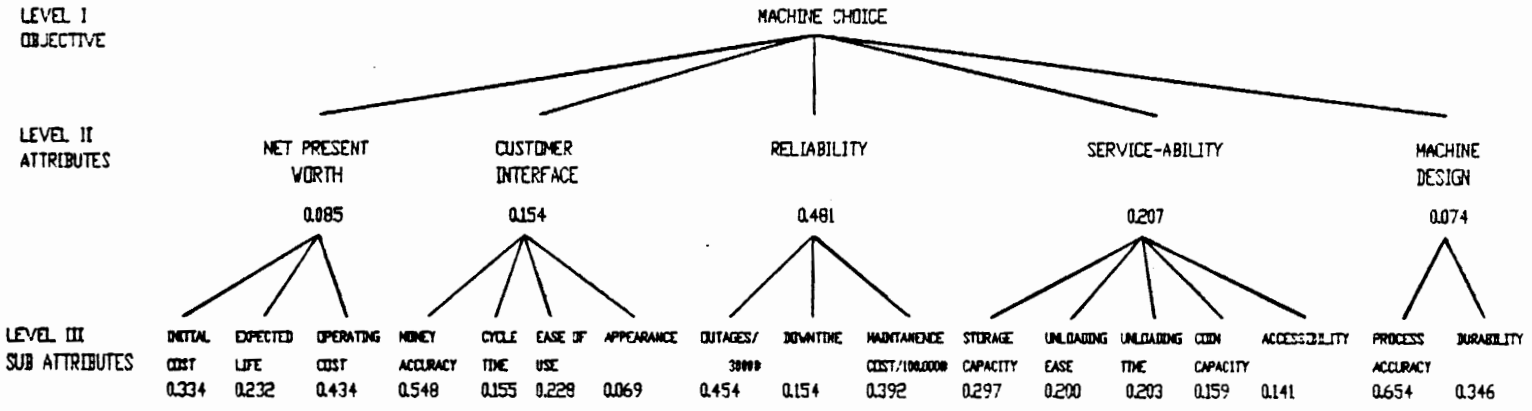
$$C.R. = \frac{C.I.}{R.I.} = \frac{0.02}{0.58} = 0.03 \qquad 0.03 < 0.10 \ldots\ldots$$

The pairwise comparison is reasonably consistent. The complete set of calculations used to generate the priority weights can be found in Appendix J.

A hierarchy structure showing all the results of the pairwise comparisons can be seen in Figure 3-2. The calculated priority weights of the machines were 0.419 for the PP machine, 0.315 for the P-II machine, and 0.267 for the P-III machine. The higher value of the PP machine indicates that it is the preferred machine.

The most popular characteristics of the initial survey were Initial Cost and Cost of Operation. (Refer to Appendix G.) These two sub-attributes were weighted the heaviest of the Net Present Worth attribute, although the Net Present Worth attribute was one of the lightest weighted of the attributes.

The heaviest weighted attributes were Reliability and Service-Ability. These are attributes that engineers and technicians would consider important. The group of experts that completed the questionnaire were made up of engineers, technicians and engineering managers. The group was lacking marketing experience. Marketing input could have led to the identification of other important attributes.



PP	0.683	0.336	0.610	0.310	0.367	0.347	0.625	0.502	0.498	0.515	0.294	0.195	0.209	0.395	0.378	0.149	0.354
P-II	0.139	0.300	0.207	0.334	0.308	0.317	0.181	0.266	0.240	0.237	0.445	0.588	0.543	0.294	0.448	0.425	0.379
P-III	0.178	0.364	0.183	0.356	0.325	0.336	0.194	0.232	0.262	0.248	0.262	0.217	0.248	0.311	0.174	0.425	0.267

ALTERNATIVE	PRIORITY WEIGHT
PP	0.419
P-II	0.315
P-III	0.267

Analytic Hierarchy Structure With Priority Weights.

Figure 3-2

Chapter IV

SUMMARY

The Life-Cycle Cost (LCC) analysis technique considers quantifiable attributes that can be related to dollar values. For the comparison of the three Reverse Vending Machines, metal income was a savings that was considered by the LCC analysis technique. The exclusion of this important attribute would dramatically affect the results of the analysis. The P-II machine was selected as the favored machine through the use of the Life-Cycle Cost technique.

A weakness of the Life-Cycle Cost technique is the difficulty in relating 'difficult to quantify' attributes to a dollar value. For example, if the ease of use of a particular software was deemed an important attribute of the product, it would be difficult to establish a dollar value for that attribute.

The Metal Income savings is a function of the quantity and quality of the metal collected. The quantity of the metal collected varied between the three different machines during the test year which was attributed to customer preference.

Possible characteristics that could have affected customer preference are the appearance, size, ease of use,

and geographic location of the machine. It would be difficult to quantify how these characteristics affect customer preference. Customer preference is an example of an attribute that is difficult to quantify for use with the LCC technique.

The Analytic Hierarchy Process (AHP) is a decision tool which enables the analysis of complex problems. It has the ability to quantify, prioritize, and weight the different attributes of a project. The hierarchy structure is an abstraction of the given system and can be used to study the interactions of its components and their impact on the entire system.

The AHP technique is not meant to replace an economic evaluation of a project. It is a good tool for identifying and prioritizing the important attributes of a problem, including the 'difficult to quantify' attributes. The use of the Analytic Hierarchy technique resulted in the PP machine being chosen as the favored machine.

The most important attribute according to the AHP technique is the reliability of the machines. Reliability would affect the time the machine was available for use, and as a result, the quantity of metal collected. Metal income is a function of metal collected. Metal income was the most important attribute using the LCC technique. To this extent, the two techniques agreed.

Neither Customer preference nor geographic location were identified as attributes for consideration according to the AHP technique. These attributes were not directly considered by the LCC technique either. Although appearance, size, and ease of use were considered by the AHP approach, they were assigned low priority weight values.

Marketing experts were omitted from the group of experts that completed the AHP questionnaire. This could account for why customer preference and geographic location were not identified as important attributes. The quality of the results of the AHP technique is only as good as the quality of the group of experts chosen to complete the questionnaire.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

The objective of this report was to demonstrate the use of the Life-Cycle Cost analysis technique, as well as the Analytic Hierarchy Process, as decision tools for comparing three Reverse Vending machine alternatives.

Having completed the objective, the following may be concluded:

a. The Life-Cycle Cost technique was easily applied to quantifiable attributes.

b. The Life-Cycle Cost technique was difficult to apply to social attributes. (Difficult to quantify attributes.)

c. The P-II machine was selected using the Life-Cycle Cost technique.

d. Metal Income is an important factor to consider when performing an analysis of Reverse Vending machine alternatives.

e. Life-Cycle Cost Sensitivity analysis concluded that the PP machine would be selected if the quantity and quality of metal collected were to match that of the existing values of the P-II machine.

f. The Analytic Hierarchy Process analyzed the interactions of complex Reverse Vending machine alternatives.
g. The Analytic Hierarchy Process had the ability to establish priority weights for social attributes.
h. The use of the Analytic Hierarchy Process resulted in the PP machine being selected.
i. The field of experts that completed the Analytic Hierarchy Process questionnaire did not include marketing experts.
j. The most important attribute identified by the Analytic Hierarchy Process was reliability.
k. The Analytic Hierarchy Process lightly weighted the attributes that would have influenced metal income.

A combination of the Life-Cycle Cost and Analytic Hierarchy Process techniques should be used when performing an analysis of different alternatives.

The Analytical Hierarchy Process would be used to identify the important attributes and their interactions, whether they are difficult to quantify or not. A Life-Cycle Cost analysis should then be done, performing a more detailed study of the important attributes identified by the Analytic Hierarchy Process.

APPENDIX A

MACHINE PARAMETERS [9]

1. Unit Cost: $15,000 -$25,000 per production unit
2. Storage Capacity: 3,000 - 6,000 lbs. at a density of 10 - 15 lbs. per cubic foot
3. Size: Small as possible consistent with design requirements
4. Construction:
   a. Modular tamper proof shell - aluminum where practical
   b. High reliability maintenance exterior
   c. Minimum maintenance exterior
   d. Aesthetically appealing exterior
   e. Sanitary storage/cleanup design
   f. Secure cash storage - $1,500
   g. Movable
   h. Wide temperature range electro/mechanical component function
   i. Weatherproof
   j. Liquid dump and collection provisions
   k. Well lighted
   l. Phone contact with service center

APPENDIX B

PROJECT ASSUMPTIONS [10]

1. Each machine will generate 4,000 lbs per week.
2. A 50 machine module will require five people for service.
   a. 1 maintenance person:
      $12.50/hr x 173 hrs/mo x 1.27% (fringes)
      = $2,746/mo ($32,956/yr)
   b. 2 cleaning people:
      2 x $8.50/hr x 240 hrs/mo x 1.27% (fringes)
      = $5,182/mo ($62,178/yr)
   c. 2 collection people:
      2 x $8.50/hr x 173 hrs/mo x 1.27% (fringes)
      = $3,735/mo ($44,820/yr)
3. Tractor rental: $3,500/mo ($42,000/yr)
4. Trailer rental (6): $300/mo ($43,200/yr)
5. Rent: $300/mo/machine
   $15,000/module/mo ($180,000/module/yr)
6. Installation cost: $5,000/machine

APPENDIX C

LIFE-CYCLE COST VARIABLES

1. C = Total System Cost
2. Cr = Research and Development Costs
3. Cp = Production and Construction Costs
4. Co = Operation and Maintenance Costs
5. Cd = Disposal Costs
6. Cpm = Manufacturing Costs
7. Cpc = Construction Costs
8. Cpl = Initial Logistic Support Costs
9. Cpn = Initial Fixed Manufacturing Costs
10. Cpr = Repeating Manufacturing Costs
11. Cprp = Production Costs
12. Cprt = Initial Testing Costs
13. Cprs = Initial Shipping Costs
14. Cpcs = Initial Site Preparation Costs
15. Cpcu = Initial Site Utility Installation Costs
16. Cpls = Initial Spare Parts Costs
17. Cpli = Initial Inventory Management Costs
18. Cpld = Initial Technical Data Preparation Costs
19. Cplt = Initial Training and Training Equipment Costs
20. Cplx = Initial Test and Support Equipment Costs
21. Coo = Operation Costs

22. Com = Maintenance Costs
23. Con = Equipment Modification Costs
24. Cool = Operating Labor Costs
25. Coop = Recurring Operator Labor Costs
26. Coot = Operator Transportation Costs
27. Coor = Site Rental Costs
28. Coou = Site Utility Costs
29. Comm = Maintenance Labor Costs
30. Comx = Replenishing Spare Parts Costs
31. Coms = Replenishing Tools and Test equipment Costs
32. Comt = Maintenance Transportation Costs
33. Comp = Replenishing Training Costs
34. Comf = Maintenance Facility Rental Costs
35. Commc = Corrective Maintenance Labor Costs
36. Commp = Preventive Maintenance Labor Costs
37. Sm = Metal Income Savings

APPENDIX D

LIFE-CYCLE COST EQUATIONS

1. C = Cr + Cp + Co + Cd
2. Cp = Cpm + Cpc + Cpl
3. Cpm = Cpn + Cpr
4. Cpr = Cprp + Cprt + Cprs
5. Cpc = Cpcs + Cpcu
6. Cpl = Cplm + Cpls + Cpli + Cpld + Cplt + Cplx
7. Co = Coo + Com + Con
8. Coo = Cool + Coop + Coot + Coor + Coou
9. Com = Comm + Comx + Coms + Comt + Comp + Comf
10. Comm = Commc + Commp
11. Comx = Csd + Csc

APPENDIX E

LIFE-CYCLE COST SPREADSHEETS

On pages 63 - 71 are the constant dollars, inflated dollar, and the 1990 present value dollars spreadsheets. The spreadsheets were used to generate the Life-Cycle Cost Summary, Table 2-6 shown on page 37. A discount rate of 10% was used for calculating the 1990 present values.

Table E-1

[1]

ALTERNATIVE PP
INCREMENTAL COST/(SAVINGS) TABLE BY CATEGORY
(CONSTANT DOLLARS)

Cost Category	Alternative	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Total
1. Prod. & Constr. cost (Cp)	PP	$875,000	$334,571							$950,000					$2,159,571
a. Manufacturing (Cpr)	PP	$875,000	$75,000							$950,000					$1,900,000
a-1. Initial cost (Cpri)	PP	$875,000								$875,000					$1,750,000
a-2. Testing (Cprt)	PP		$15,000							$15,000					$30,000
a-3. Transportation (Cprs)	PP		$60,000							$60,000					$120,000
b. Construction (Cpc)	PP		$200,000												$200,000
c. Initial logistic (Cpl)	PP		$59,571												$59,571
c-1. Int. spare parts (Cpls)	PP		$57,496												$57,496
c-2. Inventory mgmt. (Cpli)	PP		$0												$0
c-3. Data preparation (Cpld)	PP		$0												$0
c-4. Initial training (Cplt)	PP		$1,500												$1,500
c-5. Initial test eq. (Cplx)	PP		$575												$575
2. Oper. & Maintenance (Co)	PP		$352,270	$704,539	$704,539	$704,539	$704,539	$704,539	$704,539	$704,539	$704,539	$704,539	$704,539	$352,270	$7,749,930
a. Operational costs (Coo)	PP		$268,130	$536,259	$536,259	$536,259	$536,259	$536,259	$536,259	$536,259	$536,259	$536,259	$536,259	$268,130	$5,898,850
a-1. Operator labor (Cool)	PP		$31,090	$62,179	$62,179	$62,179	$62,179	$62,179	$62,179	$62,179	$62,179	$62,179	$62,179	$31,090	$683,970
a-2. Replacement training (Coop)	PP		$340	$680	$680	$680	$680	$680	$680	$680	$680	$680	$680	$340	$7,480
a-3. Transportation (Coot)	PP		$79,200	$158,400	$158,400	$158,400	$158,400	$158,400	$158,400	$158,400	$158,400	$158,400	$158,400	$79,200	$1,742,400
a-4. Rent (Coor)	PP		$90,000	$180,000	$180,000	$180,000	$180,000	$180,000	$180,000	$180,000	$180,000	$180,000	$180,000	$90,000	$1,980,000
a-5. Utilities (Coou)	PP		$67,500	$135,000	$135,000	$135,000	$135,000	$135,000	$135,000	$135,000	$135,000	$135,000	$135,000	$67,500	$1,485,000
b. Maintenance costs (Com)	PP		$84,140	$168,280	$168,280	$168,280	$168,280	$168,280	$168,280	$168,280	$168,280	$168,280	$168,280	$84,140	$1,851,080
b-1. Labor (Coml)	PP		$32,852	$65,704	$65,704	$65,704	$65,704	$65,704	$65,704	$65,704	$65,704	$65,704	$65,704	$32,852	$722,744
b-2. Replacement training (Comp)	PP		$340	$680	$680	$680	$680	$680	$680	$680	$680	$680	$680	$340	$7,480
b-3. Recurring spares (Comr)	PP		$43,748	$87,496	$87,496	$87,496	$87,496	$87,496	$87,496	$87,496	$87,496	$87,496	$87,496	$43,748	$962,456
b-4. Tools (Comu)	PP		$150	$300	$300	$300	$300	$300	$300	$300	$300	$300	$300	$150	$3,300
b-5. Transportation (Comt)	PP		$5,700	$11,400	$11,400	$11,400	$11,400	$11,400	$11,400	$11,400	$11,400	$11,400	$11,400	$5,700	$125,400
b-6. Facility (Comf)	PP		$1,350	$2,700	$2,700	$2,700	$2,700	$2,700	$2,700	$2,700	$2,700	$2,700	$2,700	$1,350	$29,700
3. Disposal (Cd)	PP									($50,000)				($471,500)	($521,500)
Cost total (C)	PP	$875,000	$686,841	$704,539	$704,539	$704,539	$704,539	$704,539	$704,539	$1,604,539	$704,539	$704,539	$704,539	($119,230)	$9,388,001
4. Metal income (Bm)	PP		($306,767)	($920,302)	($920,302)	($920,302)	($920,302)	($920,302)	($920,302)	($920,302)	($920,302)	($920,302)	($920,302)	($460,151)	($9,969,938)
Grand total		$875,000	$380,074	($215,763)	($215,763)	($215,763)	($215,763)	($215,763)	($215,763)	$684,237	($215,763)	($215,763)	($215,763)	($579,381)	($581,937)

1. For a module of 50 machines.

Table E-2

ALTERNATIVE P-II
INCREMENTAL COST/(SAVINGS) TABLE BY CATEGORY
(CONSTANT DOLLARS)

Cost Category	Alternative	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Total
1. Prod. & Constr. cost (Cp)	P-II	$1,500,000	$478,113												$1,978,113
a. Manufacturing (Cpr)	P-II	$1,500,000	$75,000												$1,575,000
a-1. Initial cost (Cpri)	P-II	$1,500,000													$1,500,000
a-2. Testing (Cprt)	P-II		$15,000												$15,000
a-3. Transportation (Cprs)	P-II		$60,000												$60,000
b. Construction (Cpc)	P-II		$250,000												$250,000
c. Initial logistic (Cpl)	P-II		$153,113												$153,113
c-1. Int. spare parts (Cpls)	P-II		$143,937												$143,937
c-2. Inventory mgmt. (Cpli)	P-II		$1,000												$1,000
c-3. Data preparation (Cpld)	P-II		$6,101												$6,101
c-4. Initial training (Cplt)	P-II		$1,500												$1,500
c-5. Initial test eq. (Cplx)	P-II		$575												$575
2. Oper. & Maintenance (Co)	P-II		$393,298	$786,596	$786,596	$786,596	$786,596	$786,596	$786,596	$786,596	$786,596	$786,596	$786,596	$393,298	$8,652,556
a. Operational costs (Coo)	P-II		$265,718	$531,435	$531,435	$531,435	$531,435	$531,435	$531,435	$531,435	$531,435	$531,435	$531,435	$265,718	$5,845,785
a-1. Operator labor (Cool)	P-II		$31,090	$62,179	$62,179	$62,179	$62,179	$62,179	$62,179	$62,179	$62,179	$62,179	$62,179	$31,090	$683,969
a-2. Replacement training (Coop)	P-II		$340	$680	$680	$680	$680	$680	$680	$680	$680	$680	$680	$340	$7,480
a-3. Transportation (Coot)	P-II		$79,200	$158,400	$158,400	$158,400	$158,400	$158,400	$158,400	$158,400	$158,400	$158,400	$158,400	$79,200	$1,742,400
a-4. Rent (Coor)	P-II		$90,000	$180,000	$180,000	$180,000	$180,000	$180,000	$180,000	$180,000	$180,000	$180,000	$180,000	$90,000	$1,980,000
a-5. Utilities (Coou)	P-II		$65,088	$130,176	$130,176	$130,176	$130,176	$130,176	$130,176	$130,176	$130,176	$130,176	$130,176	$65,088	$1,431,936
b. Maintenance costs (Com)	P-II		$127,581	$255,161	$255,161	$255,161	$255,161	$255,161	$255,161	$255,161	$255,161	$255,161	$255,161	$127,581	$2,806,771
b-1. Labor (Coml)	P-II		$33,072	$66,144	$66,144	$66,144	$66,144	$66,144	$66,144	$66,144	$66,144	$66,144	$66,144	$33,072	$727,584
b-2. Replacement training (Comp)	P-II		$340	$680	$680	$680	$680	$680	$680	$680	$680	$680	$680	$340	$7,480
b-3. Recurring spares (Comr)	P-II		$86,969	$173,937	$173,937	$173,937	$173,937	$173,937	$173,937	$173,937	$173,937	$173,937	$173,937	$86,969	$1,913,307
b-4. Tools (Comt)	P-II		$150	$300	$300	$300	$300	$300	$300	$300	$300	$300	$300	$150	$3,300
b-5. Transportation (Comt)	P-II		$5,700	$11,400	$11,400	$11,400	$11,400	$11,400	$11,400	$11,400	$11,400	$11,400	$11,400	$5,700	$125,400
b-6. Facility (Comf)	P-II		$1,350	$2,700	$2,700	$2,700	$2,700	$2,700	$2,700	$2,700	$2,700	$2,700	$2,700	$1,350	$29,700
3. Disposal (Cd)	P-II													($100,000)	($100,000)
Cost total (C)	P-II	$1,500,000	$871,411	$786,596	$786,596	$786,596	$786,596	$786,596	$786,596	$786,596	$786,596	$786,596	$786,596	$293,298	$10,530,669
4. Metal income (Sa)	P-II		($489,927)	($1,469,782)	($1,469,782)	($1,469,782)	($1,469,782)	($1,469,782)	($1,469,782)	($1,469,782)	($1,469,782)	($1,469,782)	($1,469,782)	($734,891)	($13,922,638)
Grand total		$1,500,000	$381,484	($683,186)	($683,186)	($683,186)	($683,186)	($683,186)	($683,186)	($683,186)	($683,186)	($683,186)	($683,186)	($441,593)	($3,391,969)

1. For a module of 50 machines.

Table E-3

ALTERNATIVE P-III
INCREMENTAL COST/(SAVINGS) TABLE BY CATEGORY
(CONSTANT DOLLARS)

Cost Category	Alternative	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Total
1. Prod. & Constr. cost (Cp)	P-III	$1,325,000	$407,442												$1,732,442
a. Manufacturing (Cpr)	P-III	$1,325,000	$75,000												$1,400,000
a-1. Initial cost (Cpri)	P-III	$1,325,000													$1,325,000
a-2. Testing (Cprt)	P-III		$15,000												$15,000
a-3. Transportation (Cprs)	P-III		$60,000												$60,000
b. Construction (Cpc)	P-III		$250,000												$250,000
c. Initial logistic (Cpl)	P-III		$82,442												$82,442
c-1. Int. spare parts (Cpls)	P-III		$73,266												$73,266
c-2. Inventory eqmt. (Cpli)	P-III		$1,000												$1,000
c-3. Data preparation (Cpld)	P-III		$6,101												$6,101
c-4. Initial training (Cplt)	P-III		$1,500												$1,500
c-5. Initial test eq. (Cplx)	P-III		$575												$575
2. Oper. & Maintenance (Co)	P-III		$377,681	$755,361	$755,361	$755,361	$755,361	$755,361	$755,361	$755,361	$755,361	$755,361	$755,361	$377,681	$8,308,972
a. Operational costs (Coo)	P-III		$284,336	$568,671	$568,671	$568,671	$568,671	$568,671	$568,671	$568,671	$568,671	$568,671	$568,671	$284,336	$6,255,381
a-1. Operator labor (Cool)	P-III		$31,090	$62,179	$62,179	$62,179	$62,179	$62,179	$62,179	$62,179	$62,179	$62,179	$62,179	$31,090	$683,969
a-2. Replacement training (Coop)	P-III		$340	$680	$680	$680	$680	$680	$680	$680	$680	$680	$680	$340	$7,480
a-3. Transportation (Coot)	P-III		$79,200	$158,400	$158,400	$158,400	$158,400	$158,400	$158,400	$158,400	$158,400	$158,400	$158,400	$79,200	$1,742,400
a-4. Rent (Coor)	P-III		$90,000	$180,000	$180,000	$180,000	$180,000	$180,000	$180,000	$180,000	$180,000	$180,000	$180,000	$90,000	$1,980,000
a-5. Utilities (Coou)	P-III		$83,706	$167,412	$167,412	$167,412	$167,412	$167,412	$167,412	$167,412	$167,412	$167,412	$167,412	$83,706	$1,841,532
b. Maintenance costs (Com)	P-III		$93,345	$186,690	$186,690	$186,690	$186,690	$186,690	$186,690	$186,690	$186,690	$186,690	$186,690	$93,345	$2,053,590
b-1. Labor (Coms)	P-III		$34,172	$68,344	$68,344	$68,344	$68,344	$68,344	$68,344	$68,344	$68,344	$68,344	$68,344	$34,172	$751,784
b-2. Replacement training (Comp)	P-III		$340	$680	$680	$680	$680	$680	$680	$680	$680	$680	$680	$340	$7,480
b-3. Recurring spares (Comx)	P-III		$51,633	$103,266	$103,266	$103,266	$103,266	$103,266	$103,266	$103,266	$103,266	$103,266	$103,266	$51,633	$1,135,926
b-4. Tools (Comt)	P-III		$150	$300	$300	$300	$300	$300	$300	$300	$300	$300	$300	$150	$3,300
b-5. Transportation (Comt)	P-III		$5,700	$11,400	$11,400	$11,400	$11,400	$11,400	$11,400	$11,400	$11,400	$11,400	$11,400	$5,700	$125,400
b-6. Facility (Comf)	P-III		$1,350	$2,700	$2,700	$2,700	$2,700	$2,700	$2,700	$2,700	$2,700	$2,700	$2,700	$1,350	$29,700
3. Disposal (Cd)	P-III													($75,000)	($75,000)
Cost total (C)	P-III	$1,325,000	$785,123	$755,361	$755,361	$755,361	$755,361	$755,361	$755,361	$755,361	$755,361	$755,361	$755,361	$302,681	$9,966,414
4. Metal income (Sa)	P-III		($380,962)	($1,142,886)	($1,142,886)	($1,142,886)	($1,142,886)	($1,142,886)	($1,142,886)	($1,142,886)	($1,142,886)	($1,142,886)	($1,142,886)	($571,443)	($12,381,265)
Grand total		$1,325,000	$404,161	($387,525)	($387,525)	($387,525)	($387,525)	($387,525)	($387,525)	($387,525)	($387,525)	($387,525)	($387,525)	($268,762)	($2,414,851)

1. For a module of 50 machines.

Table E-4

ALTERNATIVE PP
INCREMENTAL COST/(SAVINGS) TABLE BY CATEGORY
(INFLATED DOLLARS) 2

Cost Category	Alternative	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Total
1. Prod. & Constr. cost (Cp)	PP	$875,000	$354,646							$1,514,156					$2,743,802
a. Manufacturing (Cpr)	PP	$875,000	$79,500							$1,514,156					$2,468,656
a-1. Initial cost (Cpri)	PP	$875,000								$1,394,617					$2,269,617
a-2. Testing (Cprt)	PP		$15,900							$23,908					$39,808
a-3. Transportation (Cprs)	PP		$63,600							$95,631					$159,231
b. Construction (Cpc)	PP		$212,000												$212,000
c. Initial logistic (Cpl)	PP		$63,146												$63,146
c-1. Int. spare parts (Cpls)	PP		$60,946												$60,946
c-2. Inventory mgmt. (Cpli)	PP		$0												$0
c-3. Data preparation (Cpld)	PP		$0												$0
c-4. Initial training (Cplt)	PP		$1,590												$1,590
c-5. Initial test eq. (Cplx)	PP		$610												$610
2. Oper. & Maintenance (Co)	PP		$373,405	$791,620	$839,118	$889,464	$942,832	$999,402	$1,059,365	$1,122,928	$1,190,305	$1,261,722	$1,337,425	$708,837	$11,516,423
a. Operational costs (Coo)	PP		$284,217	$602,540	$638,693	$677,014	$717,636	$760,693	$806,334	$854,716	$905,998	$960,358	$1,017,979	$539,530	$8,765,708
a-1. Operator labor (Cool)	PP		$32,955	$69,864	$74,056	$78,500	$83,210	$88,202	$93,494	$99,104	$105,050	$111,353	$118,034	$62,559	$1,016,381
a-2. Replacement training (Coop)	PP		$360	$764	$810	$858	$910	$965	$1,022	$1,084	$1,149	$1,218	$1,291	$684	$11,115
a-3. Transportation (Coot)	PP		$83,952	$177,978	$188,657	$199,976	$211,975	$224,693	$238,175	$252,466	$267,613	$283,670	$300,690	$159,366	$2,589,211
a-4. Rent (Coor)	PP		$95,400	$202,248	$214,383	$227,246	$240,881	$255,333	$270,653	$286,893	$304,106	$322,353	$341,694	$181,098	$2,942,288
a-5. Utilities (Coou)	PP		$71,550	$151,686	$160,787	$170,434	$180,660	$191,500	$202,990	$215,169	$228,080	$241,764	$256,270	$135,823	$2,206,713
b. Maintenance costs (Com)	PP		$89,188	$189,080	$200,425	$212,450	$225,196	$238,709	$253,031	$268,212	$284,307	$301,364	$319,446	$169,307	$2,750,715
b-1. Labor (Coml)	PP		$34,823	$73,825	$78,255	$82,950	$87,927	$93,202	$98,795	$104,722	$111,006	$117,666	$124,726	$66,105	$1,074,002
b-2. Replacement training (Coop)	PP		$360	$764	$810	$858	$910	$965	$1,022	$1,084	$1,149	$1,218	$1,291	$684	$11,115
b-3. Recurring spares (Coor)	PP		$46,373	$98,311	$104,209	$110,462	$117,089	$124,115	$131,562	$139,455	$147,823	$156,692	$166,094	$88,030	$1,430,215
b-4. Tools (Coos)	PP		$139	$337	$357	$379	$401	$426	$451	$478	$507	$537	$569	$302	$4,903
b-5. Transportation (Coot)	PP		$6,042	$12,809	$13,578	$14,392	$15,256	$16,171	$17,141	$18,170	$19,260	$20,416	$21,641	$11,470	$186,346
b-6. Facility (Coof)	PP		$1,431	$3,034	$3,216	$3,409	$3,613	$3,830	$4,060	$4,303	$4,562	$4,835	$5,125	$2,716	$44,134
3. Disposal (Cd)	PP									($79,692)				($948,751)	($1,028,443)
Cost total (C)	PP	$875,000	$728,051	$791,620	$839,118	$889,464	$942,832	$999,402	$1,059,365	$2,557,392	$1,190,305	$1,261,722	$1,337,425	($239,914)	$13,231,782
4. Metal income (Sm)	PP		($325,173)	($1,034,051)	($1,096,094)	($1,161,860)	($1,231,572)	($1,305,466)	($1,383,794)	($1,466,822)	($1,554,831)	($1,648,121)	($1,747,008)	($925,914)	($14,080,706)
Grand total		$875,000	$402,878	($242,431)	($256,976)	($272,396)	($288,740)	($306,064)	($324,429)	$1,090,570	($364,526)	($386,399)	($409,583)	($1,165,828)	($1,648,924)

1. For a module of 50 machines.
2. An inflation rate of 6% was used; Inflated dollars = $(1 + f)^n$ * Constant dollars

Table E-5

[1]

ALTERNATIVE P-II
INCREMENTAL COST/(SAVINGS) TABLE BY CATEGORY
(INFLATED DOLLARS) 2

Cost Category	Alternative	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Total
1. Prod. & Constr. cost (Cp)	P-II	$1,500,000	$506,800												$2,006,800
a. Manufacturing (Cpr)	P-II	$1,500,000	$79,500												$1,579,500
a-1. Initial cost (Cpri)	P-II	$1,500,000													$1,500,000
a-2. Testing (Cprt)	P-II		$15,900												$15,900
a-3. Transportation (Cprs)	P-II		$63,600												$63,600
b. Construction (Cpc)	P-II		$265,000												$265,000
c. Initial logistic (Cpl)	P-II		$162,300												$162,300
c-1. Int. spare parts (Cpls)	P-II		$152,573												$152,573
c-2. Inventory equt. (Cpli)	P-II		$1,060												$1,060
c-3. Data preparation (Cpld)	P-II		$6,467												$6,467
c-4. Initial training (Cplt)	P-II		$1,590												$1,590
c-5. Initial test eq. (Cplx)	P-II		$610												$610
2. Oper. & Maintenance (Co)	P-II		$416,895	$883,819	$936,850	$993,058	$1,052,644	$1,115,802	$1,182,748	$1,253,715	$1,328,938	$1,408,674	$1,493,193	$791,393	$12,857,729
a. Operational costs (Coo)	P-II		$281,660	$597,120	$632,948	$670,924	$711,181	$753,850	$799,081	$847,028	$897,848	$951,719	$1,008,822	$534,676	$8,686,857
a-1. Operator labor (Cool)	P-II		$32,955	$69,864	$74,056	$78,500	$83,210	$88,202	$93,494	$99,104	$105,050	$111,353	$118,034	$62,558	$1,016,380
a-2. Replacement training (Coop)	P-II		$360	$764	$810	$858	$910	$965	$1,022	$1,084	$1,149	$1,218	$1,291	$684	$11,115
a-3. Transportation (Coot)	P-II		$83,952	$177,978	$188,657	$199,976	$211,975	$224,693	$238,175	$252,466	$267,613	$283,670	$300,690	$159,366	$2,589,211
a-4. Rent (Coor)	P-II		$95,400	$202,248	$214,383	$227,246	$240,881	$255,333	$270,653	$286,893	$304,106	$322,353	$341,694	$181,098	$2,942,288
a-5. Utilities (Coou)	P-II		$68,993	$146,266	$155,042	$164,344	$174,205	$184,657	$195,737	$207,481	$219,930	$233,125	$247,113	$130,970	$2,127,863
b. Maintenance costs (Com)	P-II		$135,235	$286,699	$303,902	$322,134	$341,463	$361,952	$383,667	$406,687	$431,090	$456,955	$484,371	$256,717	$4,170,872
b-1. Labor (Coml)	P-II		$35,056	$74,319	$78,779	$83,505	$88,516	$93,827	$99,456	$105,423	$111,749	$118,454	$125,561	$66,547	$1,081,192
b-2. Replacement training (Comp)	P-II		$360	$764	$810	$858	$910	$965	$1,022	$1,084	$1,149	$1,218	$1,291	$684	$11,115
b-3. Recurring spares (Comx)	P-II		$92,187	$195,436	$207,162	$219,591	$232,767	$246,733	$261,537	$277,229	$293,863	$311,495	$330,184	$174,998	$2,843,182
b-4. Tools (Coms)	P-II		$159	$337	$357	$379	$401	$426	$451	$478	$507	$537	$569	$302	$4,903
b-5. Transportation (Comt)	P-II		$6,042	$12,809	$13,578	$14,392	$15,256	$16,171	$17,141	$18,170	$19,260	$20,416	$21,641	$11,470	$186,346
b-6. Facility (Comf)	P-II		$1,431	$3,034	$3,216	$3,409	$3,613	$3,830	$4,060	$4,303	$4,562	$4,835	$5,125	$2,716	$44,134
3. Disposal (Cd)	P-II													($201,220)	($201,220)
Cost total (C)	P-II	$1,500,000	$923,695	$883,819	$936,850	$993,058	$1,052,644	$1,115,802	$1,182,748	$1,253,715	$1,328,938	$1,408,674	$1,493,193	$590,173	$14,663,309
4. Metal income (Sm)	P-II		($519,323)	($1,651,447)	($1,750,534)	($1,855,566)	($1,966,900)	($2,084,914)	($2,210,009)	($2,342,609)	($2,483,166)	($2,632,156)	($2,790,085)	($1,478,745)	($23,765,454)
Grand total		$1,500,000	$404,372	($767,628)	($813,684)	($862,508)	($914,256)	($969,112)	($1,027,261)	($1,088,894)	($1,154,228)	($1,223,482)	($1,296,892)	($888,572)	($9,102,145)

1. For a module of 50 machines.
2. An inflation rate of 6% was used; Inflated dollars = (1 + i)^{n} * Constant dollars

Table E-6

ALTERNATIVE P-III
INCREMENTAL COST/(SAVINGS) TABLE BY CATEGORY
(INFLATED DOLLARS) 2

Cost Category	Alternative	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Total
1. Prod. & Constr. cost (Cp)	P-III	$1,325,000	$431,889												$1,756,889
a. Manufacturing (Cpr)	P-III	$1,325,000	$79,500												$1,404,500
a-1. Initial cost (Cpri)	P-III	$1,325,000													$1,325,000
a-2. Testing (Cprt)	P-III		$15,900												$15,900
a-3. Transportation (Cprs)	P-III		$63,600												$63,600
b. Construction (Cpc)	P-III		$265,000												$265,000
c. Initial logistic (Cpl)	P-III		$87,389												$87,389
c-1. Int. spare parts (Cpls)	P-III		$77,662												$77,662
c-2. Inventory mgmt. (Cpli)	P-III		$1,060												$1,060
c-3. Data preparation (Cpld)	P-III		$6,467												$6,467
c-4. Initial training (Cplt)	P-III		$1,590												$1,590
c-5. Initial test eq. (Cplx)	P-III		$610												$610
2. Oper. & Maintenance (Co)	P-III		$400,340	$848,724	$899,647	$953,626	$1,010,843	$1,071,494	$1,135,784	$1,203,931	$1,276,167	$1,352,737	$1,433,901	$759,968	$12,347,160
a. Operational costs (Coo)	P-III		$301,395	$638,959	$677,296	$717,934	$761,010	$806,671	$855,071	$906,375	$960,758	$1,018,403	$1,079,507	$572,139	$9,295,518
a-1. Operator labor (Cool)	P-III		$32,955	$69,864	$74,056	$78,500	$83,210	$88,202	$93,494	$99,104	$105,050	$111,353	$118,034	$62,558	$1,016,380
a-2. Replacement training (Coop)	P-III		$360	$764	$810	$858	$910	$965	$1,022	$1,084	$1,149	$1,218	$1,291	$684	$11,115
a-3. Transportation (Coot)	P-III		$83,952	$177,978	$188,657	$199,976	$211,975	$224,693	$238,175	$252,466	$267,613	$283,670	$300,690	$159,366	$2,589,213
a-4. Rent (Coor)	P-III		$95,400	$202,248	$214,383	$227,246	$240,881	$255,333	$270,653	$286,893	$304,106	$322,353	$341,694	$181,098	$2,942,287
a-5. Utilities (Coou)	P-III		$88,728	$188,104	$199,390	$211,354	$224,035	$237,477	$251,726	$266,829	$282,839	$299,809	$317,798	$168,433	$2,736,523
b. Maintenance costs (Com)	P-III		$98,945	$209,765	$222,351	$235,692	$249,833	$264,823	$280,713	$297,556	$315,409	$334,333	$354,393	$187,829	$3,051,642
b-1. Labor (Coml)	P-III		$36,222	$76,791	$81,399	$86,283	$91,460	$96,947	$102,764	$108,930	$115,466	$122,394	$129,737	$68,761	$1,117,154
b-2. Replacement training (Comp)	P-III		$360	$764	$810	$858	$910	$965	$1,022	$1,084	$1,149	$1,218	$1,291	$684	$11,115
b-3. Recurring spares (Comr)	P-III		$54,731	$116,030	$122,991	$130,371	$138,193	$146,485	$155,274	$164,590	$174,466	$184,934	$196,030	$103,896	$1,687,990
b-4. Tools (Coms)	P-III		$159	$337	$357	$379	$401	$426	$451	$478	$507	$537	$569	$302	$4,904
b-5. Transportation (Comt)	P-III		$6,042	$12,809	$13,578	$14,392	$15,256	$16,171	$17,141	$18,170	$19,260	$20,416	$21,641	$11,470	$186,345
b-6. Facility (Comf)	P-III		$1,431	$3,034	$3,216	$3,409	$3,613	$3,830	$4,060	$4,303	$4,562	$4,835	$5,125	$2,716	$44,134
3. Disposal (Cd)	P-III													($130,915)	($130,915)
Cost total (C)	P-III	$1,325,000	$832,229	$848,724	$899,647	$953,626	$1,010,843	$1,071,494	$1,135,784	$1,203,931	$1,276,167	$1,352,737	$1,433,901	$609,053	$13,953,134
4. Metal income (Sm)	P-III		($403,820)	($1,284,147)	($1,361,196)	($1,442,867)	($1,529,439)	($1,621,206)	($1,718,478)	($1,821,587)	($1,930,882)	($2,046,735)	($2,169,539)	($1,149,856)	($18,479,752)
Grand total		$1,325,000	$428,409	($435,423)	($461,549)	($489,241)	($518,596)	($549,712)	($582,694)	($617,656)	($654,715)	($693,998)	($735,638)	($540,803)	($4,526,618)

1. For a module of 50 machines.
2. An inflation rate of 6% was used; Inflated dollars = (1 + f)^n * Constant dollars

Table E-7

ALTERNATIVE PP
INCREMENTAL COST/(SAVINGS) TABLE BY CATEGORY
(PRESENT VALUE DOLLARS) 2

Cost Category	Alternative	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Total
1. Prod. & Constr. cost (Cp)	PP	$875,000	$322,405							$706,365					$1,903,770
a. Manufacturing (Cpr)	PP	$875,000	$72,273							$706,365					$1,653,638
a-1. Initial cost (Cpri)	PP	$875,000								$650,599					$1,525,599
a-2. Testing (Cprt)	PP		$14,455							$11,153					$25,608
a-3. Transportation (Cprs)	PP		$57,818							$44,613					$102,431
															$0
b. Construction (Cpc)	PP		$192,727												$192,727
															$0
c. Initial logistic (Cpl)	PP		$57,405												$57,405
c-1. Int. spare parts (Cpls)	PP		$55,405												$55,405
c-2. Inventory equt. (Cpli)	PP		$0												$0
c-3. Data preparation (Cpld)	PP		$0												$0
c-4. Initial training (Cplt)	PP		$1,445												$1,445
c-5. Initial test eq. (Cplx)	PP		$555												$555
2. Oper. & Maintenance (Co)	PP		$339,458	$654,230	$630,442	$607,516	$585,425	$564,137	$543,619	$523,855	$504,804	$486,448	$468,758	$225,856	$6,134,548
a. Operational costs (Coo)	PP		$258,378	$497,966	$479,860	$462,410	$445,596	$429,392	$413,776	$398,732	$384,231	$370,259	$356,795	$171,910	$4,669,305
a-1. Operator labor (Cool)	PP		$29,959	$57,739	$55,639	$53,617	$51,667	$49,788	$47,977	$46,233	$44,551	$42,931	$41,370	$19,933	$541,404
a-2. Replacement training (Coop)	PP		$327	$631	$609	$586	$565	$545	$524	$506	$487	$470	$452	$218	$5,920
a-3. Transportation (Coot)	PP		$76,320	$147,089	$141,741	$136,586	$131,620	$126,833	$122,221	$117,777	$113,494	$109,367	$105,390	$50,779	$1,379,217
a-4. Rent (Coor)	PP		$86,727	$167,147	$161,069	$155,212	$149,568	$144,129	$138,888	$133,838	$128,971	$124,281	$119,762	$57,703	$1,567,295
a-5. Utilities (Coou)	PP		$65,045	$125,360	$120,802	$116,409	$112,176	$108,097	$104,166	$100,378	$96,728	$93,210	$89,821	$43,277	$1,175,469
b. Maintenance costs (Coo)	PP		$81,080	$156,264	$150,582	$145,106	$139,829	$134,745	$129,843	$125,123	$120,573	$116,189	$111,963	$53,946	$1,465,243
b-1. Labor (Coom)	PP		$31,657	$61,012	$58,794	$56,656	$54,596	$52,610	$50,697	$48,854	$47,077	$45,365	$43,716	$21,063	$572,097
b-2. Replacement training (Coop)	PP		$327	$631	$609	$586	$565	$545	$524	$506	$487	$470	$452	$218	$5,920
b-3. Recurring spares (Coox)	PP		$42,157	$81,249	$78,294	$75,447	$72,703	$70,060	$67,512	$65,057	$62,691	$60,412	$58,215	$28,049	$761,846
b-4. Tools (Coos)	PP		$145	$279	$268	$259	$249	$240	$231	$223	$215	$207	$199	$96	$2,611
b-5. Transportation (Coot)	PP		$5,493	$10,586	$10,201	$9,830	$9,473	$9,128	$8,796	$8,476	$8,168	$7,871	$7,585	$3,655	$99,262
b-6. Facility (Coof)	PP		$1,301	$2,507	$2,416	$2,328	$2,243	$2,162	$2,083	$2,007	$1,935	$1,864	$1,796	$865	$23,507
3. Disposal (Cd)	PP									($37,177)				($302,301)	($339,478)
Cost total (C)	PP	$875,000	$661,863	$654,230	$630,442	$607,516	$585,425	$564,137	$543,619	$1,193,043	$504,804	$486,448	$468,758	($76,445)	$7,698,840
4. Metal income (Sm)	PP		($295,612)	($854,588)	($823,512)	($793,566)	($764,709)	($736,902)	($710,105)	($684,283)	($659,400)	($635,422)	($612,316)	($295,025)	($7,865,440)
Grand total		$875,000	$366,251	($200,358)	($193,070)	($186,050)	($179,284)	($172,765)	($166,486)	$508,760	($154,596)	($148,974)	($143,558)	($371,470)	($166,600)

1. For a module of 50 machines.
2. A discount rate of 10% was used; Present value dollars = Inflated dollars * $\frac{1}{(1+i)^n}$

Table E-8

ALTERNATIVE P-II
INCREMENTAL COST/(SAVINGS) TABLE BY CATEGORY
(PRESENT VALUE DOLLARS) 2

Cost Category	Alternative	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Total
1. Prod. & Constr. cost (Cp)	P-II	$1,500,000	$460,728												$1,960,728
a. Manufacturing (Cpr)	P-II	$1,500,000	$72,273												$1,572,273
a-1. Initial cost (Cpri)	P-II	$1,500,000													$1,500,000
a-2. Testing (Cprt)	P-II		$14,455												$14,455
a-3. Transportation (Cprs)	P-II		$57,818												$57,818
b. Construction (Cpc)	P-II		$240,909												$240,909
c. Initial logistic (Cpl)	P-II		$147,546												$147,546
c-1. Int. spare parts (Cpls)	P-II		$138,703												$138,703
c-2. Inventory mgmt. (Cpli)	P-II		$964												$964
c-3. Data preparation (Cpld)	P-II		$5,879												$5,879
c-4. Initial training (Cplt)	P-II		$1,445												$1,445
c-5. Initial test eq. (Cplx)	P-II		$555												$555
2. Oper. & Maintenance (Co)	P-II		$378,995	$730,428	$703,869	$678,272	$653,609	$629,841	$606,935	$584,867	$563,599	$543,105	$523,353	$252,162	$6,849,035
a. Operational costs (Coo)	P-II		$256,054	$493,487	$475,543	$458,250	$441,588	$425,529	$410,054	$395,145	$380,775	$366,929	$353,586	$170,364	$4,627,304
a-1. Operator labor (Cool)	P-II		$29,959	$57,739	$55,639	$53,617	$51,667	$49,788	$47,977	$46,233	$44,551	$42,931	$41,370	$19,933	$541,404
a-2. Replacement training (Coop)	P-II		$327	$631	$609	$586	$565	$545	$524	$506	$487	$470	$452	$218	$5,920
a-3. Transportation (Coot)	P-II		$76,320	$147,089	$141,741	$136,586	$131,620	$126,833	$122,221	$117,777	$113,494	$109,367	$105,390	$50,779	$1,379,217
a-4. Rent (Coor)	P-II		$86,727	$167,147	$161,069	$155,212	$149,568	$144,129	$138,888	$133,838	$128,971	$124,281	$119,762	$57,703	$1,567,295
a-5. Utilities (Coou)	P-II		$62,721	$120,881	$116,485	$112,249	$108,168	$104,234	$100,444	$96,791	$93,272	$89,880	$86,612	$41,731	$1,133,468
b. Maintenance costs (Com)	P-II		$122,941	$236,941	$228,326	$220,022	$212,021	$204,312	$196,881	$189,722	$182,824	$176,176	$169,767	$81,798	$2,221,731
b-1. Labor (Coml)	P-II		$31,869	$61,421	$59,188	$57,035	$54,961	$52,963	$51,037	$49,181	$47,392	$45,669	$44,008	$21,204	$575,928
b-2. Replacement training (Comp)	P-II		$327	$631	$609	$586	$565	$545	$524	$506	$487	$470	$452	$218	$5,920
b-3. Recurring spares (Comx)	P-II		$83,806	$161,517	$155,644	$149,984	$144,530	$139,274	$134,210	$129,329	$124,627	$120,095	$115,727	$55,760	$1,514,503
b-4. Tools (Comu)	P-II		$145	$279	$268	$259	$249	$240	$231	$223	$215	$207	$199	$96	$2,611
b-5. Transportation (Comt)	P-II		$5,493	$10,586	$10,201	$9,830	$9,473	$9,128	$8,796	$8,476	$8,168	$7,871	$7,585	$3,655	$99,262
b-6. Facility (Comf)	P-II		$1,301	$2,507	$2,416	$2,328	$2,243	$2,162	$2,083	$2,007	$1,935	$1,864	$1,796	$865	$23,507
3. Disposal (Cd)	P-II													($64,115)	($64,115)
Cost total (C)	P-II	$1,500,000	$839,723	$730,428	$703,869	$678,272	$653,609	$629,841	$606,935	$584,867	$563,599	$543,105	$523,353	$188,047	$8,745,648
4. Metal income (Sm)	P-II		($472,112)	($1,364,832)	($1,315,202)	($1,267,377)	($1,221,290)	($1,176,880)	($1,134,084)	($1,092,844)	($1,053,105)	($1,014,810)	($977,908)	($471,174)	($12,561,618)
Grand total		$1,500,000	$367,611	($634,404)	($611,333)	($589,105)	($567,681)	($547,039)	($527,149)	($507,977)	($489,506)	($471,705)	($454,555)	($283,127)	($3,815,970)

1. For a module of 50 machines.
2. A discount rate of 10% was used; Present value dollars = Inflated dollars * $\frac{1}{(1+i)^n}$

Table E-9

ALTERNATIVE P-III
INCREMENTAL COST/(SAVINGS) TABLE BY CATEGORY
(PRESENT VALUE DOLLARS) 2

Cost Category	Alternative	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Total
1. Prod. & Constr. cost (Cp)	P-III	$1,325,000	$392,627												$1,717,627
a. Manufacturing (Cpr)	P-III	$1,325,000	$72,273												$1,397,273
a-1. Initial cost (Cpri)	P-III	$1,325,000													$1,325,000
a-2. Testing (Cprt)	P-III		$14,455												$14,455
a-3. Transportation (Cprs)	P-III		$57,818												$57,818
b. Construction (Cpc)	P-III		$240,909												$240,909
c. Initial logistic (Cpl)	P-III		$79,445												$79,445
c-1. Int. spare parts (Cpls)	P-III		$70,602												$70,602
c-2. Inventory mgmt. (Cpli)	P-III		$964												$964
c-3. Data preparation (Cpld)	P-III		$5,879												$5,879
c-4. Initial training (Cplt)	P-III		$1,445												$1,445
c-5. Initial test eq. (Cplx)	P-III		$555												$555
2. Oper. & Maintenance (Co)	P-III		$363,945	$701,423	$675,917	$651,338	$627,655	$604,830	$582,835	$561,645	$541,220	$521,538	$502,572	$242,148	$6,577,066
a. Operational costs (Coo)	P-III		$273,995	$528,044	$508,863	$490,358	$472,528	$455,345	$438,786	$422,832	$407,455	$392,638	$378,360	$182,301	$4,951,525
a-1. Operator labor (Cool)	P-III		$29,959	$57,739	$55,640	$53,616	$51,667	$49,788	$47,977	$46,233	$44,552	$42,931	$41,370	$19,933	$541,405
a-2. Replacement training (Coop)	P-III		$327	$631	$608	$586	$565	$544	$525	$506	$487	$470	$452	$218	$5,919
a-3. Transportation (Coot)	P-III		$76,320	$147,089	$141,741	$136,587	$131,620	$126,834	$122,221	$117,777	$113,494	$109,367	$105,390	$50,779	$1,379,219
a-4. Rent (Coor)	P-III		$86,727	$167,147	$161,069	$155,212	$149,568	$144,129	$138,888	$133,838	$128,971	$124,281	$119,762	$57,703	$1,567,295
a-5. Utilities (Coou)	P-III		$80,662	$155,458	$149,805	$144,357	$139,108	$134,050	$129,175	$124,478	$119,951	$115,589	$111,386	$53,668	$1,457,687
b. Maintenance costs (Com)	P-III		$89,950	$173,359	$167,054	$160,980	$155,127	$149,485	$144,049	$138,813	$133,765	$128,900	$124,212	$59,847	$1,625,541
b-1. Labor (Coml)	P-III		$32,929	$63,464	$61,156	$58,932	$56,789	$54,724	$52,734	$50,817	$48,969	$47,188	$45,472	$21,909	$595,083
b-2. Replacement training (Comp)	P-III		$327	$631	$608	$586	$565	$544	$525	$506	$487	$470	$452	$218	$5,919
b-3. Recurring spares (Comx)	P-III		$49,755	$95,892	$92,405	$89,045	$85,807	$82,687	$79,680	$76,783	$73,991	$71,300	$68,707	$33,104	$899,156
b-4. Tools (Coms)	P-III		$145	$279	$268	$259	$249	$240	$231	$223	$215	$207	$200	$96	$2,612
b-5. Transportation (Comt)	P-III		$5,493	$10,586	$10,201	$9,830	$9,473	$9,128	$8,796	$8,476	$8,168	$7,871	$7,585	$3,655	$99,262
b-6. Facility (Comf)	P-III		$1,301	$2,507	$2,416	$2,328	$2,244	$2,162	$2,083	$2,008	$1,935	$1,864	$1,796	$865	$23,509
3. Disposal (Cd)	P-III													($48,086)	($48,086)
Cost total (C)	P-III	$1,325,000	$756,572	$701,423	$675,917	$651,338	$627,655	$604,830	$582,835	$561,645	$541,220	$521,538	$502,572	$194,062	$8,246,607
4. Metal income (Be)	P-III		($367,109)	($1,061,279)	($1,022,687)	($985,498)	($949,661)	($915,129)	($881,851)	($849,784)	($818,882)	($789,105)	($760,410)	($366,380)	($9,767,775)
Grand total		$1,325,000	$389,463	($359,856)	($346,770)	($334,160)	($322,006)	($310,299)	($299,016)	($288,139)	($277,662)	($267,567)	($257,838)	($172,318)	($1,521,168)

1. For a module of 50 machines.
2. A discount rate of 10% was used; Present value dollars = Inflated dollars * $\frac{1}{(1+i)^n}$

APPENDIX F

SENSITIVITY ANALYSIS SPREADSHEETS

On pages 75 - 92 are the spreadsheets used for the Life-Cycle Sensitivity Analysis. Page 75 displays the 1990 present value costs for a module of the PP machines as the quantity of metal is increased to the 102,616 lbs/yr/machine level. The quality of the metal is held constant at the 10% contamination level.

Page 76 displays the 1990 present value costs for a module of the PP machines as the quantity of metal is increased to the 131,967 lbs/yr/machine level. The quality of the metal is held constant at the 10% contamination level.

Page 77 displays the 1990 present value costs for a module of the P-II machines as the quantity of metal is reduced to the 90,894 lbs/yr/machine level. The quality of the metal is held constant at the already achievable 1% contamination level.

Page 78 displays the 1990 present value costs for a module of the P-II machines as the quantity of metal is reduced to the 102,616 lbs/yr/machine level. The quality of the metal is held constant at the already achievable 1%

contamination level.

Page 79 displays the 1990 present value costs for a module of the P-III machines as the quantity of metal is reduced to the 90,894 lbs/yr/machine level. The quality of the metal is held constant at the already achievable 1% contamination level.

Page 80 displays the 1990 present value costs for a module of the P-III machines as the quantity of metal is increased to the 131,967 lbs/yr/machine level. The quality of the metal is held constant at the already achievable 1% contamination level.

A graphic display of the data is illustrated in Figure 2-7, page 42, of the three different machines, as the quantity of metal collected per year for a module of machines varies.

Page 81 displays the 1990 present value costs for a module of the PP machines as the quality of metal is increased to the 5% contamination level. The quantity of the metal is held constant at the 90,894 lbs/yr/machine level.

Page 82 displays the 1990 present value costs for a module of the PP machines as the quality of the metal is increased to the 1% contamination level. The quantity of the metal is held constant at the 90,894 lbs/yr/machine level.

A graphic display of the data is illustrated in Figure 2-8, page 44, as the quality of the metal collected per year for a module of machines is varied. The present value costs for the P-II and P-III machines are also indicated on the graph.

Page 87 displays the 1990 present value costs for a module of the PP machines as the quality of metal is increased to the 5% contamination level, and the quantity of the metal was increased to the 102,616 lbs/yr/machine level.

Page 88 displays the 1990 present value costs for a module of the PP machines as the quality of metal is increased to the 1% contamination level, and as the quantity of the metal is increased to the 131,967 lbs/yr/machine level.

A graphic display of the data is illustrated in Figure 2-9, page 46, as the quality and quantity of the metal collected per year for a module of machines is varied. The present value costs for the P-II and P-III machines are also indicated on the graph.

Table F-1

SENSITIVITY ANALYSIS ALTERNATIVE PP
VARY QUANTITY OF METAL COLLECTED: 102,616 LBS/YR
INCREMENTAL COST/(SAVINGS) TABLE BY CATEGORY
(PRESENT VALUE DOLLARS) 1, 2, 3,

Cost Category	Alternative	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Total
1. Prod. & Constr. cost (Cp)	PP	$875,000	$322,405							$706,365					$1,903,770
a. Manufacturing (Cpr)	PP	$875,000	$72,273							$706,365					$1,653,638
a-1. Initial cost (Cpri)	PP	$875,000								$650,599					$1,525,599
a-2. Testing (Cprt)	PP		$14,455							$11,153					$25,608
a-3. Transportation (Cprs)	PP		$57,818							$44,613					$102,431
b. Construction (Cpc)	PP		$192,727												$192,727
c. Initial logistic (Cpl)	PP		$57,405												$57,405
c-1. Int. spare parts (Cpls)	PP		$55,405												$55,405
c-2. Inventory mgmt. (Cpli)	PP		$0												$0
c-3. Data preparation (Cpld)	PP		$0												$0
c-4. Initial training (Cplt)	PP		$1,445												$1,445
c-5. Initial test eq. (Cplx)	PP		$555												$555
2. Oper. & Maintenance (Co)	PP		$347,846	$670,397	$646,021	$622,529	$599,892	$578,078	$557,053	$536,800	$517,278	$498,469	$480,342	$231,437	$6,286,140
a. Operational costs (Coo)	PP		$266,786	$514,133	$495,439	$477,423	$460,063	$443,333	$427,210	$411,677	$396,705	$382,280	$368,379	$177,491	$4,820,897
a-1. Operator labor (Cool)	PP		$29,959	$57,739	$55,639	$53,617	$51,667	$49,788	$47,977	$46,233	$44,551	$42,931	$41,370	$19,933	$541,404
a-2. Replacement training (Coop)	PP		$327	$631	$609	$586	$565	$545	$524	$506	$487	$470	$452	$218	$5,920
a-3. Transportation (Coot)	PP		$76,320	$147,089	$141,741	$136,586	$131,620	$126,833	$122,221	$117,777	$113,494	$109,367	$105,390	$50,779	$1,379,217
a-4. Rent (Coor)	PP		$86,727	$167,147	$161,069	$155,212	$149,568	$144,129	$138,888	$133,838	$128,971	$124,281	$119,762	$57,703	$1,567,295
a-5. Utilities (Coou)	PP		$73,433	$141,527	$136,381	$131,422	$126,643	$122,038	$117,600	$113,323	$109,202	$105,231	$101,405	$48,858	$1,327,061
b. Maintenance costs (Com)	PP		$81,080	$156,264	$150,582	$145,106	$139,829	$134,745	$129,843	$125,123	$120,573	$116,189	$111,963	$53,946	$1,465,243
b-1. Labor (Coms)	PP		$31,657	$61,012	$58,794	$56,656	$54,596	$52,610	$50,697	$48,854	$47,077	$45,365	$43,716	$21,063	$572,097
b-2. Replacement training (Comp)	PP		$327	$631	$609	$586	$565	$545	$524	$506	$487	$470	$452	$218	$5,920
b-3. Recurring spares (Comr)	PP		$42,157	$81,249	$78,294	$75,447	$72,703	$70,060	$67,512	$65,057	$62,691	$60,412	$58,215	$28,049	$761,846
b-4. Tools (Comt)	PP		$145	$279	$268	$259	$249	$240	$231	$223	$215	$207	$199	$96	$2,611
b-5. Transportation (Comt)	PP		$5,493	$10,586	$10,201	$9,830	$9,473	$9,128	$8,796	$8,476	$8,168	$7,871	$7,585	$3,655	$99,262
b-6. Facility (Comf)	PP		$1,301	$2,507	$2,416	$2,328	$2,243	$2,162	$2,083	$2,007	$1,935	$1,864	$1,796	$865	$23,507
3. Disposal (Cd)	PP									($37,177)				($302,301)	($339,478)
Cost total (C)	PP	$875,000	$670,251	$670,397	$646,021	$622,529	$599,892	$578,078	$557,053	$1,205,988	$517,278	$498,469	$480,342	($70,864)	$7,850,432
4. Metal income (Sm)	PP		($333,735)	($964,798)	($929,715)	($895,907)	($863,328)	($831,935)	($801,682)	($772,530)	($744,438)	($717,368)	($691,282)	($333,072)	($8,879,790)
Grand total		$875,000	$336,516	($294,401)	($283,694)	($273,378)	($263,436)	($253,857)	($244,629)	$433,458	($227,160)	($218,899)	($210,940)	($403,936)	($1,029,358)

1. For a module of 50 machines.
2. A discount rate of 10% was used; Present value dollars = Inflated dollars * $\frac{1}{(1+i)^n}$
3. Vary the quantity of metal received; 102,616 lbs/yr @ 10% contamination.
   102,616 lbs/machine x 90% x $.225/lb x 50 machines = $1,038,987/module
4. Utility multiplier = 1 + (102,616 - 90,894)/90,894 = 1.129

Table F-2

SENSITIVITY ANALYSIS ALTERNATIVE PP
VARY QUANTITY OF METAL COLLECTED: 131,967 LBS/YR
INCREMENTAL COST/(SAVINGS) TABLE BY CATEGORY
(PRESENT VALUE DOLLARS) 1, 2, 3,

Cost Category	Alternative	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Total
1. Prod. & Constr. cost (Cp)	PP	$875,000	$322,405							$706,365					$1,903,770
a. Manufacturing (Cpr)	PP	$875,000	$72,273							$706,365					$1,653,638
a-1. Initial cost (Cpri)	PP	$875,000								$650,599					$1,525,599
a-2. Testing (Cprt)	PP		$14,455							$11,133					$25,608
a-3. Transportation (Cprs)	PP		$57,818							$44,613					$102,431
b. Construction (Cpc)	PP		$192,727												$192,727
c. Initial logistic (Cpl)	PP		$57,405												$57,405
c-1. Int. spare parts (Cpls)	PP		$55,405												$55,405
c-2. Inventory mgmt. (Cpli)	PP		$0												$0
c-3. Data preparation (Cpld)	PP		$0												$0
c-4. Initial training (Cplt)	PP		$1,445												$1,445
c-5. Initial test eq. (Cplx)	PP		$555												$555
2. Oper. & Maintenance (Co)	PP		$368,850	$710,877	$685,030	$660,119	$636,115	$612,984	$590,689	$569,214	$548,513	$528,568	$509,346	$245,412	$6,665,717
a. Operational costs (Coo)	PP		$287,770	$554,613	$534,448	$515,013	$496,286	$478,239	$460,846	$444,091	$427,940	$412,379	$397,383	$191,466	$5,200,474
a-1. Operator labor (Cool)	PP		$29,959	$57,739	$55,639	$53,617	$51,667	$49,788	$47,977	$46,233	$44,551	$42,931	$41,370	$19,933	$541,404
a-2. Replacement training (Coop)	PP		$327	$631	$609	$586	$565	$545	$524	$506	$487	$470	$452	$218	$5,920
a-3. Transportation (Coot)	PP		$76,320	$147,089	$141,741	$136,586	$131,620	$126,833	$122,221	$117,777	$113,494	$109,367	$105,390	$50,779	$1,379,217
a-4. Rent (Coor)	PP		$86,727	$167,147	$161,069	$155,212	$149,568	$144,129	$138,888	$133,838	$128,971	$124,281	$119,762	$57,703	$1,567,295
a-5. Utilities (Coou)	PP		$94,437	$182,007	$175,390	$169,012	$162,866	$156,944	$151,236	$145,737	$140,437	$135,330	$130,409	$62,833	$1,706,638
b. Maintenance costs (Com)	PP		$81,080	$156,264	$150,582	$145,106	$139,829	$134,745	$129,843	$125,123	$120,573	$116,189	$111,963	$53,946	$1,465,243
b-1. Labor (Coma)	PP		$31,657	$61,012	$58,794	$56,656	$54,596	$52,610	$50,697	$48,854	$47,077	$45,365	$43,716	$21,063	$572,097
b-2. Replacement training (Comp)	PP		$327	$631	$609	$586	$565	$545	$524	$506	$487	$470	$452	$218	$5,920
b-3. Recurring spares (Comx)	PP		$42,157	$81,249	$78,294	$75,447	$72,703	$70,060	$67,512	$65,057	$62,691	$60,412	$58,215	$28,049	$761,846
b-4. Tools (Coms)	PP		$145	$279	$268	$259	$249	$240	$231	$223	$215	$207	$199	$96	$2,611
b-5. Transportation (Comt)	PP		$5,493	$10,586	$10,201	$9,830	$9,473	$9,128	$8,796	$8,476	$8,168	$7,871	$7,585	$3,655	$99,262
b-6. Facility (Comf)	PP		$1,301	$2,507	$2,416	$2,328	$2,243	$2,162	$2,083	$2,007	$1,935	$1,864	$1,796	$865	$23,507
3. Disposal (Cd)	PP									($37,177)				($302,301)	($339,478)
Cost total (C)	PP	$875,000	$691,255	$710,877	$685,030	$660,119	$636,115	$612,984	$590,689	$1,238,402	$548,513	$528,568	$509,346	($56,889)	$8,230,009
4. Metal income (Sa)	PP		($429,193)	($1,240,757)	($1,195,639)	($1,152,161)	($1,110,264)	($1,069,891)	($1,030,986)	($993,495)	($957,368)	($922,555)	($889,007)	($428,340)	($11,419,656)
Grand total		$875,000	$262,062	($529,880)	($510,609)	($492,042)	($474,149)	($456,907)	($440,297)	$244,907	($408,855)	($393,987)	($379,661)	($485,229)	($3,189,647)

1. For a module of 50 machines.
2. A discount rate of 10% was used; Present value dollars = Inflated dollars * $\frac{1}{(1+i)^n}$
3. Vary the quantity of metal received; 131,967 lbs/yr @ 10% contamination.
   131,967 lbs/machine x 90% x $.225/lb x 50 machines = $1,336,166/module
4. Utility multiplier = 1 + (131,967 - 90,894)/90,894 = 1.452

Table F-3

SENSITIVITY ANALYSIS ALTERNATIVE P-II
VARY QUANTITY OF METAL COLLECTED: 90,894 LBS/YR
INCREMENTAL COST/(SAVINGS) TABLE BY CATEGORY
(PRESENT VALUE DOLLARS) 1, 2, 3, 4

Cost Category	Alternative	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Total
1. Prod. & Constr. cost (Cp)	P-II	$1,500,000	$460,728												$1,960,728
a. Manufacturing (Cpr)	P-II	$1,500,000	$72,273												$1,572,273
a-1. Initial cost (Cpri)	P-II	$1,500,000													$1,500,000
a-2. Testing (Cprt)	P-II		$14,455												$14,455
a-3. Transportation (Cprs)	P-II		$57,818												$57,818
b. Construction (Cpc)	P-II		$240,909												$240,909
c. Initial logistic (Cpl)	P-II		$147,546												$147,546
c-1. Int. spare parts (Cpls)	P-II		$138,703												$138,703
c-2. Inventory mgmt. (Cpli)	P-II		$984												$984
c-3. Data preparation (Cpld)	P-II		$5,879												$5,879
c-4. Initial training (Cplt)	P-II		$1,445												$1,445
c-5. Initial test eq. (Cplx)	P-II		$555												$555
2. Oper. & Maintenance (Co)	P-II		$359,474	$692,805	$667,615	$643,336	$619,943	$597,400	$575,673	$554,742	$534,569	$515,131	$496,396	$239,174	$6,496,258
a. Operational costs (Coo)	P-II		$236,533	$455,864	$439,289	$423,314	$407,922	$393,088	$378,792	$365,020	$351,745	$338,955	$326,629	$157,376	$4,274,527
a-1. Operator labor (Cool)	P-II		$29,959	$57,739	$55,639	$53,617	$51,667	$49,788	$47,977	$46,233	$44,551	$42,931	$41,370	$19,933	$541,404
a-2. Replacement training (Coop)	P-II		$327	$631	$609	$586	$565	$545	$524	$506	$487	$470	$452	$218	$5,920
a-3. Transportation (Coot)	P-II		$76,320	$147,089	$141,741	$136,586	$131,620	$126,833	$122,221	$117,777	$113,494	$109,367	$105,390	$50,779	$1,379,217
a-4. Rent (Coor)	P-II		$86,727	$167,147	$161,069	$155,212	$149,568	$144,129	$138,888	$133,838	$128,971	$124,281	$119,762	$57,703	$1,567,295
a-5. Utilities (Coou)	P-II		$43,200	$83,258	$80,231	$77,313	$74,502	$71,793	$69,182	$66,666	$64,242	$61,906	$59,655	$28,743	$780,691
b. Maintenance costs (Com)	P-II		$122,941	$236,941	$228,326	$220,022	$212,021	$204,312	$196,881	$189,722	$182,824	$176,176	$169,767	$81,798	$2,221,731
b-1. Labor (Coml)	P-II		$31,869	$61,421	$59,188	$57,035	$54,961	$52,963	$51,037	$49,181	$47,392	$45,669	$44,008	$21,204	$575,928
b-2. Replacement training (Comp)	P-II		$327	$631	$609	$586	$565	$545	$524	$506	$487	$470	$452	$218	$5,920
b-3. Recurring spares (Comx)	P-II		$83,806	$161,517	$155,644	$149,984	$144,530	$139,274	$134,210	$129,329	$124,627	$120,095	$115,727	$55,760	$1,514,503
b-4. Tools (Coms)	P-II		$145	$279	$268	$259	$249	$240	$231	$223	$215	$207	$199	$96	$2,611
b-5. Transportation (Comt)	P-II		$5,493	$10,586	$10,201	$9,830	$9,473	$9,128	$8,796	$8,476	$8,168	$7,871	$7,585	$3,655	$99,262
b-6. Facility (Comf)	P-II		$1,301	$2,507	$2,416	$2,328	$2,243	$2,162	$2,083	$2,007	$1,933	$1,864	$1,796	$865	$23,507
3. Disposal (Cd)	P-II													($64,115)	($64,115)
Cost total (C)	P-II	$1,500,000	$820,202	$692,805	$667,615	$643,336	$619,943	$597,400	$575,673	$554,742	$534,569	$515,131	$496,396	$175,059	$8,392,871
4. Metal income (Sm)	P-II		($325,173)	($940,046)	($905,863)	($872,922)	($841,180)	($810,592)	($781,115)	($752,711)	($725,340)	($698,964)	($673,547)	($324,527)	($8,651,980)
Grand total		$1,500,000	$495,029	($247,241)	($238,248)	($229,586)	($221,237)	($213,192)	($205,442)	($197,969)	($190,771)	($183,833)	($177,151)	($149,468)	($259,109)

1. For a module of 50 machines.
2. A discount rate of 10% was used; Present value dollars = Inflated dollars $\times \frac{1}{(1+i)^n}$
3. Vary the quantity of metal received; 90,894 lbs/yr @ 1% contamination.
   90,894 lbs/machine x 99% x $.225/lb x 50 machines = $1,012,332/module
4. Utility multiplier = 90,894/131,967 = .689

Table F-4

SENSITIVITY ANALYSIS ALTERNATIVE P-II
VARY QUANTITY OF METAL COLLECTED: 102,616 LBS/YR
INCREMENTAL COST/(SAVINGS) TABLE BY CATEGORY
(PRESENT VALUE DOLLARS) 1, 2, 3, 4

Cost Category	Alternative	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Total
1. Prod. & Constr. cost (Cp)	P-II	$1,500,000	$460,728												$1,960,728
a. Manufacturing (Cpr)	P-II	$1,500,000	$72,273												$1,572,273
a-1. Initial cost (Cpri)	P-II	$1,500,000													$1,500,000
a-2. Testing (Cprt)	P-II		$14,455												$14,455
a-3. Transportation (Cprs)	P-II		$57,818												$57,818
b. Construction (Cpc)	P-II		$240,909												$240,909
c. Initial logistic (Cpl)	P-II		$147,546												$147,546
c-1. Int. spare parts (Cpls)	P-II		$138,703												$138,703
c-2. Inventory mgmt. (Cpli)	P-II		$964												$964
c-3. Data preparation (Cpld)	P-II		$5,879												$5,879
c-4. Initial training (Cplt)	P-II		$1,445												$1,445
c-5. Initial test eq. (Cplx)	P-II		$555												$555
2. Oper. & Maintenance (Co)	P-II		$345,045	$703,543	$677,961	$653,307	$629,551	$606,658	$584,595	$563,340	$542,854	$523,115	$504,089	$242,881	$6,596,938
a. Operational costs (Coo)	P-II		$242,104	$466,602	$449,635	$433,285	$417,530	$402,346	$387,714	$373,618	$360,030	$346,939	$334,322	$161,083	$4,375,207
a-1. Operator labor (Cool)	P-II		$29,959	$57,739	$55,639	$53,617	$51,667	$49,788	$47,977	$46,233	$44,551	$42,931	$41,370	$19,933	$541,404
a-2. Replacement training (Coop)	P-II		$327	$631	$609	$586	$565	$545	$524	$506	$487	$470	$452	$218	$5,920
a-3. Transportation (Coot)	P-II		$76,320	$147,089	$141,741	$136,586	$131,620	$126,833	$122,221	$117,777	$113,494	$109,367	$105,390	$50,779	$1,379,217
a-4. Rent (Coor)	P-II		$86,727	$167,147	$161,069	$155,212	$149,568	$144,129	$138,888	$133,838	$128,971	$124,281	$119,762	$57,703	$1,567,295
a-5. Utilities (Coou)	P-II		$48,771	$93,996	$90,577	$87,284	$84,110	$81,051	$78,104	$75,264	$72,527	$69,890	$67,348	$32,450	$881,371
b. Maintenance costs (Com)	P-II		$122,941	$236,941	$228,326	$220,022	$212,021	$204,312	$196,881	$189,722	$182,824	$176,176	$169,767	$81,798	$2,221,731
b-1. Labor (Coma)	P-II		$31,869	$61,421	$59,188	$57,035	$54,961	$52,963	$51,037	$49,181	$47,392	$45,669	$44,008	$21,204	$575,928
b-2. Replacement training (Comp)	P-II		$327	$631	$609	$586	$565	$545	$524	$506	$487	$470	$452	$218	$5,920
b-3. Recurring spares (Comx)	P-II		$83,806	$161,517	$155,644	$149,984	$144,530	$139,274	$134,210	$129,329	$124,627	$120,095	$115,727	$55,760	$1,514,503
b-4. Tools (Coms)	P-II		$145	$279	$268	$259	$249	$240	$231	$223	$215	$207	$199	$96	$2,611
b-5. Transportation (Comt)	P-II		$5,493	$10,586	$10,201	$9,830	$9,473	$9,128	$8,796	$8,476	$8,168	$7,871	$7,585	$3,655	$99,262
b-6. Facility (Comf)	P-II		$1,301	$2,507	$2,416	$2,328	$2,243	$2,162	$2,083	$2,007	$1,935	$1,864	$1,796	$865	$23,507
3. Disposal (Cd)	P-II													($64,115)	($64,115)
Cost total (C)	P-II	$1,500,000	$825,773	$703,543	$677,961	$653,307	$629,551	$606,658	$584,595	$563,340	$542,854	$523,115	$504,089	$178,766	$8,493,551
4. Metal income (Sm)	P-II		($367,109)	($1,061,278)	($1,022,686)	($985,498)	($949,661)	($915,128)	($881,851)	($849,784)	($818,882)	($789,105)	($760,410)	($366,379)	($9,767,771)
Grand total		$1,500,000	$458,664	($357,735)	($344,725)	($332,191)	($320,110)	($308,470)	($297,256)	($286,444)	($276,028)	($265,990)	($256,321)	($187,613)	($1,274,220)

1. For a module of 50 machines.
2. A discount rate of 10% was used; Present value dollars = Inflated dollars $\times \frac{1}{(1+i)^n}$
3. Vary the quantity of metal received; 102,616 lbs/yr @ 1% contamination.
   102,616 lbs/machine x 99% x $.225/lb x 50 machines = $1,142,686/module
4. Utility multiplier = 102,616/131,967 = .778

Table F-5

SENSITIVITY ANALYSIS ALTERNATIVE P-III
VARY QUANTITY OF METAL COLLECTED: 90,894 LBS/YR
INCREMENTAL COST/(SAVINGS) TABLE BY CATEGORY
(PRESENT VALUE DOLLARS) 1, 2, 3, 4

Cost Category	Alternative	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Total
1. Prod. & Constr. cost (Cp)	P-III	$1,325,000	$392,627												$1,717,627
a. Manufacturing (Cpr)	P-III	$1,325,000	$72,273												$1,397,273
a-1. Initial cost (Cpri)	P-III	$1,325,000													$1,325,000
a-2. Testing (Cprt)	P-III		$14,455												$14,455
a-3. Transportation (Cprs)	P-III		$57,818												$57,818
b. Construction (Cpc)	P-III		$240,909												$240,909
c. Initial logistic (Cpl)	P-III		$79,445												$79,445
c-1. Int. spare parts (Cpls)	P-III		$70,602												$70,602
c-2. Inventory mgmt. (Cpli)	P-III		$964												$964
c-3. Data preparation (Cpld)	P-III		$5,879												$5,879
c-4. Initial training (Cplt)	P-III		$1,445												$1,445
c-5. Initial test eq. (Cplx)	P-III		$555												$555
2. Oper. & Maintenance (Co)	P-III		$354,731	$683,665	$658,805	$634,848	$611,764	$589,517	$568,079	$547,426	$527,518	$508,334	$489,848	$236,017	$6,410,552
a. Operational costs (Coo)	P-III		$264,781	$510,306	$491,751	$473,868	$456,637	$440,032	$424,030	$408,613	$393,753	$379,434	$365,636	$176,170	$4,785,011
a-1. Operator labor (Cool)	P-III		$29,959	$57,739	$55,640	$53,616	$51,667	$49,788	$47,977	$46,233	$44,552	$42,931	$41,370	$19,933	$541,405
a-2. Replacement training (Coop)	P-III		$327	$631	$608	$586	$565	$544	$525	$506	$487	$470	$452	$218	$5,919
a-3. Transportation (Coot)	P-III		$76,320	$147,089	$141,741	$136,587	$131,620	$126,834	$122,221	$117,777	$113,494	$109,367	$105,390	$50,779	$1,379,219
a-4. Rent (Coor)	P-III		$86,727	$167,147	$161,069	$155,212	$149,568	$144,129	$138,888	$133,838	$128,971	$124,281	$119,762	$57,703	$1,567,295
a-5. Utilities (Coou)	P-III		$71,448	$137,700	$132,693	$127,867	$123,217	$118,737	$114,419	$110,259	$106,249	$102,385	$98,662	$47,537	$1,291,173
b. Maintenance costs (Coa)	P-III		$89,950	$173,359	$167,054	$160,980	$155,127	$149,485	$144,049	$138,813	$133,765	$128,900	$124,212	$59,847	$1,625,541
b-1. Labor (Coaa)	P-III		$32,929	$63,464	$61,156	$58,932	$56,789	$54,724	$52,734	$50,817	$48,969	$47,188	$45,472	$21,909	$595,083
b-2. Replacement training (Coap)	P-III		$327	$631	$608	$586	$565	$544	$525	$506	$487	$470	$452	$218	$5,919
b-3. Recurring spares (Coar)	P-III		$49,755	$95,892	$92,405	$89,045	$85,807	$82,687	$79,680	$76,783	$73,991	$71,300	$68,707	$33,104	$899,156
b-4. Tools (Coas)	P-III		$145	$279	$268	$259	$249	$240	$231	$223	$215	$207	$200	$96	$2,612
b-5. Transportation (Coat)	P-III		$5,493	$10,586	$10,201	$9,830	$9,473	$9,128	$8,796	$8,476	$8,168	$7,871	$7,585	$3,655	$99,262
b-6. Facility (Coaf)	P-III		$1,301	$2,507	$2,416	$2,328	$2,244	$2,162	$2,083	$2,008	$1,935	$1,864	$1,796	$865	$23,509
3. Disposal (Cd)	P-III													($48,086)	($48,086)
Cost total (C)	P-III	$1,325,000	$747,358	$683,665	$658,805	$634,848	$611,764	$589,517	$568,079	$547,426	$527,518	$508,334	$489,848	$187,931	$8,080,093
4. Metal income (Sa)	P-III		($325,173)	($940,046)	($905,863)	($872,922)	($841,180)	($810,592)	($781,115)	($752,711)	($725,340)	($698,964)	($673,547)	($324,527)	($8,651,980)
Grand total		$1,325,000	$422,185	($256,381)	($247,058)	($238,074)	($229,416)	($221,075)	($213,036)	($205,285)	($197,822)	($190,630)	($183,699)	($136,596)	($571,887)

1. For a module of 50 machines.
2. A discount rate of 10% was used; Present value dollars = Inflated dollars $\times \frac{1}{(1+i)^n}$
3. Vary the quantity of metal received; 90,894 lbs/yr @ 1% contamination.
   90,894 lbs/machine x 99% x $.225/lb x 50 machines = $1,012,332/module
4. Utility multiplier = 90,894/102,616 = .886

Table F-6

SENSITIVITY ANALYSIS ALTERNATIVE P-III
VARY QUANTITY OF METAL COLLECTED: 131,967 LBS/YR
INCREMENTAL COST/(SAVINGS) TABLE BY CATEGORY
(PRESENT VALUE DOLLARS) 1, 2, 3, 4

Cost Category	Alternative	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Total
1. Prod. & Constr. cost (Cp)	P-III	$1,325,000	$392,627												$1,717,627
a. Manufacturing (Cpr)	P-III	$1,325,000	$72,273												$1,397,273
a-1. Initial cost (Cpri)	P-III	$1,325,000													$1,325,000
a-2. Testing (Cprt)	P-III		$14,455												$14,455
a-3. Transportation (Cprs)	P-III		$57,818												$57,818
b. Construction (Cpc)	P-III		$240,909												$240,909
c. Initial logistic (Cpl)	P-III		$79,445												$79,445
c-1. Int. spare parts (Cpla)	P-III		$70,602												$70,602
c-2. Inventory mgmt. (Cpli)	P-III		$964												$964
c-3. Data preparation (Cpld)	P-III		$5,879												$5,879
c-4. Initial training (Cplt)	P-III		$1,445												$1,445
c-5. Initial test eq. (Cplx)	P-III		$555												$555
2. Oper. & Maintenance (Co)	P-III		$387,014	$745,884	$718,761	$692,624	$667,440	$643,168	$619,779	$597,246	$575,526	$554,596	$534,428	$257,497	$6,993,964
a. Operational costs (Coo)	P-III		$297,064	$572,525	$551,707	$531,644	$512,313	$493,683	$475,730	$458,433	$441,761	$425,696	$410,216	$197,650	$5,368,423
a-1. Operator labor (Cool)	P-III		$29,959	$57,739	$55,640	$53,616	$51,667	$49,788	$47,977	$46,233	$44,552	$42,931	$41,370	$19,933	$541,405
a-2. Replacement training (Coop)	P-III		$327	$631	$608	$586	$565	$544	$525	$506	$487	$470	$452	$218	$5,919
a-3. Transportation (Coot)	P-III		$76,320	$147,089	$141,741	$136,587	$131,620	$126,834	$122,221	$117,777	$113,494	$109,367	$105,390	$50,779	$1,379,219
a-4. Rent (Coor)	P-III		$86,727	$167,147	$161,069	$155,212	$149,568	$144,129	$138,888	$133,838	$128,971	$124,281	$119,762	$57,703	$1,567,295
a-5. Utilities (Coou)	P-III		$103,731	$199,919	$192,649	$185,643	$178,893	$172,388	$166,119	$160,079	$154,257	$148,647	$143,242	$69,017	$1,874,585
b. Maintenance costs (Com)	P-III		$89,950	$173,359	$167,054	$160,980	$155,127	$149,485	$144,049	$138,813	$133,765	$128,900	$124,212	$59,847	$1,625,541
b-1. Labor (Coma)	P-III		$32,929	$63,464	$61,156	$58,932	$56,789	$54,724	$52,734	$50,817	$48,969	$47,188	$45,472	$21,909	$595,083
b-2. Replacement training (Comp)	P-III		$327	$631	$608	$586	$565	$544	$525	$506	$487	$470	$452	$218	$5,919
b-3. Recurring spares (Comx)	P-III		$49,755	$95,892	$92,405	$89,045	$85,807	$82,687	$79,680	$76,783	$73,991	$71,300	$68,707	$33,104	$899,156
b-4. Tools (Coms)	P-III		$145	$279	$268	$259	$249	$240	$231	$223	$215	$207	$200	$96	$2,612
b-5. Transportation (Comt)	P-III		$5,493	$10,586	$10,201	$9,830	$9,473	$9,128	$8,796	$8,476	$8,168	$7,871	$7,585	$3,655	$99,262
b-6. Facility (Comf)	P-III		$1,301	$2,507	$2,416	$2,328	$2,244	$2,162	$2,083	$2,008	$1,935	$1,864	$1,796	$865	$23,509
3. Disposal (Cd)	P-III													($48,086)	($48,086)
Cost total (C)	P-III	$1,325,000	$779,641	$745,884	$718,761	$692,624	$667,440	$643,168	$619,779	$597,246	$575,526	$554,596	$534,428	$209,411	$8,663,505
4. Metal income (Sa)	P-III		($472,112)	($1,364,832)	($1,315,202)	($1,267,376)	($1,221,290)	($1,176,880)	($1,134,084)	($1,092,844)	($1,053,105)	($1,014,810)	($977,908)	($471,174)	($12,561,617)
Grand total		$1,325,000	$307,529	($618,948)	($596,441)	($574,752)	($553,850)	($533,712)	($514,305)	($495,598)	($477,579)	($460,214)	($443,480)	($261,763)	($3,898,112)

1. For a module of 50 machines.
2. A discount rate of 10% was used; Present value dollars = Inflated dollars * $\frac{1}{(1+i)^n}$
3. Vary the quantity of metal received; 131,967 lbs/yr @ 1% contamination.

Table F-7

SENSITIVITY ANALYSIS ALTERNATIVE PP
VARY QUALITY OF METAL COLLECTED: 5% CONTAMINATION
INCREMENTAL COST/(SAVINGS) TABLE BY CATEGORY
(PRESENT VALUE DOLLARS) 1, 2, 3, 4

Cost Category	Alternative	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Total
1. Prod. & Constr. cost (Cp)	PP	$875,000	$322,405							$706,365					$1,903,770
a. Manufacturing (Cpr)	PP	$875,000	$72,273							$706,365					$1,653,638
a-1. Initial cost (Cpri)	PP	$875,000								$650,599					$1,525,599
a-2. Testing (Cprt)	PP		$14,455							$11,153					$25,608
a-3. Transportation (Cprs)	PP		$57,818							$44,613					$102,431
b. Construction (Cpc)	PP		$192,727												$192,727
c. Initial logistic (Cpl)	PP		$57,405												$57,405
c-1. Int. spare parts (Cpls)	PP		$55,405												$55,405
c-2. Inventory mgmt. (Cpli)	PP		$0												$0
c-3. Data preparation (Cpld)	PP		$0												$0
c-4. Initial training (Cplt)	PP		$1,445												$1,445
c-5. Initial test eq. (Cplx)	PP		$555												$555
2. Oper. & Maintenance (Co)	PP		$339,458	$654,230	$630,442	$607,516	$585,425	$564,137	$543,619	$523,855	$504,804	$486,448	$468,758	$225,856	$6,134,548
a. Operational costs (Coo)	PP		$258,378	$497,966	$479,860	$462,410	$445,596	$429,392	$413,776	$398,732	$384,231	$370,259	$356,795	$171,910	$4,669,305
a-1. Operator labor (Cool)	PP		$29,959	$57,739	$55,639	$53,617	$51,667	$49,788	$47,977	$46,233	$44,551	$42,931	$41,370	$19,933	$541,404
a-2. Replacement training (Coop)	PP		$327	$631	$609	$586	$565	$545	$524	$506	$487	$470	$452	$218	$5,920
a-3. Transportation (Coot)	PP		$76,320	$147,089	$141,741	$136,586	$131,620	$126,833	$122,221	$117,777	$113,494	$109,367	$105,390	$50,779	$1,379,217
a-4. Rent (Coor)	PP		$86,727	$167,147	$161,069	$155,212	$149,568	$144,129	$138,888	$133,838	$128,971	$124,281	$119,762	$57,703	$1,567,295
a-5. Utilities (Coou)	PP		$65,045	$125,360	$120,802	$116,409	$112,176	$108,097	$104,166	$100,378	$96,728	$93,210	$89,821	$43,277	$1,175,469
b. Maintenance costs (Com)	PP		$81,080	$156,264	$150,582	$145,106	$139,829	$134,745	$129,843	$125,123	$120,573	$116,189	$111,963	$53,946	$1,465,243
b-1. Labor (Coml)	PP		$31,657	$61,012	$58,794	$56,656	$54,596	$52,610	$50,697	$48,854	$47,077	$45,365	$43,716	$21,063	$572,097
b-2. Replacement training (Comp)	PP		$327	$631	$609	$586	$565	$545	$524	$506	$487	$470	$452	$218	$5,920
b-3. Recurring spares (Comr)	PP		$42,157	$81,249	$78,294	$75,447	$72,703	$70,060	$67,512	$65,057	$62,691	$60,412	$58,215	$28,049	$761,846
b-4. Tools (Comt)	PP		$145	$279	$268	$259	$249	$240	$231	$223	$215	$207	$199	$96	$2,611
b-5. Transportation (Com)	PP		$5,493	$10,586	$10,201	$9,830	$9,473	$9,128	$8,796	$8,476	$8,168	$7,871	$7,585	$3,655	$99,262
b-6. Facility (Comf)	PP		$1,301	$2,507	$2,416	$2,328	$2,243	$2,162	$2,083	$2,007	$1,935	$1,864	$1,796	$865	$23,507
3. Disposal (Cd)	PP									($37,177)				($302,301)	($339,478)
Cost total (C)	PP	$875,000	$661,863	$654,230	$630,442	$607,516	$585,425	$564,137	$543,619	$1,193,043	$504,804	$486,448	$468,758	($76,445)	$7,698,840
4. Metal income (Sm)	PP		($312,035)	($902,065)	($869,263)	($837,653)	($807,193)	($777,841)	($749,555)	($722,299)	($696,033)	($670,723)	($646,333)	($311,415)	($8,302,408)
Grand total		$875,000	$349,828	($247,835)	($238,821)	($230,137)	($221,768)	($213,704)	($205,936)	$470,744	($191,229)	($184,275)	($177,575)	($387,860)	($603,568)

1. For a module of 50 machines.
2. A discount rate of 10% was used; Present value dollars = Inflated dollars $\times$ $\frac{1}{(1+i)^n}$
3. Vary the quality of metal received; 90,894 lbs/yr @ 5% contamination.
   90,894 lbs/machine x 95% x $.225/lb x 50 machines = $971,430/module
4. Utilities would remain at their original levels.

Table F-8

SENSITIVITY ANALYSIS ALTERNATIVE PP
VARY QUALITY OF METAL COLLECTED: 1% CONTAMINATION
INCREMENTAL COST/(SAVINGS) TABLE BY CATEGORY
(PRESENT VALUE DOLLARS) 1, 2, 3,

Cost Category	Alternative	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Total
1. Prod. & Constr. cost (Cp)	PP	$875,000	$322,405							$706,365					$1,903,770
a. Manufacturing (Cpr)	PP	$875,000	$72,273							$706,365					$1,653,638
a-1. Initial cost (Cpri)	PP	$875,000								$650,599					$1,525,599
a-2. Testing (Cprt)	PP		$14,455							$11,153					$25,608
a-3. Transportation (Cprs)	PP		$57,818							$44,613					$102,431
b. Construction (Cpc)	PP		$192,727												$192,727
c. Initial logistic (Cpl)	PP		$57,405												$57,405
c-1. Int. spare parts (Cpls)	PP		$55,405												$55,405
c-2. Inventory eqmt. (Cpli)	PP		$0												$0
c-3. Data preparation (Cpld)	PP		$0												$0
c-4. Initial training (Cplt)	PP		$1,445												$1,445
c-5. Initial test eq. (Cplx)	PP		$555												$555
2. Oper. & Maintenance (Co)	PP		$339,458	$654,230	$630,442	$607,516	$585,425	$564,137	$543,619	$523,855	$504,804	$486,448	$468,758	$225,856	$6,134,548
a. Operational costs (Coo)	PP		$258,378	$497,966	$479,860	$462,410	$445,596	$429,392	$413,776	$398,732	$384,231	$370,259	$356,795	$171,910	$4,669,305
a-1. Operator labor (Cool)	PP		$29,959	$57,739	$55,639	$53,617	$51,667	$49,788	$47,977	$46,233	$44,551	$42,931	$41,370	$19,933	$541,404
a-2. Replacement training (Coop)	PP		$327	$631	$609	$586	$565	$545	$524	$506	$487	$470	$452	$218	$5,920
a-3. Transportation (Coot)	PP		$76,320	$147,089	$141,741	$136,586	$131,620	$126,833	$122,221	$117,777	$113,494	$109,367	$105,390	$50,779	$1,379,217
a-4. Rent (Coor)	PP		$86,727	$167,147	$161,069	$155,212	$149,568	$144,129	$138,888	$133,838	$128,971	$124,281	$119,762	$57,703	$1,567,295
a-5. Utilities (Coou)	PP		$65,045	$125,360	$120,802	$116,409	$112,176	$108,097	$104,166	$100,378	$96,728	$93,210	$89,821	$43,277	$1,175,469
b. Maintenance costs (Coa)	PP		$81,080	$156,264	$150,582	$145,106	$139,829	$134,745	$129,843	$125,123	$120,573	$116,189	$111,963	$53,946	$1,465,243
b-1. Labor (Coaa)	PP		$31,657	$61,012	$58,794	$56,656	$54,596	$52,610	$50,697	$48,854	$47,077	$45,365	$43,716	$21,063	$572,097
b-2. Replacement training (Coap)	PP		$327	$631	$609	$586	$565	$545	$524	$506	$487	$470	$452	$218	$5,920
b-3. Recurring spares (Coax)	PP		$42,157	$81,249	$78,294	$75,447	$72,703	$70,060	$67,512	$65,057	$62,691	$60,412	$58,215	$28,049	$761,846
b-4. Tools (Coas)	PP		$145	$279	$268	$259	$249	$240	$231	$223	$215	$207	$199	$96	$2,611
b-5. Transportation (Coat)	PP		$5,493	$10,586	$10,201	$9,830	$9,473	$9,128	$8,796	$8,476	$8,168	$7,871	$7,585	$3,655	$99,262
b-6. Facility (Coaf)	PP		$1,301	$2,507	$2,416	$2,328	$2,243	$2,162	$2,083	$2,007	$1,935	$1,864	$1,796	$865	$23,507
3. Disposal (Cd)	PP									($37,177)				($302,301)	($339,478)
Cost total (C)	PP	$875,000	$661,863	$654,230	$630,442	$607,516	$585,425	$564,137	$543,619	$1,193,043	$504,804	$486,448	$468,758	($76,445)	$7,698,840
4. Metal income (Bm)	PP		($325,173)	($940,046)	($905,863)	($872,922)	($841,180)	($810,592)	($781,115)	($752,711)	($725,340)	($698,964)	($673,547)	($324,527)	($8,651,980)
Grand total		$875,000	$336,690	($285,816)	($275,421)	($265,406)	($255,755)	($246,455)	($237,496)	$440,332	($220,536)	($212,516)	($204,789)	($400,972)	($953,140)

1. For a module of 50 machines.
2. A discount rate of 10% was used; Present value dollars = Inflated dollars $\times \frac{1}{(1+i)^n}$
3. Vary the quality of metal received; 90,894 lbs/yr @ 1% contamination.
   90,894 lbs/machine x 99% x $.225/lb x 50 machines = $1,012,332/module
4. Utilities would remain at their original levels.

Table F-9

SENSITIVITY ANALYSIS ALTERNATIVE P-II
VARY QUALITY OF METAL COLLECTED: 5% CONTAMINATION
INCREMENTAL COST/(SAVINGS) TABLE BY CATEGORY
(PRESENT VALUE DOLLARS) 1, 2, 3, 4

Cost Category	Alternative	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Total
1. Prod. & Constr. cost (Cp)	P-II	$1,500,000	$460,728												$1,960,728
a. Manufacturing (Cpr)	P-II	$1,500,000	$72,273												$1,572,273
a-1. Initial cost (Cpri)	P-II	$1,500,000													$1,500,000
a-2. Testing (Cprt)	P-II	*	$14,455												$14,455
a-3. Transportation (Cprs)	P-II		$57,818												$57,818
b. Construction (Cpc)	P-II		$240,909												$240,909
c. Initial logistic (Cpl)	P-II		$147,546												$147,546
c-1. Int. spare parts (Cpls)	P-II		$138,703												$138,703
c-2. Inventory mgmt. (Cpli)	P-II		$964												$964
c-3. Data preparation (Cpld)	P-II		$5,879												$5,879
c-4. Initial training (Cplt)	P-II		$1,445												$1,445
c-5. Initial test eq. (Cplx)	P-II		$535												$535
2. Oper. & Maintenance (Co)	P-II		$378,995	$730,428	$703,869	$678,272	$653,609	$629,841	$606,935	$584,867	$563,599	$543,105	$523,353	$252,162	$6,849,035
a. Operational costs (Coo)	P-II		$256,054	$493,487	$475,543	$458,250	$441,588	$425,529	$410,054	$395,145	$380,775	$366,929	$353,586	$170,364	$4,627,304
a-1. Operator labor (Cool)	P-II		$29,959	$57,739	$55,639	$53,617	$51,667	$49,788	$47,977	$46,233	$44,551	$42,931	$41,370	$19,933	$541,404
a-2. Replacement training (Coop)	P-II		$327	$631	$609	$586	$565	$545	$524	$506	$487	$470	$452	$218	$5,920
a-3. Transportation (Coot)	P-II		$76,320	$147,089	$141,741	$136,586	$131,620	$126,833	$122,221	$117,777	$113,494	$109,367	$105,390	$50,779	$1,379,217
a-4. Rent (Coor)	P-II		$86,727	$167,147	$161,069	$155,212	$149,568	$144,129	$138,888	$133,838	$128,971	$124,281	$119,762	$57,703	$1,567,295
a-5. Utilities (Coou)	P-II		$62,721	$120,881	$116,485	$112,249	$108,168	$104,234	$100,444	$96,791	$93,272	$89,880	$86,612	$41,731	$1,133,468
b. Maintenance costs (Coa)	P-II		$122,941	$236,941	$228,326	$220,022	$212,021	$204,312	$196,881	$189,722	$182,824	$176,176	$169,767	$81,798	$2,221,731
b-1. Labor (Coam)	P-II		$31,869	$61,421	$59,188	$57,035	$54,961	$52,963	$51,037	$49,181	$47,392	$45,669	$44,008	$21,204	$575,928
b-2. Replacement training (Coap)	P-II		$327	$631	$609	$586	$565	$545	$524	$506	$487	$470	$452	$218	$5,920
b-3. Recurring spares (Coar)	P-II		$83,806	$161,517	$155,644	$149,984	$144,530	$139,274	$134,210	$129,329	$124,627	$120,095	$115,727	$55,760	$1,514,503
b-4. Tools (Coat)	P-II		$145	$279	$268	$259	$249	$240	$231	$223	$215	$207	$199	$96	$2,611
b-5. Transportation (Coat)	P-II		$5,493	$10,586	$10,201	$9,830	$9,473	$9,128	$8,796	$8,476	$8,168	$7,871	$7,585	$3,655	$99,262
b-6. Facility (Coaf)	P-II		$1,301	$2,507	$2,416	$2,328	$2,243	$2,162	$2,083	$2,007	$1,935	$1,864	$1,796	$865	$23,507
3. Disposal (Cd)	P-II													($64,115)	($64,115)
Cost total (C)	P-II	$1,500,000	$839,723	$730,428	$703,869	$678,272	$653,609	$629,841	$606,935	$584,867	$563,599	$543,105	$523,353	$188,047	$8,745,648
4. Metal income (Sa)	P-II		($453,037)	($1,309,688)	($1,262,063)	($1,216,169)	($1,171,945)	($1,129,329)	($1,088,262)	($1,048,689)	($1,010,555)	($973,808)	($938,396)	($452,136)	($12,054,077)
Grand total		$1,500,000	$386,686	($579,260)	($558,194)	($537,897)	($518,336)	($499,488)	($481,327)	($463,822)	($446,956)	($430,703)	($415,043)	($264,089)	($3,308,429)

1. For a module of 50 machines.
2. A discount rate of 10% was used; Present value dollars = Inflated dollars * $\frac{1}{(1+i)^n}$
3. Vary the quality of metal received; 131,967 lbs/yr @ 5% contamination.
   131,967 lbs/machine x 95% x $.225/lb x 50 machines = $1,410,397/module
4. Utilities would remain at their original levels.

Table F-10

SENSITIVITY ANALYSIS ALTERNATIVE P-II
VARY QUALITY OF METAL COLLECTED: 10% CONTAMINATION
INCREMENTAL COST/(SAVINGS) TABLE BY CATEGORY
(PRESENT VALUE DOLLARS) 1, 2, 3, 4

Cost Category	Alternative	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Total
1. Prod. & Constr. cost (Cp)	P-II	$1,500,000	$460,728												$1,960,728
a. Manufacturing (Cpr)	P-II	$1,500,000	$72,273												$1,572,273
a-1. Initial cost (Cpri)	P-II	$1,500,000													$1,500,000
a-2. Testing (Cprt)	P-II		$14,455												$14,455
a-3. Transportation (Cprs)	P-II		$57,818												$57,818
b. Construction (Cpc)	P-II		$240,909												$240,909
c. Initial logistic (Cpl)	P-II		$147,546												$147,546
c-1. Int. spare parts (Cpls)	P-II		$138,703												$138,703
c-2. Inventory mgmt. (Cpli)	P-II		$964												$964
c-3. Data preparation (Cpld)	P-II		$5,879												$5,879
c-4. Initial training (Cplt)	P-II		$1,445												$1,445
c-5. Initial test eq. (Cplx)	P-II		$555												$555
2. Oper. & Maintenance (Co)	P-II		$378,995	$730,428	$703,869	$678,272	$653,609	$629,841	$606,935	$584,867	$563,599	$543,105	$523,353	$252,162	$6,849,035
a. Operational costs (Coo)	P-II		$256,054	$493,487	$475,543	$458,250	$441,588	$425,529	$410,054	$395,145	$380,775	$366,929	$353,586	$170,384	$4,627,304
a-1. Operator labor (Cool)	P-II		$29,959	$57,739	$55,639	$53,617	$51,667	$49,788	$47,977	$46,233	$44,551	$42,931	$41,370	$19,933	$541,404
a-2. Replacement training (Coop)	P-II		$327	$631	$609	$586	$565	$545	$524	$506	$487	$470	$452	$218	$5,920
a-3. Transportation (Coot)	P-II		$76,320	$147,089	$141,741	$136,586	$131,620	$126,833	$122,221	$117,777	$113,494	$109,367	$105,390	$50,779	$1,379,217
a-4. Rent (Coor)	P-II		$86,727	$167,147	$161,069	$155,212	$149,568	$144,129	$138,888	$133,838	$128,971	$124,281	$119,762	$57,703	$1,567,295
a-5. Utilities (Coou)	P-II		$62,721	$120,881	$116,485	$112,249	$108,168	$104,234	$100,444	$96,791	$93,272	$89,880	$86,612	$41,731	$1,133,468
b. Maintenance costs (Coa)	P-II		$122,941	$236,941	$228,326	$220,022	$212,021	$204,312	$196,881	$189,722	$182,824	$176,176	$169,767	$81,798	$2,221,731
b-1. Labor (Coaa)	P-II		$31,849	$61,421	$59,188	$57,035	$54,961	$52,963	$51,037	$49,181	$47,392	$45,669	$44,008	$21,204	$575,928
b-2. Replacement training (Coap)	P-II		$327	$631	$609	$586	$565	$545	$524	$506	$487	$470	$452	$218	$5,920
b-3. Recurring spares (Coax)	P-II		$83,836	$161,517	$155,644	$149,984	$144,530	$139,274	$134,210	$129,329	$124,627	$120,095	$115,727	$55,760	$1,514,503
b-4. Tools (Coas)	P-II		$145	$279	$268	$259	$249	$240	$231	$223	$215	$207	$199	$96	$2,611
b-5. Transportation (Coat)	P-II		$5,493	$10,586	$10,201	$9,830	$9,473	$9,128	$8,796	$8,476	$8,168	$7,871	$7,585	$3,655	$99,262
b-6. Facility (Coaf)	P-II		$1,301	$2,507	$2,416	$2,328	$2,243	$2,162	$2,083	$2,007	$1,935	$1,864	$1,796	$865	$23,507
3. Disposal (Cd)	P-II													($64,115)	($64,115)
Cost total (C)	P-II	$1,500,000	$839,723	$730,428	$703,869	$678,272	$653,609	$629,841	$606,935	$584,867	$563,599	$543,105	$523,353	$188,047	$8,745,648
4. Metal income (Sm)	P-II		($429,193)	($1,240,757)	($1,195,639)	($1,152,161)	($1,110,264)	($1,069,891)	($1,030,986)	($993,495)	($957,368)	($922,555)	($889,007)	($428,340)	($11,419,656)
Grand total		$1,500,000	$410,530	($510,329)	($491,770)	($473,889)	($456,655)	($440,050)	($424,051)	($408,628)	($393,769)	($379,450)	($365,654)	($240,293)	($2,674,008)

1. For a module of 50 machines.
2. A discount rate of 10% was used; Present value dollars = Inflated dollars $\times \frac{1}{(1+i)^n}$
3. Vary the quality of metal received; 131,967 lbs/yr @ 10% contamination.
   131,967 lbs/machine x 90% x $.225/lb x 50 machines = $1,336,166/module
4. Utilities would remain at their original levels.

Table F-11

SENSITIVITY ANALYSIS ALTERNATIVE P-III
VARY QUALITY OF METAL COLLECTED: 5% CONTAMINATION
INCREMENTAL COST/(SAVINGS) TABLE BY CATEGORY
(PRESENT VALUE DOLLARS) 1, 2, 3, 4

Cost Category	Alternative	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Total
1. Prod. & Constr. cost (Cp)	P-III	$1,325,000	$392,627												$1,717,627
a. Manufacturing (Cpr)	P-III	$1,325,000	$72,273												$1,397,273
a-1. Initial cost (Cpri)	P-III	$1,325,000													$1,325,000
a-2. Testing (Cprt)	P-III		$14,455												$14,455
a-3. Transportation (Cprs)	P-III		$57,818												$57,818
b. Construction (Cpc)	P-III		$240,909												$240,909
c. Initial logistic (Cpl)	P-III		$79,445												$79,445
c-1. Int. spare parts (Cpls)	P-III		$70,602												$70,602
c-2. Inventory mgmt. (Cpli)	P-III		$964												$964
c-3. Data preparation (Cpld)	P-III		$5,879												$5,879
c-4. Initial training (Cplt)	P-III		$1,445												$1,445
c-5. Initial test eq. (Cplx)	P-III		$535												$535
2. Oper. & Maintenance (Co)	P-III		$363,945	$701,423	$675,917	$651,338	$627,655	$604,830	$582,835	$561,645	$541,220	$521,538	$502,572	$242,148	$6,577,066
a. Operational costs (Coo)	P-III		$273,995	$528,064	$508,863	$490,358	$472,528	$455,345	$438,786	$422,832	$407,455	$392,638	$378,360	$182,301	$4,951,525
a-1. Operator labor (Cool)	P-III		$29,959	$57,739	$55,640	$53,616	$51,667	$49,788	$47,977	$46,233	$44,552	$42,931	$41,370	$19,933	$541,405
a-2. Replacement training (Coop)	P-III		$327	$631	$608	$586	$565	$544	$525	$506	$487	$470	$452	$218	$5,919
a-3. Transportation (Coot)	P-III		$76,320	$147,089	$141,741	$136,587	$131,620	$126,834	$122,221	$117,777	$113,494	$109,367	$105,390	$50,779	$1,379,219
a-4. Rent (Coor)	P-III		$86,727	$167,147	$161,069	$155,212	$149,568	$144,129	$138,888	$133,838	$128,971	$124,281	$119,762	$57,703	$1,567,295
a-5. Utilities (Coou)	P-III		$80,662	$155,458	$149,805	$144,357	$139,108	$134,050	$129,175	$124,478	$119,951	$115,589	$111,386	$53,668	$1,457,687
b. Maintenance costs (Com)	P-III		$89,950	$173,359	$167,054	$160,980	$155,127	$149,485	$144,049	$138,813	$133,765	$128,900	$124,212	$59,847	$1,625,541
b-1. Labor (Coma)	P-III		$32,929	$63,464	$61,156	$58,932	$56,789	$54,724	$52,734	$50,817	$48,969	$47,188	$45,472	$21,909	$595,083
b-2. Replacement training (Comp)	P-III		$327	$631	$608	$586	$565	$544	$525	$506	$487	$470	$452	$218	$5,919
b-3. Recurring spares (Comx)	P-III		$49,755	$95,892	$92,405	$89,045	$85,807	$82,687	$79,680	$76,783	$73,991	$71,300	$68,707	$33,104	$899,156
b-4. Tools (Coms)	P-III		$145	$279	$268	$259	$249	$240	$231	$223	$215	$207	$200	$96	$2,612
b-5. Transportation (Comt)	P-III		$5,493	$10,586	$10,201	$9,830	$9,473	$9,128	$8,796	$8,476	$8,168	$7,871	$7,585	$3,655	$99,262
b-6. Facility (Comf)	P-III		$1,301	$2,507	$2,416	$2,328	$2,244	$2,162	$2,083	$2,008	$1,935	$1,864	$1,796	$865	$23,509
3. Disposal (Cd)	P-III													($48,086)	($48,086)
Cost total (C)	P-III	$1,325,000	$756,572	$701,423	$675,917	$651,338	$627,655	$604,830	$582,835	$561,645	$541,220	$521,538	$502,572	$194,062	$8,246,607
4. Metal income (Bm)	P-III		($352,276)	($1,018,399)	($981,366)	($945,680)	($911,291)	($878,154)	($846,221)	($815,449)	($785,796)	($757,222)	($729,687)	($331,576)	($9,373,117)
Grand total		$1,325,000	$404,296	($316,976)	($305,449)	($294,342)	($283,636)	($273,324)	($263,386)	($253,804)	($244,576)	($235,684)	($227,115)	($157,514)	($1,126,510)

1. For a module of 50 machines.
2. A discount rate of 10% was used; Present value dollars = Inflated dollars $\times \frac{1}{(1+i)^n}$
3. Vary the quality of metal received; 102,616 lbs/yr @ 5% contamination.
   102,616 lbs/machine x 95% x $.225/lb x 50 machines = $1,096,709/module
4. Utilities would remain at their original levels.

Table F-12

SENSITIVITY ANALYSIS ALTERNATIVE P-III
VARY QUALITY OF METAL COLLECTED: 10% CONTAMINATION
INCREMENTAL COST/(SAVINGS) TABLE BY CATEGORY
(PRESENT VALUE DOLLARS) 1, 2, 3, 4

Cost Category	Alternative	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Total
1. Prod. & Constr. cost (Cp)	P-III	$1,325,000	$392,627												$1,717,627
a. Manufacturing (Cpr)	P-III	$1,325,000	$72,273												$1,397,273
a-1. Initial cost (Cpri)	P-III	$1,325,000													$1,325,000
a-2. Testing (Cprt)	P-III		$14,455												$14,455
a-3. Transportation (Cprs)	P-III		$57,818												$57,818
b. Construction (Cpc)	P-III		$240,909												$240,909
c. Initial logistic (Cpl)	P-III		$79,445												$79,445
c-1. Int. spare parts (Cpls)	P-III		$70,602												$70,602
c-2. Inventory mgmt. (Cpli)	P-III		$964												$964
c-3. Data preparation (Cpld)	P-III		$5,879												$5,879
c-4. Initial training (Cplt)	P-III		$1,445												$1,445
c-5. Initial test eq. (Cplx)	P-III		$555												$555
2. Oper. & Maintenance (Co)	P-III		$363,945	$701,423	$675,917	$651,338	$627,655	$604,830	$582,835	$561,645	$541,220	$521,538	$502,572	$242,148	$6,577,066
a. Operational costs (Coo)	P-III		$273,995	$528,064	$508,863	$490,358	$472,528	$455,345	$438,786	$422,832	$407,455	$392,638	$378,360	$182,301	$4,951,525
a-1. Operator labor (Cool)	P-III		$29,959	$57,739	$55,640	$53,616	$51,667	$49,788	$47,977	$46,233	$44,552	$42,931	$41,370	$19,933	$541,405
a-2. Replacement training (Coop)	P-III		$327	$631	$608	$586	$565	$544	$525	$506	$487	$470	$452	$218	$5,919
a-3. Transportation (Coot)	P-III		$76,320	$147,089	$141,741	$136,587	$131,620	$126,834	$122,221	$117,777	$113,494	$109,367	$105,390	$50,779	$1,379,219
a-4. Rent (Coor)	P-III		$86,727	$167,147	$161,069	$155,212	$149,568	$144,129	$138,888	$133,838	$128,971	$124,281	$119,762	$57,703	$1,567,295
a-5. Utilities (Coou)	P-III		$80,662	$155,458	$149,805	$144,357	$139,108	$134,050	$129,175	$124,478	$119,951	$115,589	$111,386	$53,668	$1,457,687
b. Maintenance costs (Com)	P-III		$89,950	$173,359	$167,054	$160,980	$155,127	$149,485	$144,049	$138,813	$133,765	$128,900	$124,212	$59,847	$1,625,541
b-1. Labor (Coml)	P-III		$32,929	$63,464	$61,156	$58,932	$56,789	$54,724	$52,734	$50,817	$48,969	$47,188	$45,472	$21,909	$595,083
b-2. Replacement training (Comp)	P-III		$327	$631	$608	$586	$565	$544	$525	$506	$487	$470	$452	$218	$5,919
b-3. Recurring spares (Coms)	P-III		$49,755	$95,892	$92,405	$89,045	$85,807	$82,687	$79,680	$76,783	$73,991	$71,300	$68,707	$33,104	$899,156
b-4. Tools (Comt)	P-III		$145	$279	$268	$259	$249	$240	$231	$223	$215	$207	$200	$96	$2,612
b-5. Transportation (Comt)	P-III		$5,493	$10,586	$10,201	$9,830	$9,473	$9,128	$8,796	$8,476	$8,168	$7,871	$7,585	$3,655	$99,262
b-6. Facility (Comf)	P-III		$1,301	$2,507	$2,416	$2,328	$2,244	$2,162	$2,083	$2,008	$1,935	$1,864	$1,796	$865	$23,509
3. Disposal (Cd)	P-III													($48,086)	($48,086)
Cost total (C)	P-III	$1,325,000	$756,572	$701,423	$675,917	$651,338	$627,655	$604,830	$582,835	$561,645	$541,220	$521,538	$502,572	$194,062	$8,246,607
4. Metal income (Sm)	P-III		($333,735)	($964,798)	($929,715)	($895,907)	($863,328)	($831,935)	($801,682)	($772,530)	($744,438)	($717,368)	($691,282)	($333,072)	($8,879,790)
Grand total		$1,325,000	$422,837	($263,375)	($253,798)	($244,569)	($235,673)	($227,105)	($218,847)	($210,885)	($203,218)	($195,830)	($188,710)	($139,010)	($633,183)

1. For a module of 50 machines.
2. A discount rate of 10% was used; Present value dollars = Inflated dollars * $\frac{1}{(1+i)^n}$
3. Vary the quality of metal received; 102,616 lbs/yr @ 5% contamination.
   102,616 lbs/machine x 90% x $.225/lb x 50 machines = $1,038,987/module
4. Utilities would remain at their original levels.

Table F-13

SENSITIVITY ANALYSIS ALTERNATIVE PP
VARY QUANTITY & QUALITY OF METAL COLLECTED: 102,616 LBS/YR @ 5% CONTAMINATION
INCREMENTAL COST/(SAVINGS) TABLE BY CATEGORY
(PRESENT VALUE DOLLARS) 1, 2, 3, 4

Cost Category	Alternative	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Total
1. Prod. & Constr. cost (Cp)	PP	$875,000	$322,405							$706,365					$1,903,770
a. Manufacturing (Cpr)	PP	$875,000	$72,273							$706,365					$1,653,638
a-1. Initial cost (Cpri)	PP	$875,000								$650,599					$1,525,599
a-2. Testing (Cprt)	PP		$14,455							$11,153					$25,608
a-3. Transportation (Cprs)	PP		$57,818							$44,613					$102,431
b. Construction (Cpc)	PP		$192,727												$192,727
c. Initial logistic (Cpl)	PP		$57,405												$57,405
c-1. Int. spare parts (Cpls)	PP		$55,405												$55,405
c-2. Inventory mgmt. (Cpli)	PP		$0												$0
c-3. Data preparation (Cpld)	PP		$0												$0
c-4. Initial training (Cplt)	PP		$1,445												$1,445
c-5. Initial test eq. (Cplx)	PP		$555												$555
2. Oper. & Maintenance (Co)	PP		$347,846	$670,397	$646,021	$622,529	$599,892	$578,078	$557,053	$536,800	$517,278	$498,469	$480,342	$231,437	$6,286,140
a. Operational costs (Coo)	PP		$266,766	$514,133	$495,439	$477,423	$460,063	$443,333	$427,210	$411,677	$396,705	$382,280	$368,379	$177,491	$4,820,897
a-1. Operator labor (Cool)	PP		$29,959	$57,739	$55,639	$53,617	$51,667	$49,788	$47,977	$46,233	$44,551	$42,931	$41,370	$19,933	$541,404
a-2. Replacement training (Coop)	PP		$327	$631	$609	$586	$565	$545	$524	$506	$487	$470	$452	$218	$5,920
a-3. Transportation (Coot)	PP		$76,320	$147,089	$141,741	$136,586	$131,620	$126,833	$122,221	$117,777	$113,494	$109,367	$105,390	$50,779	$1,379,217
a-4. Rent (Coor)	PP		$86,727	$167,147	$161,069	$155,212	$149,568	$144,129	$138,888	$133,838	$128,971	$124,281	$119,762	$57,703	$1,567,295
a-5. Utilities (Coou)	PP		$73,433	$141,527	$136,381	$131,422	$126,643	$122,038	$117,600	$113,323	$109,202	$105,231	$101,405	$48,858	$1,327,061
b. Maintenance costs (Com)	PP		$81,080	$156,264	$150,582	$145,106	$139,829	$134,745	$129,843	$125,123	$120,573	$116,189	$111,963	$53,946	$1,465,243
b-1. Labor (Coml)	PP		$31,657	$61,012	$58,794	$56,656	$54,596	$52,610	$50,697	$48,854	$47,077	$45,365	$43,716	$21,063	$572,097
b-2. Replacement training (Comp)	PP		$327	$631	$609	$586	$565	$545	$524	$506	$487	$470	$452	$218	$5,920
b-3. Recurring spares (Comr)	PP		$42,157	$81,249	$78,294	$75,447	$72,703	$70,060	$67,512	$65,057	$62,691	$60,412	$58,215	$28,049	$761,846
b-4. Tools (Comt)	PP		$145	$279	$268	$259	$249	$240	$231	$223	$215	$207	$199	$96	$2,611
b-5. Transportation (Comt)	PP		$5,493	$10,586	$10,201	$9,830	$9,473	$9,128	$8,796	$8,476	$8,168	$7,871	$7,585	$3,655	$99,262
b-6. Facility (Comf)	PP		$1,301	$2,507	$2,416	$2,328	$2,243	$2,162	$2,083	$2,007	$1,935	$1,864	$1,796	$865	$23,307
3. Disposal (Cd)	PP									($37,177)				($302,301)	($339,478)
Cost total (C)	PP	$875,000	$670,251	$670,397	$646,021	$622,529	$599,892	$578,078	$557,053	$1,205,988	$517,278	$498,469	$480,342	($70,864)	$7,850,432
4. Metal income (Sm)	PP		($352,276)	($1,018,399)	($981,366)	($945,680)	($911,291)	($878,154)	($846,221)	($815,449)	($785,796)	($757,222)	($729,687)	($351,576)	($9,373,117)
Grand total		$875,000	$317,975	($348,002)	($335,345)	($323,151)	($311,399)	($300,076)	($289,168)	$390,539	($268,518)	($258,753)	($249,345)	($422,440)	($1,522,685)

1. For a module of 50 machines.
2. A discount rate of 10% was used; Present value dollars = Inflated dollars * $\frac{1}{(1+i)^n}$
3. Vary the quantity of metal received; 102,616 lbs/yr @ 5% contamination.
   102,616 lbs/machine x 95% x $.225/lb x 50 machines = $1,096,709/module
4. Utility multiplier = 1 + (102,616 - 90,894)/90,894 = 1.129

Table F-14

SENSITIVITY ANALYSIS ALTERNATIVE PP
VARY QUANTITY & QUALITY OF METAL COLLECTED: 131,967 LBS/YR @ 1% CONTAMINATION
INCREMENTAL COST/(SAVINGS) TABLE BY CATEGORY
(PRESENT VALUE DOLLARS) 1, 2, 3, 4

Cost Category	Alternative	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Total
1. Prod. & Constr. cost (Cp)	PP	$875,000	$322,405							$706,365					$1,903,770
a. Manufacturing (Cpr)	PP	$875,000	$72,273							$706,365					$1,653,638
a-1. Initial cost (Cpri)	PP	$875,000								$650,599					$1,525,599
a-2. Testing (Cprt)	PP		$14,455							$11,153					$25,608
a-3. Transportation (Cprs)	PP		$57,818							$44,613					$102,431
b. Construction (Cpc)	PP		$192,727												$192,727
c. Initial logistic (Cpl)	PP		$57,405												$57,405
c-1. Int. spare parts (Cpls)	PP		$55,405												$55,405
c-2. Inventory mgmt. (Cpli)	PP		$0												$0
c-3. Data preparation (Cpld)	PP		$0												$0
c-4. Initial training (Cplt)	PP		$1,445												$1,445
c-5. Initial test eq. (Cplx)	PP		$555												$555
2. Oper. & Maintenance (Co)	PP		$368,850	$710,877	$685,030	$660,119	$636,115	$612,984	$590,689	$569,214	$548,513	$528,568	$509,346	$245,412	$6,665,717
a. Operational costs (Coo)	PP		$287,770	$554,613	$534,448	$515,013	$496,286	$478,239	$460,846	$444,091	$427,940	$412,379	$397,383	$191,466	$5,200,474
a-1. Operator labor (Cool)	PP		$29,959	$57,739	$55,639	$53,617	$51,667	$49,788	$47,977	$46,233	$44,551	$42,931	$41,370	$19,933	$541,404
a-2. Replacement training (Coop)	PP		$327	$631	$609	$586	$565	$545	$524	$506	$487	$470	$452	$218	$5,920
a-3. Transportation (Coot)	PP		$76,320	$147,089	$141,741	$136,586	$131,620	$126,833	$122,221	$117,777	$113,494	$109,367	$105,390	$50,779	$1,379,217
a-4. Rent (Coor)	PP		$86,727	$167,147	$161,069	$155,212	$149,568	$144,129	$138,888	$133,838	$128,971	$124,281	$119,762	$57,703	$1,567,295
a-5. Utilities (Coou)	PP		$94,437	$182,007	$175,390	$169,012	$162,866	$156,944	$151,236	$145,737	$140,437	$135,330	$130,409	$62,833	$1,706,638
b. Maintenance costs (Com)	PP		$81,080	$156,264	$150,582	$145,106	$139,829	$134,745	$129,843	$125,123	$120,573	$116,189	$111,963	$53,946	$1,465,243
b-1. Labor (Coma)	PP		$31,657	$61,012	$58,794	$56,656	$54,596	$52,610	$50,697	$48,854	$47,077	$45,365	$43,716	$21,063	$572,097
b-2. Replacement training (Comp)	PP		$327	$631	$609	$586	$565	$545	$524	$506	$487	$470	$452	$218	$5,920
b-3. Recurring spares (Comx)	PP		$42,157	$81,249	$78,294	$75,447	$72,703	$70,060	$67,512	$65,057	$62,691	$60,412	$58,215	$28,049	$761,846
b-4. Tools (Coms)	PP		$145	$279	$268	$259	$249	$240	$231	$223	$215	$207	$199	$96	$2,611
b-5. Transportation (Comt)	PP		$5,493	$10,586	$10,201	$9,830	$9,473	$9,128	$8,796	$8,476	$8,168	$7,871	$7,585	$3,655	$99,262
b-6. Facility (Comf)	PP		$1,301	$2,507	$2,416	$2,328	$2,243	$2,162	$2,083	$2,007	$1,935	$1,864	$1,796	$865	$23,507
3. Disposal (Cd)	PP									($37,177)				($302,301)	($339,478)
Cost total (C)	PP	$875,000	$691,255	$710,877	$685,030	$660,119	$636,115	$612,984	$590,689	$1,238,402	$548,513	$528,568	$509,346	($56,889)	$8,230,009
4. Metal income (Sa)	PP		($472,112)	($1,364,832)	($1,315,202)	($1,267,376)	($1,221,290)	($1,176,880)	($1,134,084)	($1,092,844)	($1,053,105)	($1,014,810)	($977,908)	($471,174)	($12,561,617)
Grand total		$875,000	$219,143	($653,955)	($630,172)	($607,257)	($585,175)	($563,896)	($543,395)	$145,558	($504,592)	($486,242)	($468,562)	($528,063)	($4,331,608)

1. For a module of 50 machines.
2. A discount rate of 10% was used; Present value dollars = Inflated dollars * $\frac{1}{(1+i)^n}$
3. Vary the quality of metal received; 131,967 lbs/yr @ 1% contamination.
   131,967 lbs/machine x 99% x $.225/lb x 50 machines = $1,469,782/module
4. Utility multiplier = 1 + (131,967 - 90,894)/90,894 = 1.452

Table F-15

SENSITIVITY ANALYSIS ALTERNATIVE P-II
VARY QUANTITY & QUALITY OF METAL COLLECTED: 90,894 LBS/YR @ 10% CONTAMINATION
INCREMENTAL COST/(SAVINGS) TABLE BY CATEGORY
(PRESENT VALUE DOLLARS) 1, 2, 3, 4

Cost Category	Alternative	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Total
1. Prod. & Constr. cost (Cp)	P-II	$1,500,000	$460,728												$1,960,728
a. Manufacturing (Cpr)	P-II	$1,500,000	$72,273												$1,572,273
a-1. Initial cost (Cpri)	P-II	$1,500,000													$1,500,000
a-2. Testing (Cprt)	P-II		$14,455												$14,455
a-3. Transportation (Cprs)	P-II		$57,818												$57,818
b. Construction (Cpc)	P-II		$240,909												$240,909
c. Initial logistic (Cpl)	P-II		$147,546												$147,546
c-1. Int. spare parts (Cpls)	P-II		$138,703												$138,703
c-2. Inventory mgmt. (Cpli)	P-II		$964												$964
c-3. Data preparation (Cpld)	P-II		$5,879												$5,879
c-4. Initial training (Cplt)	P-II		$1,445												$1,445
c-5. Initial test eq. (Cplx)	P-II		$555												$555
2. Oper. & Maintenance (Co)	P-II		$359,474	$692,805	$667,615	$643,336	$619,943	$597,400	$575,673	$554,742	$534,569	$515,131	$496,396	$239,174	$6,496,258
a. Operational costs (Coo)	P-II		$236,533	$455,864	$439,289	$423,314	$407,922	$393,088	$378,792	$365,020	$351,745	$338,955	$326,629	$157,376	$4,274,527
a-1. Operator labor (Cool)	P-II		$29,959	$57,739	$55,639	$53,617	$51,667	$49,788	$47,977	$46,233	$44,551	$42,931	$41,370	$19,933	$541,404
a-2. Replacement training (Coop)	P-II		$327	$631	$609	$586	$565	$545	$524	$506	$487	$470	$452	$218	$5,920
a-3. Transportation (Coot)	P-II		$76,320	$147,089	$141,741	$136,586	$131,620	$126,833	$122,221	$117,777	$113,494	$109,367	$105,390	$50,779	$1,379,217
a-4. Rent (Coor)	P-II		$86,727	$167,147	$161,069	$155,212	$149,568	$144,129	$138,888	$133,838	$128,971	$124,281	$119,762	$57,703	$1,567,295
a-5. Utilities (Coou)	P-II		$43,200	$83,258	$80,231	$77,313	$74,502	$71,793	$69,182	$66,666	$64,242	$61,906	$59,655	$28,743	$780,691
b. Maintenance costs (Com)	P-II		$122,941	$236,941	$228,326	$220,022	$212,021	$204,312	$196,881	$189,722	$182,824	$176,176	$169,767	$81,798	$2,221,731
b-1. Labor (Coma)	P-II		$31,869	$61,421	$59,188	$57,035	$54,961	$52,963	$51,037	$49,181	$47,392	$45,669	$44,008	$21,204	$575,928
b-2. Replacement training (Comp)	P-II		$327	$631	$609	$586	$565	$545	$524	$506	$487	$470	$452	$218	$5,920
b-3. Recurring spares (Comx)	P-II		$83,506	$161,517	$155,644	$149,984	$144,530	$139,274	$134,210	$129,329	$124,627	$120,095	$115,727	$55,760	$1,514,503
b-4. Tools (Coms)	P-II		$145	$279	$268	$259	$249	$240	$231	$223	$215	$207	$199	$96	$2,611
b-5. Transportation (Comt)	P-II		$5,493	$10,586	$10,201	$9,830	$9,473	$9,128	$8,796	$8,476	$8,168	$7,871	$7,585	$3,655	$99,262
b-6. Facility (Comf)	P-II		$1,301	$2,507	$2,416	$2,328	$2,243	$2,162	$2,083	$2,007	$1,935	$1,864	$1,796	$865	$23,507
3. Disposal (Cd)	P-II													($64,115)	($64,115)
Cost total (C)	P-II	$1,500,000	$820,202	$692,805	$667,615	$643,336	$619,943	$597,400	$575,673	$554,742	$534,569	$515,131	$496,396	$175,059	$8,392,871
4. Metal income (Sa)	P-II		($295,612)	($854,588)	($823,512)	($793,566)	($764,709)	($736,902)	($710,105)	($684,283)	($659,400)	($635,422)	($612,316)	($295,025)	($7,865,440)
Grand total		$1,500,000	$524,590	($161,783)	($155,897)	($150,230)	($144,766)	($139,502)	($134,432)	($129,541)	($124,831)	($120,291)	($115,920)	($119,966)	$527,431

1. For a module of 50 machines.
2. A discount rate of 10% was used; Present value dollars = Inflated dollars * $\frac{1}{(1+i)^n}$
3. Vary the quantity of metal received; 90,894 lbs/yr @ 10% contamination.
   90,894 lbs/machine x 90% x $.225/lb x 50 machines = $920,302/module
4. Utility multiplier = 90,894/131,967 = .689

Table F-16

SENSITIVITY ANALYSIS ALTERNATIVE P-II
VARY QUANTITY & QUALITY OF METAL COLLECTED: 102,616 LBS/YR @ 5% CONTAMINATION
INCREMENTAL COST/(SAVINGS) TABLE BY CATEGORY
(PRESENT VALUE DOLLARS) 1, 2, 3, 4

Cost Category	Alternative	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Total
1. Prod. & Constr. cost (Cp)	P-II	$1,500,000	$460,728												$1,960,728
a. Manufacturing (Cpr)	P-II	$1,500,000	$72,273												$1,572,273
a-1. Initial cost (Cpri)	P-II	$1,500,000													$1,500,000
a-2. Testing (Cprt)	P-II		$14,455												$14,455
a-3. Transportation (Cprs)	P-II		$57,818												$57,818
b. Construction (Cpc)	P-II		$240,909												$240,909
c. Initial logistic (Cpl)	P-II		$147,546												$147,546
c-1. Int. spare parts (Cpls)	P-II		$138,703												$138,703
c-2. Inventory mgmt. (Cpli)	P-II		$964												$964
c-3. Data preparation (Cpld)	P-II		$5,879												$5,879
c-4. Initial training (Cplt)	P-II		$1,445												$1,445
c-5. Initial test eq. (Cplx)	P-II		$555												$555
2. Oper. & Maintenance (Co)	P-II		$365,645	$703,543	$677,961	$653,307	$629,551	$606,658	$584,595	$563,340	$542,854	$523,115	$504,089	$242,881	$6,596,938
a. Operational costs (Coo)	P-II		$242,104	$466,602	$449,635	$433,285	$417,530	$402,346	$387,714	$373,618	$360,030	$346,939	$334,322	$161,083	$4,375,207
a-1. Operator labor (Cool)	P-II		$29,959	$57,739	$55,639	$53,617	$51,667	$49,788	$47,977	$46,233	$44,551	$42,931	$41,370	$19,933	$541,404
a-2. Replacement training (Coop)	P-II		$327	$631	$609	$586	$565	$545	$524	$506	$487	$470	$452	$218	$5,920
a-3. Transportation (Coot)	P-II		$76,310	$147,089	$141,741	$136,586	$131,620	$126,833	$122,221	$117,777	$113,494	$109,367	$105,390	$50,779	$1,379,217
a-4. Rent (Coor)	P-II		$86,727	$167,147	$161,069	$155,212	$149,568	$144,129	$138,888	$133,838	$128,971	$124,281	$119,762	$57,703	$1,567,295
a-5. Utilities (Coou)	P-II		$48,771	$93,996	$90,577	$87,284	$84,110	$81,051	$78,104	$75,264	$72,527	$69,890	$67,348	$32,450	$881,371
b. Maintenance costs (Com)	P-II		$122,541	$236,941	$228,326	$220,022	$212,021	$204,312	$196,881	$189,722	$182,824	$176,176	$169,767	$81,798	$2,221,731
b-1. Labor (Coml)	P-II		$31,569	$61,421	$59,188	$57,035	$54,961	$52,963	$51,037	$49,181	$47,392	$45,669	$44,008	$21,204	$575,928
b-2. Replacement training (Comp)	P-II		$327	$631	$609	$586	$565	$545	$524	$506	$487	$470	$452	$218	$5,920
b-3. Recurring spares (Comx)	P-II		$81,536	$161,517	$155,644	$149,984	$144,530	$139,274	$134,210	$129,329	$124,627	$120,095	$115,727	$55,760	$1,514,503
b-4. Tools (Coms)	P-II		$145	$279	$268	$259	$249	$240	$231	$223	$215	$207	$199	$96	$2,611
b-5. Transportation (Comt)	P-II		$5,493	$10,586	$10,201	$9,830	$9,473	$9,128	$8,796	$8,476	$8,168	$7,871	$7,585	$3,655	$99,262
b-6. Facility (Comf)	P-II		$1,331	$2,507	$2,416	$2,328	$2,243	$2,162	$2,083	$2,007	$1,935	$1,864	$1,796	$865	$23,507
3. Disposal (Cd)	P-II													($64,115)	($64,115)
Cost total (C)	P-II	$1,500,000	$825,773	$703,543	$677,961	$653,307	$629,551	$606,658	$584,595	$563,340	$542,854	$523,115	$504,089	$178,766	$8,493,551
4. Metal income (Sa)	P-II		($352,276)	($1,018,399)	($981,366)	($945,680)	($911,291)	($878,154)	($846,221)	($815,449)	($785,796)	($757,222)	($729,687)	($351,576)	($9,373,117)
Grand total		$1,500,000	$473,497	($314,856)	($303,405)	($292,373)	($281,740)	($271,496)	($261,626)	($252,109)	($242,942)	($234,107)	($225,598)	($172,810)	($879,566)

1. For a module of 50 machines.
2. A discount rate of 10% was used; Present value dollars = Inflated dollars $\times \frac{1}{(1+i)^n}$
3. Vary the quality of metal received; 102,616 lbs/yr @ 5% contamination.
   102,616 lbs/machine x 95% x $.225/lb x 50 machines = $1,096,709 module
4. Utility multiplier = 102,616/131,967 = .778

Table F-17

SENSITIVITY ANALYSIS ALTERNATIVE P-III
VARY QUANTITY & QUALITY OF METAL COLLECTED: 90,894 LBS/YR @ 10% CONTAMINATION
INCREMENTAL COST/(SAVINGS) TABLE BY CATEGORY
(PRESENT VALUE DOLLARS) 1, 2, 3, 4

Cost Category	Alternative	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Total
1. Prod. & Constr. cost (Cp)	P-III	$1,325,000	$392,627												$1,717,627
a. Manufacturing (Cpr)	P-III	$1,325,000	$72,273												$1,397,273
a-1. Initial cost (Cpri)	P-III	$1,325,000													$1,325,000
a-2. Testing (Cprt)	P-III		$14,455												$14,455
a-3. Transportation (Cprs)	P-III		$57,818												$57,818
b. Construction (Cpc)	P-III		$240,909												$240,909
c. Initial logistic (Cpl)	P-III		$79,445												$79,445
c-1. Int. spare parts (Cpls)	P-III		$70,602												$70,602
c-2. Inventory mgmt. (Cpli)	P-III		$964												$964
c-3. Data preparation (Cpld)	P-III		$5,879												$5,879
c-4. Initial training (Cplt)	P-III		$1,445												$1,445
c-5. Initial test eq. (Cplx)	P-III		$555												$555
2. Oper. & Maintenance (Co)	P-III		$728,840	$653,039	$629,292	$606,409	$584,359	$563,109	$542,631	$522,903	$503,887	$485,562	$467,905	$225,445	$6,123,380
a. Operational costs (Coo)	P-III		$548,890	$479,680	$462,238	$445,429	$429,232	$413,624	$398,582	$384,090	$370,122	$356,662	$343,693	$165,598	$4,497,839
a-1. Operator labor (Cool)	P-III		$59,959	$57,739	$55,640	$53,616	$51,667	$49,788	$47,977	$46,233	$44,552	$42,931	$41,370	$19,933	$541,405
a-2. Replacement training (Coop)	P-III		$327	$631	$608	$586	$565	$544	$525	$506	$487	$470	$452	$218	$5,919
a-3. Transportation (Coot)	P-III		$76,320	$147,089	$141,741	$136,587	$131,620	$126,834	$122,221	$117,777	$113,494	$109,367	$105,390	$50,779	$1,379,219
a-4. Rent (Coor)	P-III		$86,727	$167,147	$161,069	$155,212	$149,568	$144,129	$138,888	$133,838	$128,971	$124,281	$119,762	$57,703	$1,567,295
a-5. Utilities (Coou)	P-III		$55,557	$107,074	$103,180	$99,428	$95,812	$92,329	$88,971	$85,736	$82,618	$79,613	$76,719	$36,965	$1,004,001
b. Maintenance costs (Com)	P-III		$89,950	$173,359	$167,054	$160,980	$155,127	$149,485	$144,049	$138,813	$133,765	$128,900	$124,212	$59,847	$1,625,541
b-1. Labor (Coml)	P-III		$30,929	$63,464	$61,156	$58,932	$56,789	$54,724	$52,734	$50,817	$48,969	$47,188	$45,472	$21,909	$595,083
b-2. Replacement training (Comp)	P-III		$327	$631	$608	$586	$565	$544	$525	$506	$487	$470	$452	$218	$5,919
b-3. Recurring spares (Coms)	P-III		$49,755	$95,892	$92,405	$89,045	$85,807	$82,687	$79,680	$76,783	$73,991	$71,300	$68,707	$33,104	$899,156
b-4. Tools (Comt)	P-III		$145	$279	$268	$259	$249	$240	$231	$223	$215	$207	$200	$96	$2,612
b-5. Transportation (Com)	P-III		$5,493	$10,586	$10,201	$9,830	$9,473	$9,128	$8,796	$8,476	$8,168	$7,871	$7,585	$3,655	$99,262
b-6. Facility (Comf)	P-III		$1,301	$2,507	$2,416	$2,328	$2,244	$2,162	$2,083	$2,008	$1,935	$1,864	$1,796	$865	$23,509
3. Disposal (Cd)	P-III													($48,086)	($48,086)
Cost total (C)	P-III	$1,325,000	$721,467	$653,039	$629,292	$606,409	$584,359	$563,109	$542,631	$522,903	$503,887	$485,562	$467,905	$177,359	$7,792,921
4. Metal income (Sm)	P-III		($295,612)	($854,588)	($823,512)	($793,566)	($764,709)	($736,902)	($710,105)	($684,283)	($659,400)	($635,422)	($612,316)	($295,025)	($7,865,440)
Grand total		$1,325,000	$425,855	($201,549)	($194,220)	($187,157)	($180,350)	($173,793)	($167,474)	($161,380)	($155,513)	($149,860)	($144,411)	($117,666)	($72,519)

1. For a module of 50 machines.
2. A discount rate of 10% was used; Present value dollars = Initiated dollars * $\frac{1}{(1+i)^n}$
3. Vary the quantity of metal received; 90,894 lbs/yr @ 10% contamination.
   90,894 lbs/machine x 90% x $.225/lb x 50 machines = $920,000 module
4. Utility multiplier = 90,894/131,967 = .689

Table F-18

SENSITIVITY ANALYSIS ALTERNATIVE P-III
VARY QUANTITY & QUALITY OF METAL COLLECTED: 102,616 LBS/YR @ 5% CONTAMINATION
INCREMENTAL COST/(SAVINGS) TABLE BY CATEGORY
(PRESENT VALUE DOLLARS) 1, 2, 3, 4

Cost Category	Alternative	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Total
1. Prod. & Constr. cost (Cp)	P-III	$1,325,000	$392,627												$1,717,627
a. Manufacturing (Cpr)	P-III	$1,325,000	$72,273												$1,397,273
a-1. Initial cost (Cpri)	P-III	$1,325,000													$1,325,000
a-2. Testing (Cprt)	P-III		$14,455												$14,455
a-3. Transportation (Cprs)	P-III		$57,818												$57,818
b. Construction (Cpc)	P-III		$240,909												$240,909
c. Initial logistic (Cpl)	P-III		$79,445												$79,445
c-1. Int. spare parts (Cpls)	P-III		$70,602												$70,602
c-2. Inventory mgmt. (Cpli)	P-III		$964												$964
c-3. Data preparation (Cpld)	P-III		$5,879												$5,879
c-4. Initial training (Cplt)	P-III		$1,445												$1,445
c-5. Initial test eq. (Cplx)	P-III		$555												$555
2. Oper. & Maintenance (Co)	P-III		$383,945	$701,423	$675,917	$651,338	$627,655	$604,830	$582,835	$561,645	$541,220	$521,538	$502,572	$242,148	$6,577,066
a. Operational costs (Coo)	P-III		$273,995	$528,064	$508,863	$490,358	$472,528	$455,345	$438,786	$422,832	$407,455	$392,638	$378,360	$182,301	$4,951,525
a-1. Operator labor (Cool)	P-III		$29,959	$57,739	$55,640	$53,616	$51,667	$49,788	$47,977	$46,233	$44,552	$42,931	$41,370	$19,933	$541,405
a-2. Replacement training (Coop)	P-III		$327	$631	$608	$586	$565	$544	$525	$506	$487	$470	$452	$218	$5,919
a-3. Transportation (Coot)	P-III		$76,320	$147,089	$141,741	$136,587	$131,620	$126,834	$122,221	$117,777	$113,494	$109,367	$105,390	$50,779	$1,379,219
a-4. Rent (Coor)	P-III		$86,727	$167,147	$161,069	$155,212	$149,568	$144,129	$138,888	$133,838	$128,971	$124,281	$119,762	$57,703	$1,567,295
a-5. Utilities (Coou)	P-III		$80,662	$155,458	$149,805	$144,357	$139,108	$134,050	$129,175	$124,478	$119,951	$115,589	$111,386	$53,668	$1,457,687
b. Maintenance costs (Com)	P-III		$89,950	$173,359	$167,054	$160,980	$155,127	$149,485	$144,049	$138,813	$133,765	$128,900	$124,212	$59,847	$1,625,541
b-1. Labor (Coml)	P-III		$32,929	$63,484	$61,156	$58,932	$56,789	$54,724	$52,734	$50,817	$48,969	$47,188	$45,472	$21,909	$595,083
b-2. Replacement training (Comp)	P-III		$327	$631	$608	$586	$565	$544	$525	$506	$487	$470	$452	$218	$5,919
b-3. Recurring spares (Comx)	P-III		$49,755	$95,892	$92,405	$89,045	$85,807	$82,687	$79,680	$76,783	$73,991	$71,300	$68,707	$33,104	$899,156
b-4. Tools (Coms)	P-III		$145	$279	$268	$259	$249	$240	$231	$223	$215	$207	$200	$96	$2,612
b-5. Transportation (Coot)	P-III		$5,493	$10,586	$10,201	$9,830	$9,473	$9,128	$8,796	$8,476	$8,168	$7,871	$7,585	$3,655	$99,262
b-6. Facility (Comf)	P-III		$1,301	$2,507	$2,416	$2,328	$2,244	$2,162	$2,083	$2,008	$1,935	$1,864	$1,796	$865	$23,509
3. Disposal (Cd)	P-III													($48,086)	($48,086)
Cost total (C)	P-III	$1,325,000	$776,572	$701,423	$675,917	$651,338	$627,655	$604,830	$582,835	$561,645	$541,220	$521,538	$502,572	$194,062	$8,246,607
4. Metal income (Sm)	P-III		($252,276)	($1,018,399)	($981,366)	($945,680)	($911,291)	($878,154)	($846,221)	($815,449)	($785,796)	($757,222)	($729,687)	($351,576)	($9,373,117)
Grand total		$1,325,000	$524,296	($316,976)	($305,449)	($294,342)	($283,636)	($273,324)	($263,386)	($253,804)	($244,576)	($235,684)	($227,115)	($157,514)	($1,126,510)

1. For a module of 50 machines.
2. A discount rate of 10% was used; Present value dollars = Inflated dollars * $\frac{1}{(1+i)^n}$
3. Vary the quality of metal received; 102,616 lbs/yr @ 5% contamination.
   102,616 lbs/machine x 95% x $.225/lb x 50 machines = $1,096,[illegible]/module
4. Utilities would remain at their original levels.

APPENDIX G

EXPERT OPINION SURVEY

LIFE EXPECTANCY

PP	7	5	6	5	10	6	5	15	10	5		7.4	AVERAGE
P-II	15	10	7	10	10	15	9	15	12	7		11	
P-III	15	10	7	10	10	15	9	15	12	7		11	

MAJOR DECISION FACTORS

1. RELIABILITY	X	X	X		X		X	X	X			7	TOTAL TIMES SELECTED
2. COST OF OPERATION	X	X	X	X		X		X	X	X		8	
3. INITIAL COST	X	X	X	X	X		X	X	X	X		9	
4. APPEARANCE	X				X		X		X	X		5	
5. PAYOUT ACCURACY		X										1	
6. LIFE EXPECTANCY			X					X				2	
7. RETURN ON INVESTMENT				X								1	
8. PROCESS ACCURACY				X	X	X	X					4	
9. SERVICE-ABILITY						X						1	
10. DURABILITY						X						1	
11. EASE OF INSTALLATION										X		1	
EXPERT	G. E. M.	J. L.	B. B. H.	J. F. K.	R. B. H.	K. D. P.	L. C. V.	C. W. R.	R. J. W.	A. D.			

EXPERT COMPOSITE

MANAGERS	4
ENGINEERS	3
TECHNICIANS	3

APPENDIX H

ANALYTIC HIERARCHY PROCESS QUESTIONNAIRE

On pages 95 - 97 is a copy of the letter that accompanied the Analytic Hierarchy Process Questionnaire. Pages 91 - 93 contains the Definition Of Terms that also accompanied the questionnaire. Pages 98 - 107 is an example of the actual questionnaire form that the participants were asked to complete.

March 5, 1990

To: RV Survey Participants

From: P. E. Smith - PDC

Subject: REVERSE VENDING MACHINES - ANALYSIS

This questionnaire is designed to identify the criteria most important to you in how you would select a reverse vending machine. It follows with a series of questions to answer on which of the three types of RV machines would best conform to the selection criteria.

RV machine descriptions and definitions of the selection and evaluation criteria are attached to the questionnaire.

The scale of RV selection preference goes from: a nine (9) rating for the strongest, or absolute preference for the attribute in the left-hand column over those in the right-hand column, down to a one (1) rating which is equality or no preference; then rising to a nine (9) rating, the absolute preference for the attributes in the right-hand column over those in the left-hand column.

The first six sections list the choices between the attributes seen in the left and right-hand columns with respect to the RV machine that you plan to use.

The next seventeen (17) sections are designed to compare the RV machine attributes among the three available RV machines. For example, in the sections relating to Net Present Worth, you are asked to list your preferences among the three machines as related to initial cost, expected life, and operating cost. Similar logic applies to the remaining sections, wherein each section a comparison is made between all three machines.

Following you will find basic information relating to the available machines.

Thank you for your assistance in providing the information requested.

P. E. Smith [11]

BASIC INFORMATION PERTAINING

TO AVAILABLE RV MACHINES

	PP	P-II	P-III
Initial cost:	$17,500	$30,000	$26,500
Failure rate (bd/yr):	8	9	14
Expected life:	7 yrs	11 yrs	11 yrs
Repair costs/breakdown:	$6.50	$6.50	$6.50
Money accuracy:	Fair	Good	Good
Cycle time (min/cycle):	3	2	2
Ease of use:	Fair	Good	Good
Storage capacity (lbs):	2,000	4,000	3,000
Unloading ease:	Poor	Excellent	Fair
Coin capacity:	$1,000	$1,500	$1,500
Durability:	Poor	Excellent	Fair

DEFINITION OF TERMS

A. NET PRESENT WORTH - Considering all expenses, what the machine would cost in today's dollars.

A-1. INITIAL COST - The initial basic cost of the machine.

A-2. EXPECTED LIFE - Based on expert opinion, what the life of the machine is expected to be.

A-3. OPERATING COST - What it will cost to operate the machine. This includes power, maintenance, spare parts, rent, insurance, etc.

B. CUSTOMER INTERFACE - The acceptance of the machine by the user.

B-1. MONEY ACCURACY - The accuracy of the machine to pay the proper value for a given weight of UBCs.

B-2. CYCLE TIME - The time that it takes the machine to weigh, pay, and process a given weight of UBCs.

B-3. EASE OF USE - How 'user friendly' the machine is. The clearness of instructions, the simplicity of use, and how well lighted the machine is, are examples.

B-4. APPEARANCE - Refers to the aesthetics of the machine. Size, color, shape, and cleanliness are examples of factors that affect appearance.

C. RELIABILITY - The probability that the machine will operate satisfactorily for 3,000 lbs. of UBCs processed under normal operating conditions.

C-1. OUTAGES PER 3,000 LBS - The number of machine malfunctions that result in machine shutdown during the time frame of normally processing 3,000 pounds of UBCs.

C-2. DOWNTIME - The duration that the machine is out of service due to a machine malfunction.

C-3. MAINTENANCE COST/100,000 LBS. - The cost to service and repair the machine per 100,000 lbs. of UBCs processed.

D. SERVICE-ABILITY - The degree of ease that the machine can be serviced.

D-1. STORAGE CAPACITY - The volume of the storage container. The storage capacity directly affects the required number of service calls to the machine for a given volume of UBCs.

D-2. UNLOADING EASE - The ease that the machine can be unloaded. This affects service personnel's desire to service the machine.

D-3. UNLOADING TIME - The time required to unload the machine. This affects the number of machines that service personnel can service in a given period of time.

D-4. COIN CAPACITY - The volume of the coin hoppers. This volume directly affects the required number of service calls to the machine.

D-5. ACCESSIBILITY - The ease that service personnel can enter and service the machine.

E. MACHINE DESIGN - The technology, sophistication, and quality of materials used in the fabrication of the machine.

E-1. PROCESS ACCURACY - The degree of accuracy of the machine to receive UBCs from a user, process the material, and display and pay the accurate weight and value.

E-2. DURABILITY - The durability of materials used to fabricate the machine. This is a factor of heavy-duty versus light-duty materials.

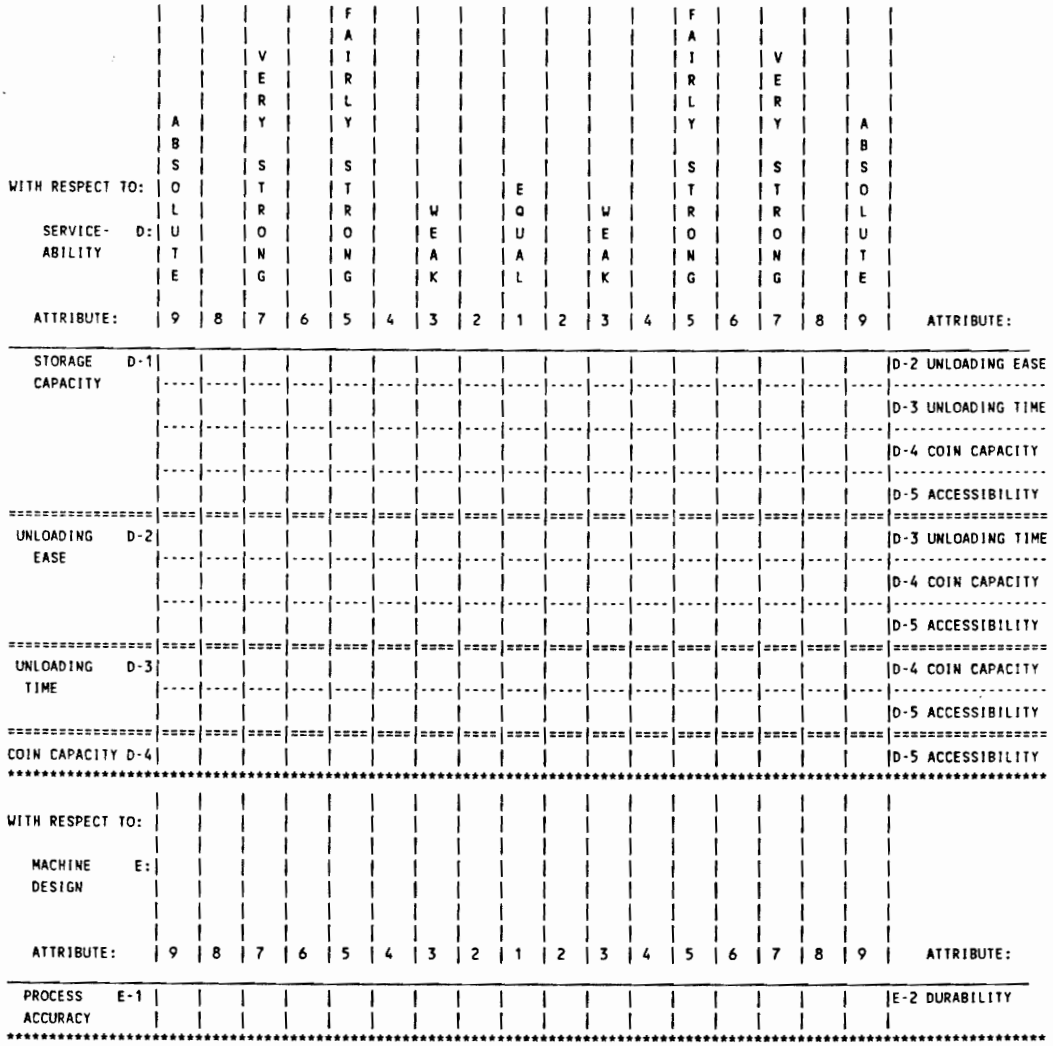
AHP QUESTIONNAIRE

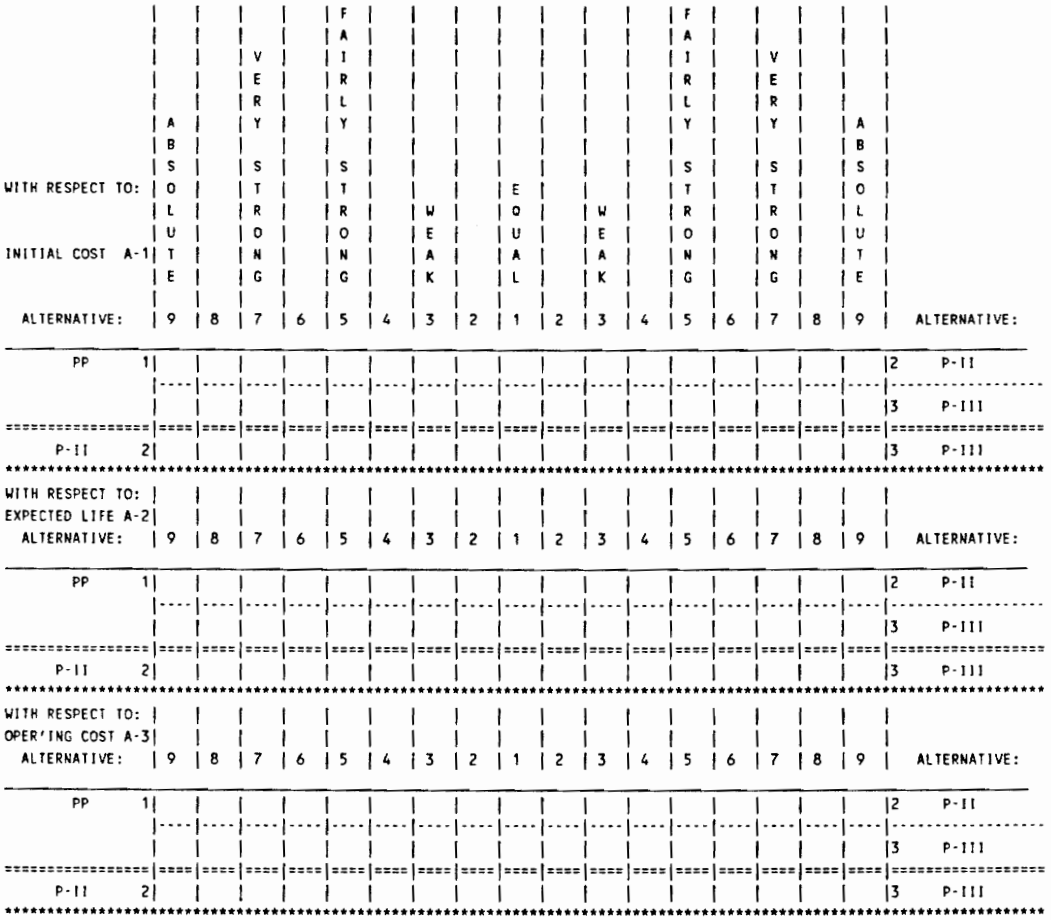
WITH RESPECT TO: MACHINE CHOICE :	ABSOLUTE	VERY STRONG	FAIRLY STRONG	WEAK	EQUAL	WEAK	FAIRLY STRONG	VERY STRONG	ABSOLUTE	
ATTRIBUTE:	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ATTRIBUTE:
NET PRESENT WORTH A.																		B. CUSTOMER INTERFACE
																		C. RELIABILITY
																		D. SERVICE-ABILITY
																		E. MACHINE DESIGN
CUSTOMER INTERFACE B.																		C. RELIABILITY
																		D. SERVICE-ABILITY
																		E. MACHINE DESIGN
RELIABILITY C.																		D. SERVICE-ABILITY
																		E. MACHINE DESIGN
SERVICE-ABILITY D.																		E. MACHINE DESIGN

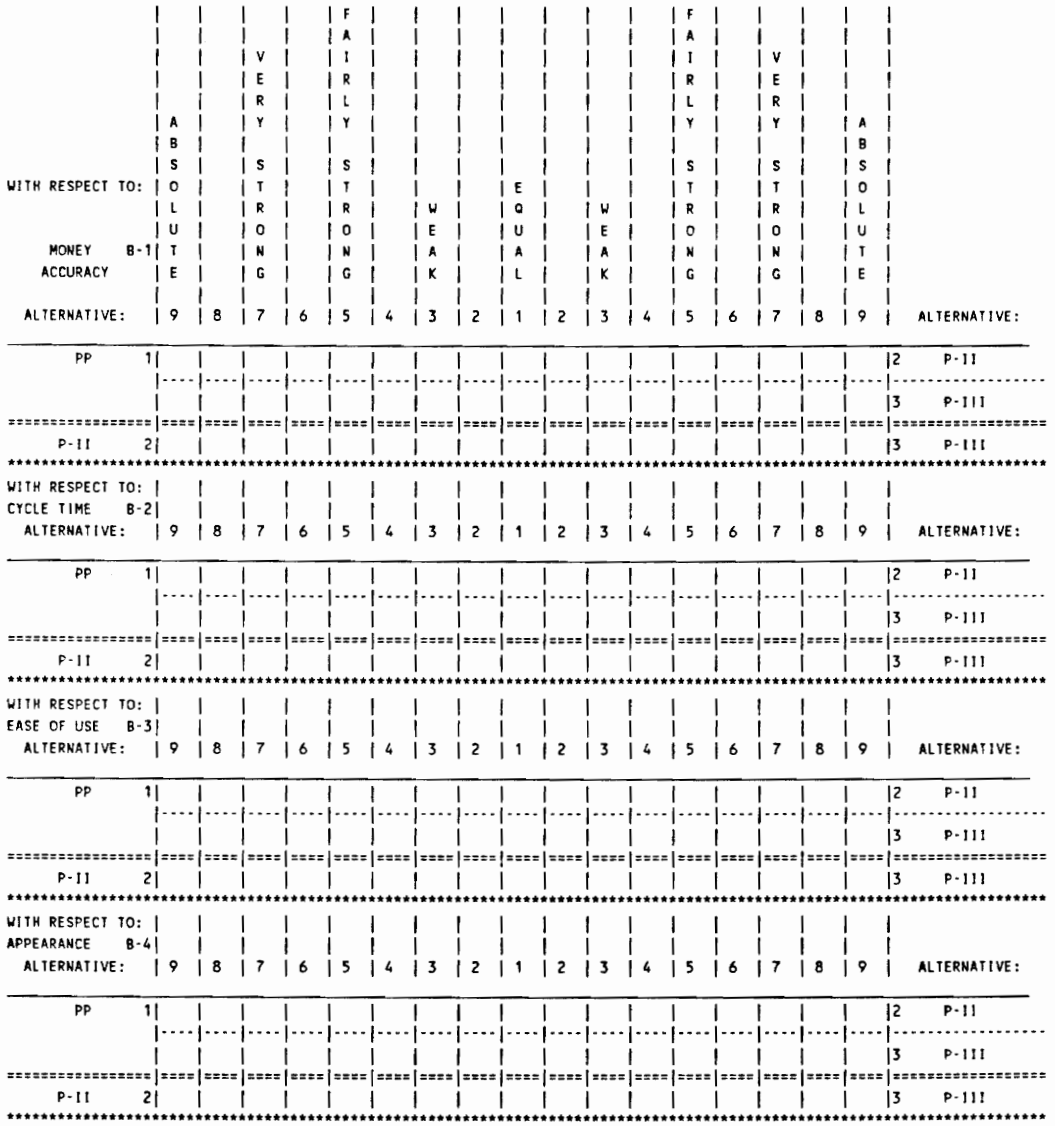
WITH RESPECT TO: NET PRESENT WORTH A:																		
ATTRIBUTE:	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ATTRIBUTE:
INITIAL COST A-1																		A-2 EXPECTED LIFE
																		A-3 OPERATING COST
EXPECTED LIFE A-2																		A-3 OPERATING COST

WITH RESPECT TO: CUSTOMER INTERFACE B:	ABSOLUTE	VERY STRONG	FAIRLY STRONG	WEAK	EQUAL	WEAK	FAIRLY STRONG	VERY STRONG	ABSOLUTE	
ATTRIBUTE:	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ATTRIBUTE:
MONEY B-1 ACCURACY																		B-2 CYCLE TIME
																		B-3 EASE OF USE
																		B-4 APPEARANCE
CYCLE TIME B-2																		B-3 EASE OF USE
																		B-4 APPEARANCE
EASE OF USE B-3																		B-4 APPEARANCE

WITH RESPECT TO: RELIABILITY C:																		
ATTRIBUTE:	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ATTRIBUTE:
OUTAGES C-1 PER 3000 LBS.																		C-2 DOWNTIME
																		C-3 MAINTENANCE COST/100000 LBS
DOWNTIME C-2																		C-3 MAINTENANCE COST/100000 LBS


WITH RESPECT TO:
SERVICE-ABILITY D:
ABSOLUTE
VERY STRONG
FAIRLY STRONG
WEAK
EQUAL
WEAK
FAIRLY STRONG
VERY STRONG
ABSOLUTE
ATTRIBUTE:
9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9
ATTRIBUTE:
STORAGE CAPACITY D-1
D-2 UNLOADING EASE
D-3 UNLOADING TIME
D-4 COIN CAPACITY
D-5 ACCESSIBILITY
UNLOADING EASE D-2
D-3 UNLOADING TIME
D-4 COIN CAPACITY
D-5 ACCESSIBILITY
UNLOADING TIME D-3
D-4 COIN CAPACITY
D-5 ACCESSIBILITY
COIN CAPACITY D-4
D-5 ACCESSIBILITY
WITH RESPECT TO:
MACHINE DESIGN E:
9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9
ATTRIBUTE:
PROCESS ACCURACY E-1
E-2 DURABILITY

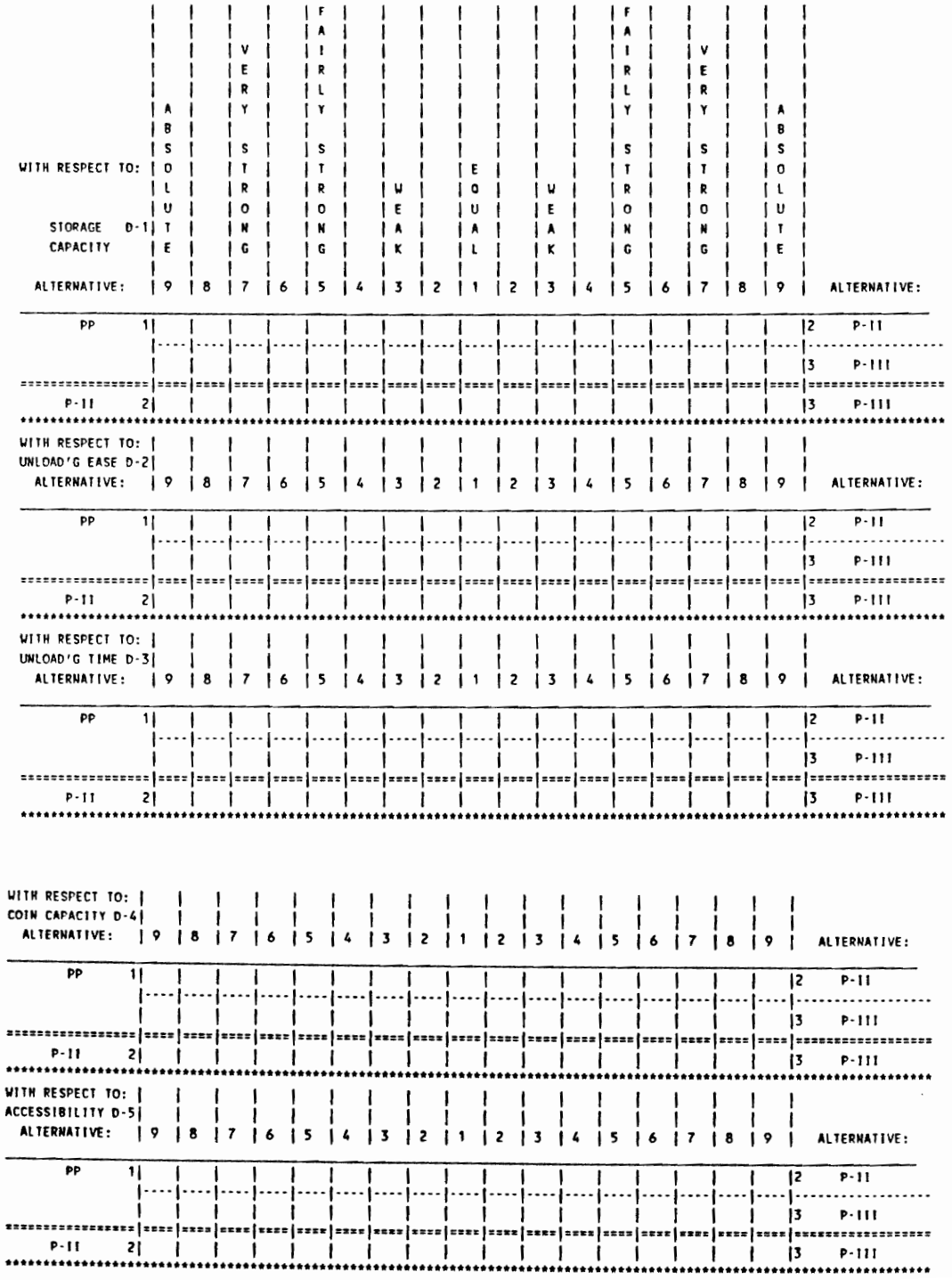

WITH RESPECT TO:
INITIAL COST A-1
ABSOLUTE
FAIRLY
VERY
EQUAL
WEAK
ALTERNATIVE:
9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9
PP 1
P-II 2
P-II
P-III
WITH RESPECT TO:
EXPECTED LIFE A-2
ALTERNATIVE:
PP 1
P-II 2
P-II
P-III
WITH RESPECT TO:
OPER'ING COST A-3
ALTERNATIVE:
PP 1
P-II 2
P-II
P-III


WITH RESPECT TO:
MONEY B-1
ACCURACY
ALTERNATIVE:
ABSOLUTE
VERY STRONG
FAIRLY STRONG
WEAK
EQUAL
WEAK
FAIRLY STRONG
VERY STRONG
ABSOLUTE
9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9
PP 1
P-II 2
2 P-II
3 P-III
3 P-III
WITH RESPECT TO:
CYCLE TIME B-2
ALTERNATIVE:
9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9
PP 1
P-II 2
2 P-II
3 P-III
3 P-III
WITH RESPECT TO:
EASE OF USE B-3
ALTERNATIVE:
9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9
PP 1
P-II 2
2 P-II
3 P-III
3 P-III
WITH RESPECT TO:
APPEARANCE B-4
ALTERNATIVE:
9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9
PP 1
P-II 2
2 P-II
3 P-III
3 P-III

WITH RESPECT TO:	ABSOLUTE	VERY STRONG	FAIRLY STRONG	FAIRLY WEAK	EQUAL	WEAK	FAIRLY STRONG	VERY STRONG	ABSOLUTE
OUTAGES C-1 PER 3000 LBS									
ALTERNATIVE:	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ALTERNATIVE:
PP 1																		2 P-II
																		3 P-III
P-II 2																		3 P-III

WITH RESPECT TO: DOWNTIME C-2																		
ALTERNATIVE:	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ALTERNATIVE:
PP 1																		2 P-II
																		3 P-III
P-II 2																		3 P-III

WITH RESPECT TO: MAINT'COST C-3																		
ALTERNATIVE:	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ALTERNATIVE:
PP 1																		2 P-II
																		3 P-III
P-II 2																		3 P-III


WITH RESPECT TO:
STORAGE CAPACITY D-1
ABSOLUTE
VERY STRONG
FAIRLY STRONG
WEAK
EQUAL
WEAK
FAIRLY STRONG
VERY STRONG
ABSOLUTE
ALTERNATIVE: 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 ALTERNATIVE:
PP 1
P-II 2
P-II
P-III
P-III
WITH RESPECT TO:
UNLOAD'G EASE D-2
ALTERNATIVE: 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 ALTERNATIVE:
PP 1
P-II 2
P-II
P-III
P-III
WITH RESPECT TO:
UNLOAD'G TIME D-3
ALTERNATIVE: 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 ALTERNATIVE:
PP 1
P-II 2
P-II
P-III
P-III
WITH RESPECT TO:
COIN CAPACITY D-4
ALTERNATIVE: 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 ALTERNATIVE:
PP 1
P-II 2
P-II
P-III
P-III
WITH RESPECT TO:
ACCESSIBILITY D-5
ALTERNATIVE: 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 ALTERNATIVE:
PP 1
P-II 2
P-II
P-III
P-III

APPENDIX I

RESULTS OF AHP QUESTIONNAIRE

Pages 109 - 115 contain the results and the averages from the AHP Questionnaire. The averaged values were then compiled into the matrixes used for calculation of the priority weights for the Analytic Hierarchy Structure. Refer to Appendix H for the actual calculations of the priority weights.

WITH RESPECT TO: MACHINE CHOICE : ATTRIBUTE:	GEM	JL	BBH	JFK	RBH	KDP	LCV	CWR	RJW	AD	AVG	ATTRIBUTE:
NET PRESENT WORTH A.	0.25	0.2	0.2	0.2	5	0.2	1	0.14	0.25	0.25	0.769	B. CUSTOMER INTERFACE
	0.11	0.14	0.14	0.2	0.2	0.2	0.14	0.11	0.25	0.11	0.161	C. RELIABILITY
	0.14	0.2	0.2	0.14	0.14	0.2	0.2	1	0.25	0.14	0.262	D. SERVICE-ABILITY
	7	0.14	0.33	1	0.2	0.2	0.33	1	1	1	1.220	E. MACHINE DESIGN
CUSTOMER INTERFACE B.	0.11	0.14	0.33	1	0.2	0.14	0.5	1	0.5	0.11	0.404	C. RELIABILITY
	0.14	1	5	1	0.2	0.11	0.5	0.14	2	0.14	1.023	D. SERVICE-ABILITY
	5	1	5	1	1	0.11	0.2	1	3	1	1.831	E. MACHINE DESIGN
RELIABILITY C.	7	1	5	1	5	1	1	7	7	6	4.1	D. SERVICE-ABILITY
	9	1	5	6	5	1	1	9	5	8	5	E. MACHINE DESIGN
SERVICE-ABILITY D.	5	1	3	6	5	1	1	7	1	9	3.9	E. MACHINE DESIGN

WITH RESPECT TO: NET PRESENT WORTH A: ATTRIBUTE:	GEM	JL	BBH	JFK	RBH	KDP	LCV	CWR	RJW	AD	AVG	ATTRIBUTE:
INITIAL COST A-1	0.2	0.2	5	1	5	0.2	0.33	0.12	0.25	5	1.730	A-2 EXPECTED LIFE
	0.14	0.14	3	0.2	1	0.2	0.33	0.12	0.25	1	0.639	A-3 OPERATING COST
EXPECTED LIFE A-2	7	1	0.33	1	0.2	3	1	0.12	1	1	1.565	A-3 OPERATING COST
INITIAL COST A-1					5	0.2	0.33		0.25		1.445	
					1	0.2	0.33		0.25		0.445	
EXPECTED LIFE A-2					0.2	3	1		1		1.3	

WITH RESPECT TO: CUSTOMER INTERFACE B: / ATTRIBUTE:	GEM	JL	BBH	JFK	RBH	KDP	LCV	CWR	RJW	AD	AVG	ATTRIBUTE:
MONEY ACCURACY B-1	3	0.33	5	5	5	5	4	9	9	4	4.933	B-2 CYCLE TIME
	1	0.14	3	0.2	5	1	2	1	9	4	2.634	B-3 EASE OF USE
	7	3	7	5	1	3	7	5	9	8	5.5	B-4 APPEARANCE
CYCLE TIME B-2	0.2	0.2	0.33	1	0.2	0.2	0.25	0.14	1	4	0.752	B-3 EASE OF USE
	3	3	3	5	0.2	1	5	1	0.16	7	2.836	B-4 APPEARANCE
EASE OF USE B-3	7	1	5	5	1	5	5		1	7	4.111	B-4 APPEARANCE

WITH RESPECT TO: RELIABILITY C: / ATTRIBUTE:	GEM	JL	BBH	JFK	RBH	KDP	LCV	CWR	RJW	AD	AVG	ATTRIBUTE:
OUTAGES PER 3000 LBS. C-1	9	0.14	0.2	0.2	5	0.2	1	9	1	6	3.174	C-2 DOWNTIME
	3	0.2	3	1	1	0.14	0.2	1		0.2	1.082	C-3 MAINTENANCE COST/100000 LBS
DOWNTIME C-2	5	0.2	7	3	0.25	0.2	4	1	3	0.2	2.385	C-3 MAINTENANCE COST/100000 LBS

WITH RESPECT TO:

SERVICE-ABILITY D: / ATTRIBUTE:	GEM	JL	BBH	JFK	RBH	KDP	LCV	CWR	RJW	AD	AVG	ATTRIBUTE:
STORAGE CAPACITY D-1	0.14	0.2	0.33	0.2	1	0.2	1	1	1	7	1.207	D-2 UNLOADING EASE
	0.14	0.14	5	0.2	1	0.2	0.25	7	1	7	2.193	D-3 UNLOADING TIME
	1	0.2	0.33	0.2	4	0.14	1	7	1	7	2.187	D-4 COIN CAPACITY
	0.14	0.14	3	0.2	1	0.14	3	1	1	7	1.662	D-5 ACCESSIBILITY
UNLOADING EASE D-2	1	0.2	0.33	5	1	1	0.25	1	1	0.14	1.092	D-3 UNLOADING TIME
	7	0.2	0.2	3	3	1	0.2	0.2	1	0.11	1.591	D-4 COIN CAPACITY
	1	0.14	3	1		1	0.2	0.2	1	0.25	0.865	D-5 ACCESSIBILITY
UNLOADING TIME D-3	7	0.2	0.33	3	3	1	0.25	0.2	1	0.11	1.609	D-4 COIN CAPACITY
	1	0.33	3	3		1	0.25	0.2	1	9	2.087	D-5 ACCESSIBILITY
COIN CAPACITY D-4	0.14	0.2	3	1	1	0.33	4	1	1	9	2.067	D-5 ACCESSIBILITY

WITH RESPECT TO:

MACHINE DESIGN E: / ATTRIBUTE:	GEM	JL	BBH	JFK	RBH	KDP	LCV	CWR	RJW	AD	AVG	ATTRIBUTE:
PROCESS ACCURACY E-1	0.2	0.14	0.33	1	5	0.2	3	1	7	1	1.887	E-2 DURABILITY

WITH RESPECT TO:

INITIAL COST A-1

ALTERNATIVE:		GEM	JL	BBH	JFK	RBH	KDP	LCV	CWR	RJW	AD	AVG	ALTERNATIVE:
PP	1	7	5	9	0.2	5	0.2	5	0.2	7	9	4.76	2 P-II
		5	1	9	0.33	5	0.2	3	0.2	7	9	3.973	3 P-III
P-II	2	0.33	0.2	1	3	0.33	0.33	0.2	0.2	1	1	0.76	3 P-III

WITH RESPECT TO:
EXPECTED LIFE A-2

ALTERNATIVE:		GEM	JL	BBH	JFK	RBH	KDP	LCV	CWR	RJW	AD	AVG	ALTERNATIVE:
PP	1	0.14	0.14	0.33	0.11	5	0.14	0.16	0.2	0.5	7	1.373	2 P-II
		0.2	0.14	0.33	0.12	5	0.14	0.16	0.2	0.5		0.756	3 P-III
P-II	2		3	1	0.5	0.33	1	1	0.2	1	1	1.003	3 P-III

WITH RESPECT TO:
OPER'ING COST A-3

ALTERNATIVE:		GEM	JL	BBH	JFK	RBH	KDP	LCV	CWR	RJW	AD	AVG	ALTERNATIVE:
PP	1	0.11	0.2	7	0.2	5	0.14	0.5	0.2	9	9	3.135	2 P-II
		0.14	0.2	7	0.2	5	0.14	0.5	0.2	9	9	3.138	3 P-III
P-II	2	5	1	1	0.25	1	1	0.5	0.2	1	1	1.195	3 P-III

WITH RESPECT TO:

MONEY B-1
ACCURACY

ALTERNATIVE:	GEM	JL	BBH	JFK	RBH	KDP	LCV	CWR	RJW	AD	AVG	ALTERNATIVE:
PP 1	0.11	0.11	3	0.11	1	0.2	0.25	0.2	1	3	0.898	2 P-II
	0.11	0.11	3	0.11	1	0.2	0.25	0.2	1	3	0.898	3 P-III
P-II 2	1	1	1	1	1	1	1	0.2	1		0.911	3 P-III

WITH RESPECT TO:
CYCLE TIME B-2

ALTERNATIVE:	GEM	JL	BBH	JFK	RBH	KDP	LCV	CWR	RJW	AD	AVG	ALTERNATIVE:
PP 1	0.14	0.33	0.33	0.11	0.33	0.33	0.5	0.2	0.33	9	1.162	2 P-II
	0.14	0.33	0.33	0.11	0.33	0.33	0.5	0.2	0.33	9	1.162	3 P-III
P-II 2	1	1	1	1	1	1	1	0.2	1	1	0.92	3 P-III

WITH RESPECT TO:
EASE OF USE B-3

ALTERNATIVE:	GEM	JL	BBH	JFK	RBH	KDP	LCV	CWR	RJW	AD	AVG	ALTERNATIVE:
PP 1	0.2	0.2	0.33	0.2	1	1	0.5	0.2	1	6	1.063	2 P-II
	0.2	0.2	0.33	0.2	1	1	0.5	0.2	1	6	1.063	3 P-III
P-II 2	1	1	1	1	1	1	1	0.2	1	1	0.92	3 P-III

WITH RESPECT TO:
APPEARANCE B-4

ALTERNATIVE:	GEM	JL	BBH	JFK	RBH	KDP	LCV	CWR	RJW	AD	AVG	ALTERNATIVE:
PP 1	0.16	1	9	0.2	7	0.14	0.25	0.2	7	9	3.395	2 P-II
	1	1	7	0.11	7	0.14	0.2	0.2	7	9	3.265	3 P-III
P-II 2	5	1	0.2	0.2	0.25	1	0.25	0.2	0.12	1	0.922	3 P-III

WITH RESPECT TO: OUTAGES C-1 PER 3000 LBS ALTERNATIVE:	GEM	JL	BBH	JFK	RBH	KDP	LCV	CWR	RJW	AD	AVG	ALTERNATIVE:
PP 1	0.11	0.14	5	0.14	4	0.14	0.25	0.14	0.33	9	1.926	2 P-II
		0.14	5	0.14	4	0.14	0.25	0.14	0.33	9	2.128	3 P-III
P-II 2		1	1	0.33	1	1	1	0.2	1	4	1.170	3 P-III

WITH RESPECT TO: DOWNTIME C-2 ALTERNATIVE:	GEM	JL	BBH	JFK	RBH	KDP	LCV	CWR	RJW	AD	AVG	ALTERNATIVE:
PP 1	0.11	0.2	5	0.14	3	0.14	0.2	0.14	1	9	1.893	2 P-II
		0.2	5	0.14	3	0.14	0.2	0.14	1	9	2.092	3 P-III
P-II 2		1	1	0.33	1	1	1	0.2	1	1	0.837	3 P-III

WITH RESPECT TO: MAINT'COST C-3 ALTERNATIVE:	GEM	JL	BBH	JFK	RBH	KDP	LCV	CWR	RJW	AD	AVG	ALTERNATIVE:
PP 1	0.14	0.2	5	0.2	4	0.14	0.33	0.2	3	7	2.021	2 P-II
		0.2	5	0.2	4	0.14	0.33	0.2	3	7	2.230	3 P-III
P-II 2		1	1	0.33	0.5	1	2	0.2	1	1	0.892	3 P-III

WITH RESPECT TO:

STORAGE D-1 / CAPACITY / ALTERNATIVE:	GEM	JL	BBH	JFK	RBH	KDP	LCV	CWR	RJW	AD	AVG	ALTERNATIVE:
PP 1	0.2	0.14	0.33	0.14	0.25	0.2	0.5	0.14	0.2	6	0.811	2 P-II
	0.33	0.2	0.33	0.14	0.25	0.2	0.5	0.14	1	6	0.910	3 P-III
P-II 2	3	3	3	1	1	1	1	0.2	5	3	2.12	3 P-III

WITH RESPECT TO: UNLOAD'G EASE D-2 / ALTERNATIVE:	GEM	JL	BBH	JFK	RBH	KDP	LCV	CWR	RJW	AD	AVG	ALTERNATIVE:
PP 1	0.11	0.14	0.2	0.11	0.2	0.14	0.25	0.2	0.11	3	0.446	2 P-II
	0.2	0.14	1	0.11	0.33	0.2	1	0.2	0.2	3	0.638	3 P-III
P-II 2	7	3	5	5	0.2	7	0.5	0.2	9	3	3.99	3 P-III

WITH RESPECT TO: UNLOAD'G TIME D-3 / ALTERNATIVE:	GEM	JL	BBH	JFK	RBH	KDP	LCV	CWR	RJW	AD	AVG	ALTERNATIVE:
PP 1	0.11	0.2	0.2	0.2	0.2	0.2	0.5	0.2	0.25	3	0.506	2 P-II
	0.2	0.2	1	0.2	0.25	0.2	0.5	0.2	0.5	3	0.625	3 P-III
P-II 2	9	3	5	4	0.2	5	0.5	0.2		0.5	3.044	3 P-III

WITH RESPECT TO: COIN CAPACITY D-4 / ALTERNATIVE:	GEM	JL	BBH	JFK	RBH	KDP	LCV	CWR	RJW	AD	AVG	ALTERNATIVE:
PP 1	0.14	0.2	3	0.14	0.25	0.2	2	0.14	1	6	1.307	2 P-II
	0.14	0.2	3	0.14	0.25	0.2	2	0.14	1	6	1.307	3 P-III
P-II 2	1	1	1	1	1	1	1	0.2	1	1	0.92	3 P-III

WITH RESPECT TO: ACCESSIBILITY D-5 / ALTERNATIVE:	GEM	JL	BBH	JFK	RBH	KDP	LCV	CWR	RJW	AD	AVG	ALTERNATIVE:
PP 1	0.5	0.2	3	0.11	0.5	0.14	0.25	0.2	0.33	6	1.123	2 P-II
	1	0.2	3	0.11	0.5	0.2	0.25	0.2	5	6	1.646	3 P-III
P-II 2	7	3	1	5	2	5	2	0.2	7	3	3.52	3 P-III

APPENDIX J

PRIORITY WEIGHT CALCULATIONS

Pages 117 - 143 contain the actual AHP calculations of the priority weights. An example of the procedure is explained on pages 48 - 50. The resultant priority weights are displayed on the Hierarchy Structure on page 51.

MATRIX OF LEVEL II PAIRED COMPARISONS
WITH RESPECT TO MACHINE CHOICE

	A	B	C	D	E
A. NET PRESENT WORTH	1.000	0.769	0.161	0.262	1.220
B. CUSTOMER INTERFACE	1.300	1.000	0.404	1.023	1.831
C. RELIABILITY	6.211	2.475	1.000	4.100	5.000
D. SERVICE-ABILITY	3.817	0.978	0.244	1.000	3.900
E. MACHINE DESIGN	0.820	0.546	0.200	0.256	1.000
TOTALS	13.148	5.768	2.009	6.641	12.951

NORMALIZED MATRIX OF
LEVEL II PAIRED COMPARISONS
WITH RESPECT TO MACHINE CHOICE

	A	B	C	D	E	ROW SUM	AVG
A. NET PRESENT WORTH	0.076	0.133	0.080	0.039	0.094	0.423	0.085
B. CUSTOMER INTERFACE	0.099	0.173	0.201	0.154	0.141	0.769	0.154
C. RELIABILITY	0.472	0.429	0.498	0.617	0.386	2.403	0.481
D. SERVICE-ABILITY	0.290	0.169	0.121	0.151	0.301	1.033	0.207
E. MACHINE DESIGN	0.062	0.095	0.100	0.039	0.077	0.372	0.074
TOTALS	1.000	1.000	1.000	1.000	1.000		1.000

CALCULATION OF CONSISTENCY RATIO (C.R.)

1.000	0.769	0.161	0.262	1.220		0.085
1.300	1.000	0.404	1.023	1.831		0.154
6.211	2.475	1.000	4.100	5.000	X	0.481
3.817	0.978	0.244	1.000	3.900		0.207
0.820	0.546	0.200	0.256	1.000		0.074

$$= \begin{matrix} 0.4252 \\ 0.8056 \\ 2.6061 \\ 1.0875 \\ 0.3769 \end{matrix} \qquad D = \begin{matrix} 5.0243 \\ 5.2397 \\ 5.4233 \\ 5.2648 \\ 5.0604 \end{matrix}$$

LAMBDA MAX = 5.2025

$$CI = \frac{\text{LAMDA MAX} - N}{N - 1} = 0.05$$

GIVEN: N	1	2	3	4	5	6	7
R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32

$$C.R. = \frac{CI}{RI} = \frac{0.05}{1.12} = 0.04$$

0.04 < .10 ...PAIRWISE COMPARISON IS REASONABLY CONSISTENT

MATRIX OF LEVEL III PAIRED COMPARISONS
WITH RESPECT TO: A. NET PRESENT WORTH

	A-1	A-2	A-3
A-1 INITIAL COST	1.000	1.730	0.639
A-2 EXPECTED LIFE	0.578	1.000	1.565
A-3 OPERATING COST	1.565	0.639	1.000
TOTALS	3.143	3.369	3.204

NORMALIZED MATRIX OF
LEVEL III PAIRED COMPARISONS
WITH RESPECT TO: A. NET PRESENT WORTH

	A-1	A-2	A-3	ROW SUM	AVG
A-1 INITIAL COST	0.318	0.514	0.199	1.031	0.344
A-2 EXPECTED LIFE	0.184	0.297	0.488	0.969	0.323
A-3 OPERATING COST	0.498	0.190	0.312	1.000	0.333
TOTALS	1.000	1.000	1.000		1.000

CALCULATION OF CONSISTENCY RATIO (C.R.)

$$\begin{vmatrix} 1.000 & 1.730 & 0.639 \\ 0.578 & 1.000 & 1.565 \\ 1.565 & 0.639 & 1.000 \end{vmatrix} \times \begin{vmatrix} 0.344 \\ 0.323 \\ 0.333 \end{vmatrix}$$

$$= \begin{matrix} 1.116 \\ 1.043 \\ 1.078 \end{matrix} \qquad D = \begin{matrix} 3.25 \\ 3.23 \\ 3.23 \end{matrix}$$

LAMBDA MAX = 3.24

$$CI = \frac{\text{LAMDA MAX} - N}{N - 1} = 0.12$$

GIVEN: N	1	2	3	4	5	6	7
R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32

$$C.R. = \frac{CI}{RI} = \frac{0.12}{0.58} = 0.21$$

0.21 > .10 ...PAIRWISE COMPARISON IS NOT CONSISTENT

USING ADJUSTED MATRIX
MATRIX OF LEVEL III PAIRED COMPARISONS
WITH RESPECT TO: A. NET PRESENT WORTH

	A-1	A-2	A-3
A-1 INITIAL COST	1.000	1.730	0.639
A-2 EXPECTED LIFE	0.578	1.000	0.639
A-3 OPERATING COST	1.565	1.565	1.000
TOTALS	3.143	4.295	2.278

NORMALIZED MATRIX OF
LEVEL III PAIRED COMPARISONS
WITH RESPECT TO: A. NET PRESENT WORTH

	A-1	A-2	A-3	ROW SUM	AVG
A-1 INITIAL COST	0.318	0.403	0.281	1.001	0.334
A-2 EXPECTED LIFE	0.184	0.233	0.281	0.697	0.232
A-3 OPERATING COST	0.498	0.364	0.439	1.301	0.434
TOTALS	1.000	1.000	1.000		1.000

CALCULATION OF CONSISTENCY RATIO (C.R.)

1.000	1.730	0.639		0.334
0.578	1.000	0.639	X	0.232
1.565	1.565	1.000		0.434

	1.013		3.03
=	0.703	D =	3.02
	1.320		3.04

LAMBDA MAX = 3.03

$$CI = \frac{\text{LAMDA MAX} - N}{N - 1} = 0.02$$

	N	1	2	3	4	5	6	7
GIVEN:	R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32

$$C.R. = \frac{CI}{RI} = \frac{0.02}{0.58} = 0.03$$

0.03 < .10 ...PAIRWISE COMPARISON IS REASONABLY CONSISTENT

MATRIX OF LEVEL III PAIRED COMPARISONS
WITH RESPECT TO: B. CUSTOMER INTERFACE

	B-1	B-2	B-3	B-4
B-1 MONEY ACCURACY	1.000	4.933	2.634	5.500
B-2 CYCLE TIME	0.203	1.000	0.752	2.836
B-3 EASE OF USE	0.380	1.330	1.000	4.111
B-4 APPEARANCE	0.182	0.353	0.243	1.000
TOTALS	1.764	7.615	4.629	13.447

NORMALIZED MATRIX OF
LEVEL III PAIRED COMPARISONS
WITH RESPECT TO: B. CUSTOMER INTERFACE

	B-1	B-2	B-3	B-4	ROW SUM	AVG
B-1 MONEY ACCURACY	0.567	0.648	0.569	0.409	2.193	0.548
B-2 CYCLE TIME	0.115	0.131	0.162	0.211	0.620	0.155
B-3 EASE OF USE	0.215	0.175	0.216	0.306	0.912	0.228
B-4 APPEARANCE	0.103	0.046	0.053	0.074	0.276	0.069
TOTALS	1.000	1.000	1.000	1.000		1.000

CALCULATION OF CONSISTENCY RATIO (C.R.)

1.000	4.933	2.634	5.500		0.548
0.203	1.000	0.752	2.836		0.155
0.380	1.330	1.000	4.111	X	0.228
0.182	0.353	0.243	1.000		0.069

$$= \begin{matrix} 2.2923 \\ 0.6332 \\ 0.9259 \\ 0.2787 \end{matrix} \qquad D = \begin{matrix} 4.1820 \\ 4.0884 \\ 4.0629 \\ 4.0363 \end{matrix}$$

LAMBDA MAX = 4.0924

$$CI = \frac{\text{LAMDA MAX} - N}{N - 1} = 0.03$$

GIVEN: N	1	2	3	4	5	6	7
R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32

$$C.R. = \frac{CI}{RI} = \frac{0.03}{0.90} = 0.03$$

0.03 < .10 ...PAIRWISE COMPARISON IS REASONABLY CONSISTENT

MATRIX OF LEVEL III PAIRED COMPARISONS
WITH RESPECT TO: C. RELIABILITY

	C-1	C-2	C-3
C-1 OUTAGES PER 3,000 LBS	1.000	3.174	1.082
C-2 DOWNTIME	0.315	1.000	2.385
C-3 MAINTENANCE COST	0.924	0.419	1.000
TOTALS	2.239	4.593	4.467

NORMALIZED MATRIX OF
LEVEL III PAIRED COMPARISONS
WITH RESPECT TO: C. RELIABILITY

	C-1	C-2	C-3	ROW SUM	AVG
C-1 OUTAGES PER 3,000 LBS	0.447	0.691	0.242	1.380	0.460
C-2 DOWNTIME	0.141	0.218	0.534	0.892	0.297
C-3 MAINTENANCE COST	0.413	0.091	0.224	0.728	0.243
TOTALS	1.000	1.000	1.000		1.000

CALCULATION OF CONSISTENCY RATIO (C.R.)

1.000	3.174	1.082	0.460
0.315	1.000	2.385	X 0.297
0.924	0.419	1.000	0.243

	1.667		3.62
=	1.021	D =	3.43
	0.792		3.27
		LAMBDA MAX =	3.44

$$CI = \frac{\text{LAMDA MAX} - N}{N - 1} = 0.22$$

GIVEN: N	1	2	3	4	5	6	7
R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32

$$C.R. = \frac{CI}{RI} = \frac{0.22}{0.58} = 0.38$$

0.38 > .10 ...PAIRWISE COMPARISON IS NOT CONSISTENT

USING MODIFIED MATRIX
MATRIX OF LEVEL III PAIRED COMPARISONS
WITH RESPECT TO: C. RELIABILITY

	C-1	C-2	C-3
C-1 OUTAGES PER 3,000 LBS	1.000	3.174	1.082
C-2 DOWNTIME	0.315	1.000	0.419
C-3 MAINTENANCE COST	0.924	2.385	1.000
TOTALS	2.239	6.559	2.501

NORMALIZED MATRIX OF
LEVEL III PAIRED COMPARISONS
WITH RESPECT TO: C. RELIABILITY

	C-1	C-2	C-3	ROW SUM	AVG
C-1 OUTAGES PER 3,000 LBS	0.447	0.484	0.433	1.363	0.454
C-2 DOWNTIME	0.141	0.152	0.168	0.461	0.154
C-3 MAINTENANCE COST	0.413	0.364	0.400	1.176	0.392
TOTALS	1.000	1.000	1.000		1.000

CALCULATION OF CONSISTENCY RATIO (C.R.)

1.000	3.174	1.082	0.454
0.315	1.000	0.419	X 0.154
0.924	2.385	1.000	0.392

	1.366		3.01
=	0.461	D =	3.00
	1.178		3.01

LAMBDA MAX = 3.00

$$CI = \frac{\text{LAMDA MAX} - N}{N - 1} = 0.00$$

GIVEN: N	1	2	3	4	5	6	7
R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32

$$C.R. = \frac{CI}{RI} = \frac{0.00}{0.58} = 0.00$$

0.00 < .10 ...PAIRWISE COMPARISON IS REASONABLY CONSISTENT

MATRIX OF LEVEL III PAIRED COMPARISONS
WITH RESPECT TO: D. SERVICE-ABILITY

	D-1	D-2	D-3	D-4	D-5
D-1 STORAGE CAPACITY	1.000	1.207	2.193	2.187	1.662
D-2 UNLOADING EASE	0.829	1.000	1.092	1.591	0.865
D-3 UNLOADING TIME	0.456	0.916	1.000	1.609	2.087
D-4 COIN CAPACITY	0.457	0.629	0.622	1.000	2.067
D-5 ACCESSIBILITY	0.602	1.156	0.479	0.484	1.000
TOTALS	3.343	4.907	5.386	6.871	7.681

NORMALIZED MATRIX OF
LEVEL III PAIRED COMPARISONS
WITH RESPECT TO: D. SERVICE-ABILITY

	D-1	D-2	D-3	D-4	D-5	ROW SUM	AVG
D-1 STORAGE CAPACITY	0.299	0.246	0.407	0.318	0.216	1.487	0.297
D-2 UNLOADING EASE	0.248	0.204	0.203	0.232	0.113	0.999	0.200
D-3 UNLOADING TIME	0.136	0.187	0.186	0.234	0.272	1.015	0.203
D-4 COIN CAPACITY	0.137	0.128	0.115	0.146	0.269	0.795	0.159
D-5 ACCESSIBILITY	0.180	0.236	0.089	0.070	0.130	0.705	0.141
TOTALS	1.000	1.000	1.000	1.000	1.000		1.000

CALCULATION OF CONSISTENCY RATIO (C.R.)

1.000	1.207	2.193	2.187	1.662			0.297
0.829	1.000	1.092	1.591	0.865			0.200
0.456	0.916	1.000	1.609	2.087		X	0.203
0.457	0.629	0.622	1.000	2.067			0.159
0.602	1.156	0.479	0.484	1.000			0.141

	1.5654		5.2641
	1.0425		5.2206
=	1.0715	D =	5.2806
	0.8380		5.2716
	0.7249		5.1407
		LAMBDA MAX =	5.2355

$$CI = \frac{\text{LAMDA MAX} - N}{N - 1} = 0.06$$

GIVEN: N	1	2	3	4	5	6	7
R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32

$$C.R. = \frac{CI}{RI} = \frac{0.06}{1.12} = 0.05$$

0.05 < .10 ...PAIRWISE COMPARISON IS REASONABLY CONSISTENT

MATRIX OF LEVEL III PAIRED COMPARISONS
WITH RESPECT TO: E. MACHINE DESIGN

	E-1	E-2
E-1 PROCESS ACCCURACY	1.000	1.887
E-2 DURABILITY	0.530	1.000
TOTALS	1.530	2.887

NORMALIZED MATRIX OF
LEVEL III PAIRED COMPARISONS
WITH RESPECT TO: E. MACHINE DESIGN

	E-1	E-2	ROW SUM	AVG
E-1 PROCESS ACCCURACY	0.654	0.654	1.307	0.654
E-2 DURABILITY	0.346	0.346	0.693	0.346
TOTALS	1.000	1.000		1.000

CALCULATION OF CONSISTENCY RATIO (C.R.)

1.000	1.887		0.654
0.530	1.000	X	0.346

$$= \frac{1.307}{0.693} \qquad D = 2.00$$

LAMBDA MAX = 2.00

$$CI = \frac{\text{LAMDA MAX} - N}{N - 1} = 0.00$$

GIVEN:

N	1	2	3	4	5	6	7
R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32

$$C.R. = \frac{CI}{RI} = \frac{0.00}{0.00}$$

...PAIRWISE COMPARISON IS REASONABLY CONSISTENT

ALTERNATIVES
MATRIX OF LEVEL IV PAIRED COMPARISONS
WITH RESPECT TO: A-1 INITIAL COST

	PP	P-II	P-III
PP	1.000	4.760	3.973
P-II	0.210	1.000	0.760
P-III	0.252	1.316	1.000
TOTALS	1.462	7.076	5.733

NORMALIZED MATRIX OF
LEVEL IV PAIRED COMPARISONS
WITH RESPECT TO: A-1 INITIAL COST

	PP	P-II	P-III	ROW SUM	AVG
PP	0.684	0.673	0.693	2.050	0.683
P-II	0.144	0.141	0.133	0.418	0.139
P-III	0.172	0.186	0.174	0.533	0.178
TOTALS	1.000	1.000	1.000		1.000

CALCULATION OF CONSISTENCY RATIO (C.R.)

1.000	4.760	3.973			0.683
0.210	1.000	0.760		X	0.139
0.252	1.316	1.000			0.178

$$= \begin{matrix} 2.051 \\ 0.418 \\ 0.533 \end{matrix} \qquad D = \begin{matrix} 3.00 \\ 3.00 \\ 3.00 \end{matrix}$$

LAMBDA MAX = 3.00

$$CI = \frac{\text{LAMDA MAX} - N}{N - 1} = 0.00$$

GIVEN: N	1	2	3	4	5	6	7
R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32

$$C.R. = \frac{CI}{RI} = \frac{0.00}{0.58} = 0.00$$

0.00 < .10 ...PAIRWISE COMPARISON IS REASONABLY CONSISTENT

ALTERNATIVES
MATRIX OF LEVEL IV PAIRED COMPARISONS
WITH RESPECT TO: A-2 EXPECTED LIFE

	PP	P-II	P-III
PP	1.000	1.373	0.756
P-II	0.728	1.000	1.003
P-III	1.323	0.997	1.000
TOTALS	3.051	3.370	2.759

NORMALIZED MATRIX OF
LEVEL IV PAIRED COMPARISONS
WITH RESPECT TO: A-2 EXPECTED LIFE

	PP	P-II	P-III	ROW SUM	AVG
PP	0.328	0.407	0.274	1.009	0.336
P-II	0.239	0.297	0.364	0.899	0.300
P-III	0.434	0.296	0.362	1.092	0.364
TOTALS	1.000	1.000	1.000		1.000

CALCULATION OF CONSISTENCY RATIO (C.R.)

1.000	1.373	0.756	0.336
0.728	1.000	1.003	X 0.300
1.323	0.997	1.000	0.364

	1.023		3.04
=	0.910	D =	3.04
	1.108		3.04
		LAMBDA MAX =	3.04

$$CI = \frac{\text{LAMDA MAX} - N}{N - 1} = 0.02$$

GIVEN: N	1	2	3	4	5	6	7
R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32

$$C.R. = \frac{CI}{RI} = \frac{0.02}{0.58} = 0.03$$

0.03 < .10 ...PAIRWISE COMPARISON IS REASONABLY CONSISTENT

ALTERNATIVES
MATRIX OF LEVEL IV PAIRED COMPARISONS
WITH RESPECT TO: A-3 OPERATING COST

	PP	P-II	P-III
PP	1.000	3.135	3.138
P-II	0.319	1.000	1.195
P-III	0.319	0.837	1.000
TOTALS	1.638	4.972	5.333

NORMALIZED MATRIX OF
LEVEL IV PAIRED COMPARISONS
WITH RESPECT TO: A-3 OPERATING COST

	PP	P-II	P-III	ROW SUM	AVG
PP	0.611	0.631	0.588	1.830	0.610
P-II	0.195	0.201	0.224	0.620	0.207
P-III	0.195	0.168	0.188	0.550	0.183
TOTALS	1.000	1.000	1.000		1.000

CALCULATION OF CONSISTENCY RATIO (C.R.)

1.000	3.135	3.138		0.610
0.319	1.000	1.195	X	0.207
0.319	0.837	1.000		0.183

	1.833		3.01
=	0.620	D =	3.00
	0.551		3.00
		LAMBDA MAX =	3.00

$$CI = \frac{\text{LAMDA MAX} - N}{N - 1} = 0.00$$

GIVEN: N	1	2	3	4	5	6	7
R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32

$$C.R. = \frac{CI}{RI} = \frac{0.00}{0.58} = 0.00$$

0.00 < .10 ...PAIRWISE COMPARISON IS REASONABLY CONSISTENT

ALTERNATIVES
MATRIX OF LEVEL IV PAIRED COMPARISONS
WITH RESPECT TO: B-1 MONEY ACCURACY

	PP	P-II	P-III
PP	1.000	0.898	0.898
P-II	1.114	1.000	0.911
P-III	1.114	1.098	1.000
TOTALS	3.227	2.996	2.809

NORMALIZED MATRIX OF
LEVEL IV PAIRED COMPARISONS
WITH RESPECT TO: B-1 MONEY ACCURACY

	PP	P-II	P-III	ROW SUM	AVG
PP	0.310	0.300	0.320	0.929	0.310
P-II	0.345	0.334	0.324	1.003	0.334
P-III	0.345	0.366	0.356	1.067	0.356
TOTALS	1.000	1.000	1.000		1.000

CALCULATION OF CONSISTENCY RATIO (C.R.)

1.000	0.898	0.898		0.310
1.114	1.000	0.911	X	0.334
1.114	1.098	1.000		0.356

	0.930		3.00
=	1.004	D =	3.00
	1.068		3.00

LAMBDA MAX = 3.00

$$CI = \frac{\text{LAMDA MAX} - N}{N - 1} = 0.00$$

N	1	2	3	4	5	6	7
R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32

GIVEN:

$$C.R. = \frac{CI}{RI} = \frac{0.00}{0.58} = 0.00$$

0.00 < .10 ...PAIRWISE COMPARISON IS REASONABLY CONSISTENT

ALTERNATIVES
MATRIX OF LEVEL IV PAIRED COMPARISONS
WITH RESPECT TO: B-2 CYCLE TIME

	PP	P-II	P-III
PP	1.000	1.162	1.162
P-II	0.861	1.000	0.920
P-III	0.861	1.087	1.000
TOTALS	2.721	3.249	3.082

NORMALIZED MATRIX OF
LEVEL IV PAIRED COMPARISONS
WITH RESPECT TO: B-2 CYCLE TIME

	PP	P-II	P-III	ROW SUM	AVG
PP	0.367	0.358	0.377	1.102	0.367
P-II	0.316	0.308	0.299	0.923	0.308
P-III	0.316	0.335	0.324	0.975	0.325
TOTALS	1.000	1.000	1.000		1.000

CALCULATION OF CONSISTENCY RATIO (C.R.)

$$\begin{vmatrix} 1.000 & 1.162 & 1.162 \\ 0.861 & 1.000 & 0.920 \\ 0.861 & 1.087 & 1.000 \end{vmatrix} \times \begin{matrix} 0.367 \\ 0.308 \\ 0.325 \end{matrix}$$

$$= \begin{matrix} 1.102 \\ 0.923 \\ 0.976 \end{matrix} \qquad D = \begin{matrix} 3.00 \\ 3.00 \\ 3.00 \end{matrix}$$

LAMBDA MAX = 3.00

$$CI = \frac{\text{LAMDA MAX} - N}{N - 1} = 0.00$$

GIVEN: N	1	2	3	4	5	6	7
R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32

$$C.R. = \frac{CI}{RI} = \frac{0.00}{0.58} = 0.00$$

0.00 < .10 ...PAIRWISE COMPARISON IS REASONABLY CONSISTENT

ALTERNATIVES
MATRIX OF LEVEL IV PAIRED COMPARISONS
WITH RESPECT TO: B-3 EASE OF USE

	PP	P-II	P-III
PP	1.000	1.063	1.063
P-II	0.941	1.000	0.920
P-III	0.941	1.087	1.000
TOTALS	2.881	3.150	2.983

NORMALIZED MATRIX OF
LEVEL IV PAIRED COMPARISONS
WITH RESPECT TO: B-3 EASE OF USE

	PP	P-II	P-III	ROW SUM	AVG
PP	0.347	0.337	0.356	1.041	0.347
P-II	0.326	0.317	0.308	0.952	0.317
P-III	0.326	0.345	0.335	1.007	0.336
TOTALS	1.000	1.000	1.000		1.000

CALCULATION OF CONSISTENCY RATIO (C.R.)

1.000	1.063	1.063		0.347
0.941	1.000	0.920	X	0.317
0.941	1.087	1.000		0.336

	1.041		3.00
=	0.953	D =	3.00
	1.007		3.00

LAMBDA MAX = 3.00

$$CI = \frac{\text{LAMDA MAX} - N}{N - 1} = 0.00$$

N	1	2	3	4	5	6	7
R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32

GIVEN:

$$C.R. = \frac{CI}{RI} = \frac{0.00}{0.58} = 0.00$$

0.00 < .10 ...PAIRWISE COMPARISON IS REASONABLY CONSISTENT

ALTERNATIVES
MATRIX OF LEVEL IV PAIRED COMPARISONS
WITH RESPECT TO: B-4 APPEARANCE

	PP	P-II	P-III
PP	1.000	3.395	3.265
P-II	0.295	1.000	0.922
P-III	0.306	1.085	1.000
TOTALS	1.601	5.480	5.187

NORMALIZED MATRIX OF
LEVEL IV PAIRED COMPARISONS
WITH RESPECT TO: B-4 APPEARANCE

	PP	P-II	P-III	ROW SUM	AVG
PP	0.625	0.620	0.629	1.874	0.625
P-II	0.184	0.182	0.178	0.544	0.181
P-III	0.191	0.198	0.193	0.582	0.194
TOTALS	1.000	1.000	1.000		1.000

CALCULATION OF CONSISTENCY RATIO (C.R.)

1.000	3.395	3.265		0.625
0.295	1.000	0.922	X	0.181
0.306	1.085	1.000		0.194

	1.874		3.00
=	0.544	D =	3.00
	0.582		3.00

LAMBDA MAX = 3.00

$$CI = \frac{\text{LAMDA MAX} - N}{N - 1} = 0.00$$

GIVEN:

N	1	2	3	4	5	6	7
R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32

$$C.R. = \frac{CI}{RI} = \frac{0.00}{0.58} = 0.00$$

0.00 < .10 ...PAIRWISE COMPARISON IS REASONABLY CONSISTENT

ALTERNATIVES
MATRIX OF LEVEL IV PAIRED COMPARISONS
WITH RESPECT TO: C-2 DOWNTIME

	PP	P-II	P-III
PP	1.000	1.893	2.092
P-II	0.528	1.000	0.837
P-III	0.478	1.195	1.000
TOTALS	2.006	4.088	3.929

NORMALIZED MATRIX OF
LEVEL IV PAIRED COMPARISONS
WITH RESPECT TO: C-2 DOWNTIME

	PP	P-II	P-III	ROW SUM	AVG
PP	0.498	0.463	0.532	1.494	0.498
P-II	0.263	0.245	0.213	0.721	0.240
P-III	0.238	0.292	0.255	0.785	0.262
TOTALS	1.000	1.000	1.000		1.000

CALCULATION OF CONSISTENCY RATIO (C.R.)

1.000	1.893	2.092	0.498
0.528	1.000	0.837	X 0.240
0.478	1.195	1.000	0.262

$$= \begin{matrix} 1.500 \\ 0.722 \\ 0.787 \end{matrix} \qquad D = \begin{matrix} 3.01 \\ 3.01 \\ 3.01 \end{matrix}$$

LAMBDA MAX = 3.01

$$CI = \frac{\text{LAMDA MAX} - N}{N - 1} = 0.00$$

N	1	2	3	4	5	6	7
GIVEN: R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32

$$C.R. = \frac{CI}{RI} = \frac{0.00}{0.58} = 0.00$$

0.00 < .10 ...PAIRWISE COMPARISON IS REASONABLY CONSISTENT

ALTERNATIVES
MATRIX OF LEVEL IV PAIRED COMPARISONS
WITH RESPECT TO: C-1 OUTAGES PER 3,000 LBS

	PP	P-II	P-III
PP	1.000	1.926	2.128
P-II	0.519	1.000	1.170
P-III	0.470	0.855	1.000
TOTALS	1.989	3.781	4.298

NORMALIZED MATRIX OF
LEVEL IV PAIRED COMPARISONS
WITH RESPECT TO: C-1 OUTAGES PER 3,000 LBS

	PP	P-II	P-III	ROW SUM	AVG
PP	0.503	0.509	0.495	1.507	0.502
P-II	0.261	0.265	0.272	0.798	0.266
P-III	0.236	0.226	0.233	0.695	0.232
TOTALS	1.000	1.000	1.000		1.000

CALCULATION OF CONSISTENCY RATIO (C.R.)

1.000	1.926	2.128		0.502
0.519	1.000	1.170	X	0.266
0.470	0.855	1.000		0.232

	1.508		3.00
=	0.798	D =	3.00
	0.695		3.00

LAMBDA MAX = 3.00

$$CI = \frac{\text{LAMDA MAX} - N}{N - 1} = 0.00$$

N	1	2	3	4	5	6	7
R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32

GIVEN:

$$C.R. = \frac{CI}{RI} = \frac{0.00}{0.58} = 0.00$$

0.00 < .10 ...PAIRWISE COMPARISON IS REASONABLY CONSISTENT

ALTERNATIVES
MATRIX OF LEVEL IV PAIRED COMPARISONS
WITH RESPECT TO: C-3 MAINTENANCE COST

	PP	P-II	P-III
PP	1.000	2.021	2.230
P-II	0.495	1.000	0.892
P-III	0.448	1.121	1.000
TOTALS	1.943	4.142	4.122

NORMALIZED MATRIX OF
LEVEL IV PAIRED COMPARISONS
WITH RESPECT TO: C-3 MAINTENANCE COST

	PP	P-II	P-III	ROW SUM	AVG
PP	0.515	0.488	0.541	1.544	0.515
P-II	0.255	0.241	0.216	0.712	0.237
P-III	0.231	0.271	0.243	0.744	0.248
TOTALS	1.000	1.000	1.000		1.000

CALCULATION OF CONSISTENCY RATIO (C.R.)

1.000	2.021	2.230		0.515
0.495	1.000	0.892	X	0.237
0.448	1.121	1.000		0.248

	1.548		3.01
=	0.713	D =	3.00
	0.745		3.00

LAMBDA MAX = 3.01

$$CI = \frac{\text{LAMDA MAX} - N}{N - 1} = 0.00$$

N	1	2	3	4	5	6	7
GIVEN: R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32

$$C.R. = \frac{CI}{RI} = \frac{0.00}{0.58} = 0.00$$

0.00 < .10 ...PAIRWISE COMPARISON IS REASONABLY CONSISTENT

ALTERNATIVES
MATRIX OF LEVEL IV PAIRED COMPARISONS
WITH RESPECT TO: D-1 STORAGE CAPACITY

	PP	P-II	P-III
PP	1.000	0.811	0.910
P-II	1.233	1.000	2.120
P-III	1.099	0.472	1.000
TOTALS	3.332	2.283	4.030

NORMALIZED MATRIX OF
LEVEL IV PAIRED COMPARISONS
WITH RESPECT TO: D-1 STORAGE CAPACITY

	PP	P-II	P-III	ROW SUM	AVG
PP	0.300	0.355	0.226	0.881	0.294
P-II	0.370	0.438	0.526	1.334	0.445
P-III	0.330	0.207	0.248	0.785	0.262
TOTALS	1.000	1.000	1.000		1.000

CALCULATION OF CONSISTENCY RATIO (C.R.)

1.000	0.811	0.910			0.294
1.233	1.000	2.120		X	0.445
1.099	0.472	1.000			0.262

	0.892		3.04
=	1.361	D =	3.06
	0.794		3.04

LAMBDA MAX = 3.05

$$CI = \frac{\text{LAMDA MAX} - N}{N - 1} = 0.02$$

GIVEN: N	1	2	3	4	5	6	7
R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32

$$C.R. = \frac{CI}{RI} = \frac{0.02}{0.58} = 0.03$$

0.03 < .10 ...PAIRWISE COMPARISON IS REASONABLY CONSISTENT

ALTERNATIVES
MATRIX OF LEVEL IV PAIRED COMPARISONS
WITH RESPECT TO: D-2 UNLOADING EASE

	PP	P-II	P-III
PP	1.000	0.446	0.638
P-II	2.242	1.000	3.990
P-III	1.567	0.251	1.000
TOTALS	4.810	1.697	5.628

NORMALIZED MATRIX OF
LEVEL IV PAIRED COMPARISONS
WITH RESPECT TO: D-2 UNLOADING EASE

	PP	P-II	P-III	ROW SUM	AVG
PP	0.208	0.263	0.113	0.584	0.195
P-II	0.466	0.589	0.709	1.765	0.588
P-III	0.326	0.148	0.178	0.651	0.217
TOTALS	1.000	1.000	1.000		1.000

CALCULATION OF CONSISTENCY RATIO (C.R.)

1.000	0.446	0.638			0.195
2.242	1.000	3.990		X	0.588
1.567	0.251	1.000			0.217

	0.596		3.06
=	1.891	D =	3.21
	0.670		3.08

LAMBDA MAX = 3.12

$$CI = \frac{\text{LAMDA MAX} - N}{N - 1} = 0.06$$

GIVEN: N	1	2	3	4	5	6	7
R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32

$$C.R. = \frac{CI}{RI} = \frac{0.06}{0.58} = 0.10$$

0.10 = .10 ...PAIRWISE COMPARISON IS REASONABLY CONSISTENT

ALTERNATIVES
MATRIX OF LEVEL IV PAIRED COMPARISONS
WITH RESPECT TO: D-3 UNLOADING TIME

	PP	P-II	P-III
PP	1.000	0.506	0.625
P-II	1.976	1.000	3.044
P-III	1.600	0.329	1.000
TOTALS	4.576	1.835	4.669

NORMALIZED MATRIX OF
LEVEL IV PAIRED COMPARISONS
WITH RESPECT TO: D-3 UNLOADING TIME

	PP	P-II	P-III	ROW SUM	AVG
PP	0.219	0.276	0.134	0.628	0.209
P-II	0.432	0.545	0.652	1.629	0.543
P-III	0.350	0.179	0.214	0.743	0.248
TOTALS	1.000	1.000	1.000		1.000

CALCULATION OF CONSISTENCY RATIO (C.R.)

1.000	0.506	0.625			0.209
1.976	1.000	3.044		X	0.543
1.600	0.329	1.000			0.248

	0.639		3.05
=	1.711	D =	3.15
	0.761		3.07

LAMBDA MAX = 3.09

$$CI = \frac{\text{LAMDA MAX} - N}{N - 1} = 0.05$$

GIVEN:

N	1	2	3	4	5	6	7
R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32

$$C.R. = \frac{CI}{RI} = \frac{0.05}{0.58} = 0.09$$

0.09 < .10 ...PAIRWISE COMPARISON IS REASONABLY CONSISTENT

ALTERNATIVES
MATRIX OF LEVEL IV PAIRED COMPARISONS
WITH RESPECT TO: D-4 COIN CAPACITY

	PP	P-II	P-III
PP	1.000	1.307	1.307
P-II	0.765	1.000	0.920
P-III	0.765	1.087	1.000
TOTALS	2.530	3.394	3.227

NORMALIZED MATRIX OF
LEVEL IV PAIRED COMPARISONS
WITH RESPECT TO: D-4 COIN CAPACITY

	PP	P-II	P-III	ROW SUM	AVG
PP	0.395	0.385	0.405	1.185	0.395
P-II	0.302	0.295	0.285	0.882	0.294
P-III	0.302	0.320	0.310	0.933	0.311
TOTALS	1.000	1.000	1.000		1.000

CALCULATION OF CONSISTENCY RATIO (C.R.)

1.000	1.307	1.307		0.395
0.765	1.000	0.920	X	0.294
0.765	1.087	1.000		0.311

	1.186		3.00
=	0.882	D =	3.00
	0.933		3.00

LAMBDA MAX = 3.00

$$CI = \frac{\text{LAMDA MAX} - N}{N - 1} = 0.00$$

N	1	2	3	4	5	6	7
R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32

GIVEN:

$$C.R. = \frac{CI}{RI} = \frac{0.00}{0.58} = 0.00$$

0.00 < .10 ...PAIRWISE COMPARISON IS REASONABLY CONSISTENT

ALTERNATIVES
MATRIX OF LEVEL IV PAIRED COMPARISONS
WITH RESPECT TO: D-5 ACCESSIBILITY

	PP	P-II	P-III
PP	1.000	1.123	1.646
P-II	0.890	1.000	3.520
P-III	0.608	0.284	1.000
TOTALS	2.498	2.407	6.166

NORMALIZED MATRIX OF
LEVEL IV PAIRED COMPARISONS
WITH RESPECT TO: D-5 ACCESSIBILITY

	PP	P-II	P-III	ROW SUM	AVG
PP	0.400	0.467	0.267	1.134	0.378
P-II	0.356	0.415	0.571	1.343	0.448
P-III	0.243	0.118	0.162	0.523	0.174
TOTALS	1.000	1.000	1.000		1.000

CALCULATION OF CONSISTENCY RATIO (C.R.)

1.000	1.123	1.646			0.378
0.890	1.000	3.520		X	0.448
0.608	0.284	1.000			0.174

	1.168		3.09
=	1.398	D =	3.12
	0.531		3.04

LAMBDA MAX = 3.09

$$CI = \frac{\text{LAMDA MAX} - N}{N - 1} = 0.04$$

GIVEN: N	1	2	3	4	5	6	7
R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32

$$C.R. = \frac{CI}{RI} = \frac{0.04}{0.58} = 0.07$$

0.07 < .10 ...PAIRWISE COMPARISON IS REASONABLY CONSISTENT

ALTERNATIVES
MATRIX OF LEVEL IV PAIRED COMPARISONS
WITH RESPECT TO: E-1 PROCESS ACCURACY

	PP	P-II	P-III
PP	1.000	0.351	0.351
P-II	2.849	1.000	1.000
P-III	2.849	1.000	1.000
TOTALS	6.698	2.351	2.351

NORMALIZED MATRIX OF
LEVEL IV PAIRED COMPARISONS
WITH RESPECT TO: E-1 PROCESS ACCURACY

	PP	P-II	P-III	ROW SUM	AVG
PP	0.149	0.149	0.149	0.448	0.149
P-II	0.425	0.425	0.425	1.276	0.425
P-III	0.425	0.425	0.425	1.276	0.425
TOTALS	1.000	1.000	1.000		1.000

CALCULATION OF CONSISTENCY RATIO (C.R.)

1.000	0.351	0.351	0.149
2.849	1.000	1.000	X 0.425
2.849	1.000	1.000	0.425

$$= \begin{matrix} 0.448 \\ 1.276 \\ 1.276 \end{matrix} \qquad D = \begin{matrix} 3.00 \\ 3.00 \\ 3.00 \end{matrix}$$

LAMBDA MAX = 3.00

$$CI = \frac{\text{LAMDA MAX} - N}{N - 1} = 0.00$$

N	1	2	3	4	5	6	7
GIVEN: R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32

$$C.R. = \frac{CI}{RI} = \frac{0.00}{0.58} = 0.00$$

0.00 < .10 ...PAIRWISE COMPARISON IS REASONABLY CONSISTENT

ALTERNATIVES
MATRIX OF LEVEL IV PAIRED COMPARISONS
WITH RESPECT TO: E-2 DURABILITY

	PP	P-II	P-III
PP	1.000	1.115	1.116
P-II	0.897	1.000	1.700
P-III	0.896	0.588	1.000
TOTALS	2.793	2.703	3.816

NORMALIZED MATRIX OF
LEVEL IV PAIRED COMPARISONS
WITH RESPECT TO: E-2 DURABILITY

	PP	P-II	P-III	ROW SUM	AVG
PP	0.358	0.412	0.292	1.063	0.354
P-II	0.321	0.370	0.445	1.137	0.379
P-III	0.321	0.218	0.262	0.800	0.267
TOTALS	1.000	1.000	1.000		1.000

CALCULATION OF CONSISTENCY RATIO (C.R.)

1.000	1.115	1.116		0.354
0.897	1.000	1.700	X	0.379
0.896	0.588	1.000		0.267

	1.075		3.03
=	1.150	D =	3.04
	0.807		3.03

LAMBDA MAX = 3.03

$$CI = \frac{\text{LAMDA MAX} - N}{N - 1} = 0.02$$

GIVEN:

N	1	2	3	4	5	6	7
R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32

$$C.R. = \frac{CI}{RI} = \frac{0.02}{0.58} = 0.03$$

0.03 < .10 ...PAIRWISE COMPARISON IS REASONABLY CONSISTENT

SUBATTRIBUTE: NET PRESENT WORTH

	A-1	A-2	A-3	
WEIGHT	0.334	0.232	0.434	ALT.
ALTERNATIVE				PRIORITY WEIGHT
PP	0.683	0.336	0.610	0.571
P-II	0.139	0.300	0.207	0.206
P-III	0.178	0.364	0.183	0.223
				1.00

SUBATTRIBUTE: CUSTOMER INTERFACE

	B-1	B-2	B-3	B-4	
WEIGHT	0.548	0.155	0.228	0.069	ALT.
ALTERNATIVE					PRIORITY WEIGHT
PP	0.310	0.367	0.347	0.625	0.349
P-II	0.334	0.308	0.317	0.181	0.316
P-III	0.356	0.325	0.336	0.194	0.335
					1.00

SUBATTRIBUTE: RELIABILITY

	C-1	C-2	C-3	
WEIGHT	0.454	0.392	0.154	ALT.
ALTERNATIVE				PRIORITY WEIGHT
PP	0.502	0.498	0.515	0.502
P-II	0.266	0.240	0.237	0.251
P-III	0.232	0.262	0.248	0.246
				1.00

SUBATTRIBUTE: SERVICE-ABILITY

	D-1	D-2	D-3	D-4	D-5	
WEIGHT	0.297	0.200	0.203	0.159	0.141	ALT.
ALTERNATIVE						PRIORITY WEIGHT
PP	0.294	0.195	0.209	0.395	0.378	0.285
P-II	0.445	0.588	0.543	0.294	0.448	0.470
P-III	0.262	0.217	0.248	0.311	0.174	0.246
						1.00

SUBATTRIBUTE: MACHINE DESIGN

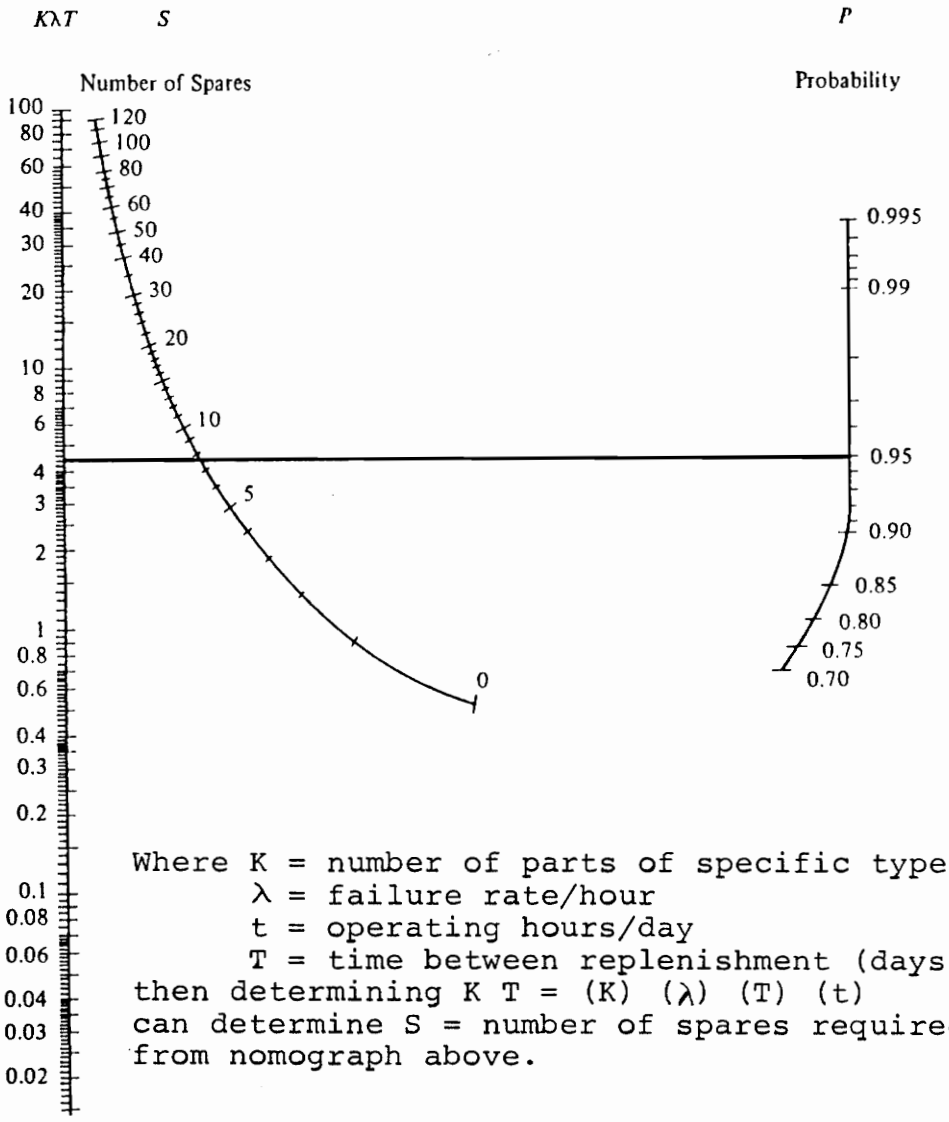
	E-1	E-2	
WEIGHT	0.654	0.346	ALT.
ALTERNATIVE			PRIORITY WEIGHT
PP	0.149	0.354	0.220
P-II	0.425	0.379	0.409
P-III	0.425	0.267	0.370
			1.00

	ATTRIBUTE					
	A	B	C	D	E	
	NET PRESENT WORTH	CUSTOMER INTERFACE	RELIABILITY	SERVICE-ABILITY	MACHINE DESIGN	
WEIGHT	0.085	0.154	0.481	0.207	0.074	ALT. PRIORITY WEIGHT
ALTERNATIVE						
PP	0.571	0.349	0.502	0.285	0.220	0.419
P-II	0.206	0.316	0.251	0.470	0.409	0.315
P-III	0.223	0.335	0.246	0.246	0.370	0.267
	1.00	1.00	1.00	1.00	1.00	1.00

APPENDIX K

SPARE SUB-ASSEMBLY REQUIREMENTS

Appendix K provides the spare sub-assembly requirements for each configuration. Figuire K-1 explains the derivation of requirements. Tables K-1, K-2, and K-3 contain the spare sub-assembly requirements for each alternative. Tables K-4, K-5, and K-6 contain the cost for the derived requirements for each alternative machine.



Where K = number of parts of specific type
λ = failure rate/hour
t = operating hours/day
T = time between replenishment (days)
then determining K T = (K) (λ) (T) (t)
can determine S = number of spares required from nomograph above.

Spare Part Requirement Determination (3)

Figure K-1

Table K-1

PP Machine 1
Spare Parts Requirements

	Assembly	λ/Assembly (bd/hr)	Quantity of Assemblies	λ/Assembly (Quantity)	2 KλT	3,4 Assemblies Required
1	Input Device	0.001546	1	0.001546	6.40044	10
2	Input Conveyor	0.000992	1	0.000992	4.10688	6
3	Air Classifier	0.002061	1	0.002061	8.53254	12
4	Weigh System	0.000004	1	0.000004	0.01656	1
5	Flattener	0.001195	1	0.001195	4.94730	8
6	Blower	0.001198	1	0.001198	4.95972	8
7	Pay System	0.000986	1	0.000986	4.08204	7
8	Computer	0.000001	1	0.000001	0.00414	1

Sum of λ/Assembly = 0.007983 bd/hr

1. For a module of 50 machines.
2. K = 50, T = 30 days, t = 2.76 hrs/day, P = 90%
3. Fractional 'Assemblies Required' were rounded up.
4. Whenever 0 assemblies were required, a nominal 1 was was used.

Table K-2

P-II Machine 1
Spare Parts Requirements

	Assembly	λ/Assembly (bd/hr)	Quantity of Assemblies	λ/Assembly (Quantity)	2 KλT	3,4 Assemblies Required
1	Input Device	0.001443	1	0.001443	4.06926	6
2	Input Conveyor	0.000855	1	0.000855	2.41110	4
3	Cross Conveyor	0.000792	1	0.000792	2.23344	4
4	Air Classifier	0.003623	1	0.003623	10.21686	14
5	Weigh System	0.000002	1	0.000002	0.00564	1
6	Flattener	0.001194	1	0.001194	3.36708	6
7	Blower	0.001004	1	0.001004	2.83128	4
8	Pay System	0.000432	1	0.000432	1.21824	3
9	Computer	0.000001	1	0.000001	0.00282	1
10	Unloading System	0.003854	1	0.003854	10.86828	15

Sum of λ/Assembly = 0.0132 bd/hr

1. For a module of 50 machines.
2. K = 50, T = 30 days, t = 1.88 hrs/day, P = 90%
3. Fractional 'Assemblies Required' were rounded up.
4. Whenever 0 assemblies were required, a nominal 1 was was used.

Table K-3

P-III Machine 1
Spare Parts Requirements

	Assembly	λ/Assembly (bd/hr)	Quantity of Assemblies	λ/Assembly (Quantity)	$K\lambda T^2$	Assemblies Required[3,4]
1	Input Device	0.003129	1	0.003129	6.99332	10
2	Input Conveyor	0.002888	1	0.002888	6.45468	10
3	Cross Conveyor	0.001986	1	0.001986	4.43871	7
4	Air Classifier	0.004522	1	0.004522	10.10667	14
5	Weigh System	0.000002	1	0.000002	0.00447	1
6	Flattener	0.001186	1	0.001186	2.65071	5
7	Blower	0.001094	2	0.002188	4.89018	8
8	Pay System	0.000432	1	0.000432	0.96552	2
9	Computer	0.000001	1	0.000001	0.00224	1
10	Unloading System	0.009472	1	0.009472	21.16992	28

Sum of λ'Assembly = 0.025806 bd/hr

1. For a module of 50 machines.
2. K = 50, T = 30 days, t = 1.49 hrs/day, P = 90%
3. Fractional 'Assemblies Required' were rounded up.
4. Whenever 0 assemblies were required, a nominal 1 was was used.

Table K-4

PP Machine 1
Spare Parts Cost

	Assembly	Cost Per Assembly ($)	2 Assemblies Required	Total cost ($)
1	Input Device	542.00	10	5420.00
2	Input Conveyor	1582.00	6	9492.00
3	Air Classifier	865.00	12	10380.00
4	Weigh System	964.00	1	964.00
5	Flattener	1575.00	8	12600.00
6	Blower	1350.00	8	10800.00
7	Pay System	850.00	7	5950.00
8	Computer	1890.00	1	1890.00

$57,496.00

1. For a module of 50 machines.
2. Values from Table K-1.

Table K-5

P-II Machine 1
Spare Parts Cost

	Assembly	Cost Per Assembly ($)	2 Assemblies Required	Total cost ($)
1	Input Device	778.00	6	4668.00
2	Input Conveyor	3152.00	4	12608.00
3	Cross Conveyor	3054.00	4	12216.00
4	Air Classifier	552.00	14	7728.00
5	Weigh System	1542.00	1	1542.00
6	Flattener	1974.00	6	11844.00
7	Blower	1548.00	4	6192.00
8	Pay System	1688.00	3	5064.00
9	Computer	2035.00	1	2035.00
10	Unloading System	5336.00	15	80040.00

$143,937.00

1. For a module of 50 machines.
2. Values from Table K-2.

Table K-6

P-III Machine 1
Spare Parts Cost

	Assembly	Cost Per Assembly ($)	2 Assemblies Required	Total cost ($)
1	Input Device	662.00	6	3972.00
2	Input Conveyor	2315.00	4	9260.00
3	Cross Conveyor	2883.00	4	11532.00
4	Air Classifier	552.00	14	7728.00
5	Weigh System	1253.00	1	1253.00
6	Flattener	1974.00	6	11844.00
7	Blower	1342.00	4	5368.00
8	Pay System	1658.00	3	4974.00
9	Computer	2035.00	1	2035.00
10	Unloading System	1020.00	15	15300.00

$73,266.00

1. For a module of 50 machines.
2. Values from Table K-3.

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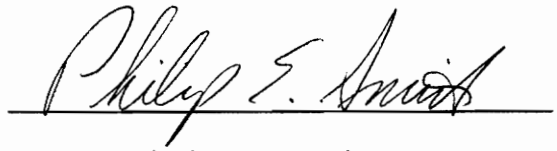
VITA

Philip E. Smith was born November 19, 1953, in Evansville, Indiana. He graduated from Trinity High School, Shiremanstown, Pennsylvania, in 1971. He attended the Herff's School of Engineering, Memphis State University where he earned a Bachelor of Science degree in Civil Engineering graduating in May, 1977. He also earned a Bachelor of Science degree in Mechanical Engineering in December, 1977.

After graduation, Phil began a career in the aluminum industry with Reynolds International, a subsidiary of Reynolds Metals Company where he served in various engineering capacities in Venezuela and Brazil.

Phil is now with the Recycling and Reclamation Division in Richmond, Virginia. In his current position as facility manager of the Process Development Center, he is involved in the development and testing of materials, products, and processes.

He began graduate studies in Systems Engineering at Virginia Polytechnic Institute and State University in September, 1986.



Philip E. Smith

Richmond, Virginia

April 16, 1990