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ECONOMIC ANALYSIS OF SOLVENT MANAGEMENT OPTIONS

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ENVIRONMENTAL PROTECTION
ECONOMIC ANALYSIS OF SOLVENT MANAGEMENT OPTIONS

1. Purpose. This Public Works Technical Bulletin (PWTB) transmits information useful for ascertaining the most economical method of complying with the DoD Used Solvent Elimination (USE) Program.

2. Applicability. This PWTB applies to all U.S. Army Public Works activities responsible for implementing the USE program at Army installations.

3. Reference. AR 200-1, Environmental Protection and Enhancement, 21 February 1997.

4. Discussion.

a. Most Army installations use large quantities of solvents in activities such as degreasing in industrial operations, cleaning vehicular parts in motor pools, or stripping paint. Many used solvents are hazardous wastes by definition, and must be managed in accordance with the most recent amendments to the Resource Conservation and Recovery Act. Other solvents, such as PD 680 type II (stoddard), are petroleum distillates and are not hazardous by definition; however, they can become contaminated with hazardous materials and therefore must be managed properly.

b. One of the biggest problems in managing solvents to comply with the USE program is economics. The manager must decide whether it is most cost-effective to recycle (1) on-post, (2) commercially, (3) with a full-service contractor, or (4) by burning in an approved or certified industrial boiler. Appendix A explains how to do a life-cycle cost (LCC) analysis for each of these four solvent management options. Results of the analysis can then be used to implement the USE program in the most cost effective manner.

5. Points of Contact. Questions and/or comments regarding this subject that cannot be resolved at the installation level should be directed to: US Army Corps of Engineers, CEMP-RI, 441 G Street, NW, Washington, DC, 20314-1000; or: US Army Engineer Research and Development Center, Construction Engineering Research Laboratory, at 1 (800) USA-CERL, for Mr. Bernard Donahue (e-mail: b-donahue@cecer.army.mil).

FOR THE COMMANDER:

/S/
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Chief, Installation Support Policy Branch

APPENDIX A
ECONOMIC ANALYSIS OF SOLVENT MANAGEMENT OPTIONS

1. The LCC analysis presented here* provides a way to select the most economical of the four available solvent management options: recycling on-post, recycling off-post, recycle by full service contract, and burning in industrial boilers. Tables A1 through A4, which are sample charts for each of the respective options, can be followed to make economic comparisons. Each chart has been partially filled with sample calculations. Each life-cycle comparison must be calculated for the same number of years so that the costs are comparable. Ten years is the anticipated equipment life, but 5 years may often be more appropriate. For this sample, the cost has been calculated for 3 years to show how to use the cost-calculation tables. The following steps are used to calculate life-cycle costs for solvent management. (Parenthetical letters that follow each step are keyed to appropriate columns of Tables A1 through A4 where calculations will be made.)

a. Determine the cost of new solvent to be purchased each year (column A).

b. Determine the cost of capital equipment or investment for each year (column B).

c. Determine recurring costs for each year (column C).

d. Calculate any cost-reducing factors, such as heating value, and enter the results as a negative figure (column D).

e. Calculate total annual cost by summary columns A, B, C, D (column X).

f. Calculate the present value for each year by multiplying the total annual cost by the present-value factors for each year (column Z).

g. Add the annual present-value factors for the lifetime of the project to arrive at the life-cycle cost (Total T).

2. Columns A, B, C, D, X, Y, Z in Tables A1 through A4 represent costs that must be calculated for each year. A brief explanation of what should be entered in each column appears at the bottom of each figure. Each explanation also refers to the tables that can be used to calculate costs to be entered in each column.** The sample values shown in the figures and tables are for a facility that uses 1000 gal of PD 680 type II (stoddard) solvent per year.

It should be noted that these values, prices, and wage rates differ for each installation and for each type of solvent being evaluated, and are given only as a sample; the user must verify or alter them to reflect his/her installation's conditions.

3. Normally when there is no existing solvent management program, the option with the lowest calculated LCC is selected for implementation. The LCC calculation method discussed above is normally used when the installation has no existing means of recycling/disposal. For example, it would be used if a new process were being set up that would require use of solvents. When the installation already has a recycling/disposal method, a primary analysis should be used. This type of economic analysis determines if a different option will produce dollar savings over a

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* Based on methodology provided in R.D. Neathammer, Economic Analysis Description and Methods, Technical Report P-151/ADA135280 (U.S. Army Construction Engineering Research Laboratory, 1983.)

** Information in Tables A5 to A27 corresponds to the columns in Tables A1 through A4 as noted in the table captions (e.g., Table A5 pertains to Column A in Tables A1 to A4).

reasonably short period of time. Table A5, which shows the calculation procedure to use in estimating the savings-to-investment ratio (SIR) and the discounted payback period (DPP), should be used to compare each feasible option with the existing method. The columns identified as A, B, and C in Table A5 represent the cost difference between the existing method and the proposed option(s). Columns X, Y, and Z show the savings during the period of 1 to 10 years. The information on page A-6 is also relevant to conducting a primary analysis. For a proposed option to be feasible, its SIR must be greater than 1.0 and its DPP less than 10 years. Usually, the option with highest SIR and lowest DPP would replace the existing method if it is found to be more economical.

Table A1. Sample LCC Calculation for Recycle On-Post.

Year	(A) Cost of New Solvent ($)	(B) Invest-ment ($)	(C) Recurring Cost ($)	(X) Total Annual Cost ($)	(Y) 10% Present Value Factor	(Z) Present Value ($)
0	-	15,139	-	15,139	1.000	15,139
1	793	0	7,755	8,548	.954	8,548
2	793	0	7,755	8,548	.867	8,155
3	793	0	7,755	8,548	.788	7,411
4	-	-	-	-	.717	-
5	-	-	-	-	.652	-
6	-	-	-	-	.592	-
7	-	-	-	-	.538	-
8	-	-	-	-	.489	-
9	-	-	-	-	.445	-
10	-	-	-	-	.405	-

(T) Total LCC ___________

(A) Cost of new solvent that must be purchased each year due to losses during use (35 to 40 percent of the total required solvents).

(B) Cost of the equipment needed to distill used solvent plus installation cost. (Calculate using Tables A8 through A11)

(C) Recurring costs. (Calculate using Tables A15 through A20)

- Labor required to tend the still and make minor repairs.
- Power required to operate the still.
- Materials, such as disposable still liners for the residue, etc.
- Maintenance on the still, such as replacing the heating element.
- Disposal cost of the sludge disposal through a hazardous waste disposal contractor.
- Testing to verify waste solvent quality.

(X) The total cost for each year -- columns A+B+C.

(Y) Present-value factors, using a 10 percent discount rate (taken from standard economic tables).

(T) LCC = the sum of all annual present-value costs for the life of the project (not totaled for this example).

Table A2. Sample LCC Calculation for Recycle Off-Post.

Year	(A) Cost of New Solvent ($)	(B) Invest-ment ($)	(C) Recurring Cost ($)	(X) Total Annual Cost ($)	(Y) 10% Present Value Factor	(Z) Present Value ($)
0	-	4353	-	4353	1.000	4353
1	793	0	1289	2082	.954	1986
2	793	0	1289	2082	.867	1805
3	793	0	1289	2082	.788	1641
4	-	-	-	-	.717	-
5	-	-	-	-	.652	-
6	-	-	-	-	.592	-
7	-	-	-	-	.538	-
8	-	-	-	-	.489	-
9	-	-	-	-	.445	-
10		-	-	-	.405	-

(T) Total LCC ___________

(A) Cost of new solvent that must be purchased each year due to losses during use and the refining processes. (A loss of 30 percent of new solvent is typical during use, with 5 to 10 percent being lost during refining; therefore, 35 to 40 percent of the total solvent requirement must be replaced.)

(B) Cost of the equipment used for storage and storage costs. (Calculate using Tables A12 and A13.)

(C) Recurring costs include testing, refining, labor, and transportation.(Calculate using Tables A20 through A23.)

(X) The total cost for each year -- columns A+B+C.

(Y) Present-value factors, using a 10 percent discount rate (taken from standard economic tables).

(Z) Present value for each year of projected operation -

(AA) Column X x column Y.

(BB) LCC = the sum of all annual present-value costs for the life of the project (not totaled for this example).

Table A3. Sample LCC calculation for solvent supply disposal by service contract.

Year	(A) Cost of New Solvent ($)	(B) Invest-ment ($)	(C) Recurring Cost ($)	(X) Total Annual Cost ($)	(Y) 10% Present Value Factor	(Z) Present Value ($)
0	-	-	-	0	1.000	0
1	-	-	3924	3924	.954	3743
2	-	-	3924	3924	.867	3402
3	-	-	3924	3924	.788	3092
4	-	-	-	-	.717	-
5	-	-	-	-	.652	-
6	-	-	-	-	.592	-
7	-	-	-	-	.538	-
8	-	-	-	-	.489	-
9	-	-	-	-	.445	-
10		-	-	-	.405	-

(T) Total LCC ___________

(A) Cost of new solvent (NA).

(B) Investment costs (NA).

(C) Recurring cost is the contractor's cost to supply a certain amount of new solvent for one year and to dispose of the waste solvent. (Calculate using Table A25.)

(X) The total cost for each year -- columns A+B+C.

(Y) Present-value factors, using a 10 percent discount rate (taken from standard economic tables).

(Z) Present value for each year of projected operation--column X x column Y.

(T) LCC = the sum of all annual present-value costs for the life of the project (not totaled for this example).

Table A4. Sample LCC calculations for disposal by burning in industrial boiler.

Year	(A) Cost of New Solvent ($)	(B) Invest-ment ($)	(C) Recurring Cost ($)	(D) Heating Value ($)	(X) Total Annual Cost ($)	(Y) 10% Present Value Factor	(Z) Present Value($)
0	-	36,591	-	0	36,591	1.000	36,591
1	2250	0	2473	-145	4578	.954	4367
2	2250	0	2473	-145	4578	.867	3969
3	2250	0	2473	-145	4578	.788	3607
4	-	-	-	-	-	.717	-
5	-	-	-	-	-	.652	-
6	-	-	-	-	-	.592	-
7	-	-	-	-	-	.538	-
8	-	-	-	-	-	.489	-
9	-	-	-	-	-	.445	-
10	-	-	-	-	-	.405	-

(T) Total LCC __________

(A) Cost of new solvent required per year. (Calculate using Table A7.)

(B) Capital investment for storage, treatment, and burning equipment. (Calculate using Tables A10, A12 and A14.)

(C) Recurring costs include labor for treating and processing solvent prior to combustion, as well as residue disposal and extra boiler maintenance. (Calculate using Tables A23, A26 and A27.)

(D) The heating value of the solvent burned. (This value, which would be entered as a negative number, reduces the gross solvent cost.) (Calculate using Table A28.)

(X) The total cost for each year -- columns A+B+C+D.

(Y) Present-value factors, using a 10 percent discount rate (taken from standard economic tables).

(Z) Present value for each year of projected operation--column X x column Y.

(T) LCC = the sum of all annual present-value costs for the life of the project (not totaled for this example).

Table A5. Sample primary analysis chart.

Year	(A) Recurring Existing	(B) Costs Proposed	(C) Difference (A - B)	(X) 10% Present Value Factor	(Y) Present Value of Savings	(Z) Accum. Present Value of Savings
1	3500	1300	2200	.954	2099	2099
2	3500	1300	2200	.867	1907	4006
3	3500	1300	2200	.788	1734	5740
4	3500	1300	2200	.717	1577	7317
5	3500	1300	2200	.652	1434	8751
6	3500	1300	2200	.592	1302	10,053
7	3500	1300	2200	.538	1184	11,237
8	3500	1300	2200	.489	1076	12,313
9	3500	1300	2200	.445	979	13,292
10	3500	1300	2200	.405	891	14,183

(T) Total Savings = $14,183

(A) and (B) Recurring costs for each option-- new solvent, labor, power, materials, maintenance, sludge disposal, and testing.

(C) The difference between recurring costs for the two options; if all differences are negative, the proposed option cannot be the more economical.

(X) Present value factors, using a 10 percent discount rate (taken from standard economic table).

(Y) The present value of the difference (savings) column C x column X.

(Z) The accumulated present value of the difference (savings).

(T) The sum of all annual present-value savings over the project's life.

The following items should be considered in primary analysis:

(D) Investment Cost for Proposed Option. This cost includes equipment and installation costs. If an investment occurs in out-years (e.g., replacing a pump in year 8), its present value must be included. This cost also includes any renovation/major repairs in 2 to 10 years.

(E) Salvage Value of Existing Option. This value is positive if the old equipment can be sold, or negative if there is a cost to remove the existing equipment.

(F) Present value of existing assets that will be replaced. If existing assets are to be sold or used on another project, their present value is calculated for the year of sale or transfer (usually the first year).

Calculation of Savings-to-Investment Ratio* = T/(D - E - F)

*If the numerator of this equation is either zero or negative, the proposed investment will not yield any savings over the analysis period, so the status quo is the preferred alternative. If the denominator is zero or negative there is probably an error in the calculations. If no error is found, the assumptions underlying the values D, E, and F should be examined and the life cycle costs computed as in Tables A1 through A4.

Calculations for the discounted Payback Period (DPP)

To estimate the DPP, find the point in time in the accumulated present-value column that the accumulated savings equal the investment. In the example shown in Table A5, suppose the investment cost = $6500. Go to column Z, and note the accumulated savings = $5740 for 3 years and $7317 for 4 years. The DPP is therefore between 3 and 4 years. Interpolation gives:

$$\frac{6500 - 5740}{7317 - 5740} = 0.5, \qquad \text{so the DPP} = 3 + 0.5 = 3.5 \text{ years.}$$

That is, the proposed option will produce savings that pay back the investment cost in 3.5 years.

Table A6. Cost of New Solvent; Corresponds to Tables A1-A5, Column (A).

Line	Item	Unit	Example	Result
1	Initial solvent needed for first year (assumed)	gal.	1000	
2	Average price of initial solvent per gallon for PD 680*	$	2.25	
3	Cost of initial solvent (line 1 x line 2)*	$	2250	
4	Solvent lost during use (average)**	%	30	
5	Volume of solvent during use (line 1 x line 4) / 100	Gal		300
6	Solvent available for recycle (line 1 - line 5)	Gal		700
7	If line 6 is less than 400			stop
8	Average recycle solvent lost as still bottoms**	%	7.5	
9	Volume recycle solvent lost as still bottoms (line 6 x line 8) / 100	Gal		52.5
10	Volume of makeup solvent required at end of first year	Gal		352.5
11	Cost of new solvent at end of first year (line 2 x line 10)	$		793.13 Enter amount in column A for each year of operation.

*Refers to lines in this table.
**From B.A. Donahue and M.B. Carmer, Solvent "Cradle-to Grave" Management Guidelines for Use at Army Installations, Technical Report N-168/A137063 (U.S. Army Construction Engineering Research Laboratory, 1983)

Solvent Cost Data

Solvent	Price ($/gal)
1,1,1-trichloroethane*	11.33
Mineral Spirits: Stoddard*	2.25
Methanol, paint thinner, toluene, xylene, MEK, Acetone, benzene	-------

*From U.S. GSA Federal Supply Catalog, Spring 1995.

Table A7. Cost of New Solvent; Corresponds to Tables A1-A5, Column (A).

Line	Item	Unit	Example	Result
1	Total use of solvent for first year	gal.	1000	
2	Average price of solvent per gallon	$	2.25 or PD 680*	
3	Cost of initial solvent (line 1 x line 2)	$	2,250.00 Enter this amount in column A for one year of operation.	

*See Table A6, "Solvent Cost Data."

Table A8. Cost of Equipment, Distillation*; Corresponds to Tables A1-A5, Column (B).

Line	Item	Unit	Example	Result
1	Workweeks in a year**	Weeks	52	
2	Batch operations per workweek (assumed)	No.	2	
3	Backup capacity***	%	25	
4	Solvent to be recycled in a year [equal to Table A6, line 6]	Gal	700	
5	Potential batch operations per year (line 1 x line 2)	No.		104
6	Solvent to be recycled per workweek (line 4 / line 5)			6.37
7	Backup capacity (line 3 x line 6)	Gal		1.68
8	Solvent to be recycled and backup capacity per batch (line 6 + line 7)	Gal		8.41
9	Is boiling point of solvent greater than 300 F? (for PD 680, averaged)	Y/N		Yes
10	If line 8 is less than 15 gal/batch and line 9 is "no", enter $5700 on line 10.			
11	If line 8 is less than 55 gal/batch and greater than 15 gal/batch and line 9 is "no", enter $14,815 on line 11.			
12	If line 8 is less than 15 gal/batch and line 9 is "yes", enter $10,625 on line 12.	$	10,625.00	
13	If line 8 is less than 55 gal/batch and greater than 15gal/batch and line 9 is "yes", enter $22,020 on line 13.			
14	If line 8 is greater than 55 gal/batch and line 9 is "yes", consult with specific manufacturers for appropriate equipment			
15	Cost of temperature shutoff with timer (assumed).	$	1,065.00	
16	Cost of timer	$	93.00	
17	Cost of flow switch interlock	$		
18	Additional cost options	$		
19	Total distillation equipment cost (line 10 + line 11 + line 12 + line 13 + line 14 + line 15 + line 16 + line 17 + line 18)	$		11,785.00 Enter this amount in column B for the first year of operation.

Equipment	Cost
15 gal/batch distillation unit	$ 5,700.00
15 gal/batch distillation unit w/vacuum	10,625.00
55 gal/batch distillation unit	14,815.00
55 gal/batch distillation unit w/vacuum	22,020.00
Timer	70.00
Temperature shutoff with timer	1,065.00
Flow switch interlock	790.00

*Solvent Distillation Equipment Cost Data (Source: Authorized Federal Supply Schedule Price List, General Services Administration, Office of Federal Supply Services, March 23, 1984).

**52 weeks/year

***Backup capacity is equal to 25 percent of the solvent that must be recycled: 700 / 104 x .25 = 1.68 gal.

Table A9. Installation Cost; Corresponds to Tables A1-A5, Column (B).

Line	Item	Unit	Example	Result
1	Number of systems to install (assumed)	No.	1	
2	Number of electricians per system	No.	1	
3	Number of pipe fitters per system	No.	1	
4	Period of labor per system per electrician	No.	4	
5	Period of labor per system per pipe fitter	No.	4	
6	Labor rate base per electrician per hour**	$	28.61	
7	Labor rate base per pipe fitter per hour**	$	29.44	
8	Cost of labor [(line 4 x line 6) + (line 5 x line 7)]	$		232.20
9	Labor burden***	%	25	
10	Labor cost plus burden [line 8 +(line8 x line 9)]	$		290.25
11	Overhead***	%	40	
12	Total labor cost [line 10 + (line 8 x line 11)]	$		383.13
13	Materials (piping + hoses; wire 220 service) (assumed)	$	200	
14	Total installation cost [line 1 x (line 12 + line 13)]	$ Enter this amount in column B for the first year of operation.		583.13

Labor Hourly Wage Rates

Position	Rate
Electrician**	$28.61/hr
Plumber/pipe fitter**	29.44/hr
Operator***	21.00/hr
Labor Burden***	25% of base
Overhead***	40% of base

*Labor wages and rates vary according to geographic location and availability of skilled labor.

**Means Labor Rates for the Construction Industry, 22nd Annual Edition, (R.S. Means Company, Inc., 1994), data January 1995.

***Peters and Timmerhaus, Plant Design and Economics for Chemical Engineers, (McGraw-Hill 1991), p200.

Table A10: Transfer Equipment Cost; Corresponds to Tables A1-A5, Column (B).

Line	Item	Unit	Example	Result
1	Number of transfer pumps required (assumed)	No.	1	
2	Cost per transfer pump*	$	1,500.00	
3	Total Cost (line 1 x line 2)	$ 1,500.00 Enter this amount in column B for the first year of operation.		

*See Miscellaneous Investment Costs

Miscellaneous Investment Costs

Item	Costs
Transfer pump, (10 gal/min)*	$ 1,500.00
Forklift, 3000 lb (capacity)**	$ 22,050.00
Hand truck, heavy-duty (dolly)**	$ 188.00
Warehouse; single-story, 15-ft clearance, steel frame, masonry walls, floor, roof, lighting, heating and plumbing (labor included)***	$ 28.00/sq ft
Concrete, slab, mesh reinforced (labor included)***	
a) Thickness 4 in; subbase 6 in thick	$ 2.39/sq ft
b) Thickness 8 in; subbase 6 in thick	$ 2.94 / sq ft
6-ft chainlink fence (3-strand B.W.)***	$ 7.78/ln ft
30-ft-wide, double gate, (manual)***	$ 644.00
55-gal steel drum, used, cleaned****	$ 13.60
55-gal steel drum, new****	$ 24.30

*Peters and Timmerhaus, p 528.
**Peters and Timmerhaus, p 568.
***Peters and Timmerhaus, p 804-806.
****Peters and Timmerhaus, p 541 (data January 1990).

Table A11. Space Cost; Corresponds to Tables A1-A5, Column (B).

Line	Item	Unit	Example	Result
1	Number of 15-gal systems	No.		
2	Number of 15-gal systems with vacuum	No.	1	
3	Number of 55-gal systems	No.		
4	Number of 55-gal systems with vacuum	No.		
5	Floor space for 15-gal system	sq ft	7.5	
6	Floor space for 15-gal system with vacuum	sq ft	15.4	15.4
7	Floor space for 55-gal system	sq ft	13.1	
8	Floor space for 55-gal system with vacuum	sq ft	30.2	
9	Work space	sq ft	30.0	
10	Cost of space per square foot	$	28.00	
11	Space required [(line 1 x line 5) + (line 2 x line 6) + (line 3 x line 7) + (line 4 x line 8)]	sq ft		15.4
12	Total space required [line 9 x (line1 + line 2 + line 3 + line 4) + line11]	sq ft		45.4
13	Total space cost (line 12 x line 10)	$ 1,271.20 Enter this amount in column B for the first year of operation.		

Table A12. Storage Site Cost; Corresponds to Tables A1-A5, Column (B).

Line	Item	Unit	Example	Result
1	Cost of storage site; berm + slab, fence + gate*	$ 3,891.54 Enter this amount in column B for the first year of operation.		
Estimate: Cost of 120-drum site 120 drum site = 1 1/2 truck loads 10 drums x 12 drums = 120 Assume 2-ft-diameter/drum: (10 x 2) + (12 x 2) = 20 ft x 24 ft Assume 5 ft extra space around perimeter: (20 ft + 5 ft + 5 ft) x (24 ft + 5 ft + 5 ft) = 1020 sq ft				
Components: Concrete Slab (4 in), concrete berm (8 in), fence, 30-ft double gate(manual) Length of fence: 30 + 30 + 34 +34 - 30 (gate) = 98 ft Berm (sq ft): 2(8/12 x 34) + 2(8/12 x 30) = 86 sq ft Berm: 86 sq ft x $2.94 / sq ft — $ 252.84 Slab: (1020 - 86) sq ft x $2.39 / sq ft — 2232.26 Fence: 98 ft x $7.78 / ft — 762.44 Gate: 1 x $ 644.00 / gate — 644.00 $3891.54				
* See Table A10, "Miscellaneous Investment Costs."				

Table A13. Replacement Drums; Corresponds to Tables A1-A5, Column (B).

Line	Item	Unit	Example	Result
1	Number of drums (Table A6, line 1)/ 55 gal per drum	No.	19	
2	Cost per drum*	$	24.30	
3	Total cost (line 1 x line 2)**	$ 461.70 Enter this amount in column B where drums are replaced		
*See Table A10, "Miscellaneous Investment Costs." **The investment cost should appear as an expense in the year or years in which the drums are replaced.				

Table A14. Burning Equipment Adapters or Modifications; Corresponds to Tables A1-A5, Column (B).

Line	Item	Unit	Example	Result
1	Cost of liquid injector adapter*	$	6,200.00	
2	Installation Cost**	$	25,000.00	
3	Total cost (line 1 + line 2)	$ 31,200 Enter this amount in column B for the first year of operation.		
*The figure for the adapter is for small-capacity (several thousand gallons/year) boiler that burns solid waste. (Source: Consutech Systems, LLC, Mechanicsville, VA, (804) 746-4120) (adjusted for inflation to present cost). **Boiler and installation costs for a large-capacity (more than 1 million gal per year) operation are about $30,000 to $35,000. (Source" Process combustion, Pittsburgh, PA.)(adjusted for inflation to present cost).				

Table A15. Labor. Corresponds to Tables A1-A5, Column (C).

Line	Item	Unit	Example	Result
1	Time to empty distillate product per batch	Hr	½	
2	Time to empty still bottoms and inspect system per batch	Hr	½	
3	Time to load and start system per batch	Hr	½	
4	Time to deliver product and collect used solvent per batch	Hr	½	
5	Total labor time per batch (line 1 + line 2 + line 3 + line 4)	Hr		2
6	Labor rate per hour* of operator	$	21.00	21.00
7	Labor burden*	%	25	
8	Cost of burden per hour(line 6 x line 7)	$		4.25
9	Labor rate (base) plus burden (line 6 + line 8)	$		25.25
10	Overhead*	%	40	
11	Cost of overhead per hour (line 6 x line 10)	$		8.40
12	Total labor cost per hour (line 9 + line 11)	$		33.65
13	Number of systems	No.		
14	Workweeks per year	Week		
15	Batches per workweek	Batch		
16	Total labor cost per year (line 5 x line 12 x line 13 x line 14 x line 15)	$ 6,999.20 Enter this amount in column C for each year of operation.		
*See Table A9, "Labor Hourly Wage Rates."				

Table A16. Utilities. Corresponds to Tables A1-A5, Column (C).

Line	Item	Unit	Example	Result
1	15-gal system power consumption	kW	1.65	
2	15-gal system with vacuum power consumption	kW	2.2	2.2
3	55-gal system power consumption	kW	6.6	
4	55-gal system with vacuum power consumption	kW	7.7	
5	Operating time per batch	hr	10	
6	15-gal system batches per year (Table A6, line 6)/15	batch	700/15	47
7	15-gal system with vacuum batches per year (Table A6, line 6) / 15	batch		
8	55-gal system batches per year (Table A6, line 6) / 15	batch		
9	55-gal system with vacuum batches per year (Table A6, line 6) / 15	batch		
10	Cost of electricity per kilowatt hour*	$	0.08	
11	Power cost, 15-gal system (line 1 x line 6 x line 5 x line 10)	$		
12	Power cost, 15-gal system with vacuum (line 2 x line 7 x line 5 x line 10)	$		82.72

13	Power cost, 55-gal system (line 3 x line 8 x line 5 x line 10)	$		
14	Power cost, 55-gal system with vacuum (line 4 x line 9 x line 5 x line 10)	$		
15	Total power cost per year (line 11 + line 12 + line 13 + line 14)	$		82.72
16	15-gal system, water consumption per hour	gal	15	
17	15-gal system with vacuum, water consumption per hour	gal	15	15
18	55-gal system, water consumption per hour	gal	60	
19	55-gal system with vacuum, water consumption per hour	gal	60	
20	Cost of water per hour*	$	0.0009	
21	Water cost, 15-gal system, per year (line 16 x line 6 x line 5 x line 20)	$		
22	Water cost, 15-gal system w/ vacuum, per year (line 17 x line 7 x line 5 x line 20)	$		6.35
23	Water cost, 55-gal system, per year (line 18 x line 8 x line 5 x line 20)	$		
24	Water cost, 55-gal system w/vacuum per, year (line 19 x line 9 x line 5 x line 20)			
25	Quench water operating time (assumed)	hr	1	
26	Water consumption per batch	gal	60	
27	Quench water batches (line 6 + line 7 + line 8 + line 9)	batches		47
28	Quench water cost (line 25 x line 26 x line 27 x line 20)	$		2.54
29	Total water cost per year (line 21 + line 22 + line 23 + line 24 + line 28)	$		8.89
30	Total utilities (line 15 + line 29)	$ 91.61 Enter this amount in column C for each year of operation		

*Utilities and Operating Data

Item Cost	
Electricity*	$0.08
Water*	$4.00 / 1000gal
No. 2 Distillate Fuel Oil*	$0.50
Operations, Maintenance, and Fuel for Forklift**	$8.95 / hr
Transportation (distance)***	$0.50 - $3.00/mile
Transportation (weight and distance)***	$0.10 - $0.30/ton-mile

*Peters and Timmerhaus, p 815, data January 1990
**Building Construction Cost Data, 52nd Edition, 1994, p 17.
***Evaluation of Disposal Concepts for Used Solvents at DOD Bases, The Aero Space Corp., Feb. 83, p 6 - 20.

Table A17. Disposal of Bottoms; Corresponds to Tables A1-A5, Column (C).

Line	Item	Unit	Example	Result
1	Volume of still bottoms (Table A6, line 9)	gal		52.5
2	Disposal cost per gallon*	$	1.93	
3	Cost of disposal per year (line 1 x line 2)	$ 101.33 Enter this amount in column C for each year of operation.		

*Used Solvent Disposal Costs

Type	Cost
-Reclaimable grade solvent (before recycle)	
-1,1,1-TCE*	$0.67 - 0.95/gal
-PD 680*	1.93/gal
-Dry cleaning solvent*	1.00/gal
-1,1,1-TCE (Rock Island)**	1.60/gal
-PD 680 (Rock Island)**	0.67/gal
Waste grade solvent (after recycle)	
-halogenated***	200.00/drum
-nonhalogenated***	$100.00/drum

*Donahue and Carmer, p 51.
**B. Donahue, G. Server, and E. Bellino, Economic Analysis for Rock Island Arsenal Solvent Recycle Management, Draft Special Report (USACERL)
***Evaluation and Disposal Concepts for Used Solvents at DOD Bases (The Aerospace Corporation, February 1983, pp 4-6.

Table A18. Materials and Maintenance Corresponds to Tables A1-A5, Column (C).

Line	Item	Unit	Example	Result
1	Capital cost	%	0.01	
2	Capital equipment cost (Table A8, line 19)	$	11,785.00	
3	Materials and maintenance cost per year (line 1 x line 2)	$ 117.85 Enter this amount in column C for each year of operation.		

Table A19. Transportation. Corresponds to Tables A1-A5, Column (C).

Line	Item	Unit	Example	Result
1	Forklift operation cost*	$	8.95	
2	Time allotment for transportation per batch	Hr	1/2	
3	Number of batches per year, Option 1, column C, Table A16, line 27	Batch		47.00
4	Transportation cost per year (line 1 x line 2 x line 3)	$ 210.33 Enter this amount in column C for each year of operation.		
*See Table A16, "Utilities and Operating Data."				

Table A20. Testing. Corresponds to Tables A1-A5, Column (C).

Line	Item	Unit	Example	Result
1	Cost per test on batch*	$	5.00	
2	Number of batches per year (Table A16, line 27)	Batch		47
3	Cost of testing per year (line 1 x line 2)	$ 235.00 Enter this amount in column C for each year of operation.		
*A simple test to confirm user data is $5.00 (Evaluation for Disposal Concepts for Used Solvents at DOD Bases, pp 6-22).				

Table A21. Transportation; Corresponds to Tables A1-A5, Column (C).

Line	Item	Unit	Example	Result
1	Solvent to be shipped / year (Table A6, line 6)	Gal	700	
2	Drums of solvent shipped (line 1/55 gal per drum)	Drum		13
3	Number of truckloads (line 2 / line 3)	Truck		1
4	Round trip distance to recycling facility	Mile	200	
5	Average cost per mile ($0.50 - $3.00)*	$	1.75	
6	Annual transportation cost (line3 x line 4 x line 5)	$ 350.00 Enter this amount in column C for each year of operation		
*Varies according to local transportation modes, competition, etc.				

Table A22. Repurchase of Recycled Solvents; Corresponds to Tables A1-A5, Column (C).

Line	Item	Unit	Example	Result
1	Solvent avail. for recycle/yr (Table A6, line 6)	Gal	700	
2	Volume of non-recyclable solvents per year (Table A6, line 9)	Gal	52.5	
3	Solvents avail. for repurchase (line1 - line2)	Gal	647.5	
4	Service charge for refining each gal of solvent	$	0.65	
5	Total cost (line 3 x line 4)	$	420.90 Enter this amount in column C for each year of operation.	
*Service charges may vary among re-refiners depending on the services rendered, such as transportation, containerization, quality of product, etc.				

Table A23. Transportation and Labor On-Post; Corresponds to Tables A1-A5, Column (C).

Line	Item	Unit	Example	Result
1	Forklift operation cost per hour	$	8.95	
2	Drums of solvent (C7, line 2)	drum		13
3	Average time to move drum to central storage site	hr	1/2	
4	Base cost of labor per hour	$	21.00	
5	Labor burden*	%	25	
6	Labor overhead*	%	40	
7	Base plus burden [line 4 + (line 4 x line 5) / 100]	$		26.25
8	Cost of labor per hour [line 7 + (line 4 x line 6) / 100]	$		34.65
9	Transportation cost (line 1 x line 2 x line 3)	$		58.18
10	Labor cost (line 2 x line 3 x line 8)	$		225.23
11	Total cost (line 9 + line 10)	$ 283.41 Enter this amount in column C for each year of operation.		
*See Table A9, "Labor Hourly Wage Rates."				

Table A24. Disposal of Reclaimable Solvent; Corresponds to Tables A1-A5, Column (C).

Line	Item	Unit	Example	Result
1	Reclaimable solvent available per year	Gal	700	
2	Disposal cost per gallon*	$	0.67	
3	Total disposal cost (line 1 x line 2)	$ 469.00 Enter this amount in column C for each year of operation.		
*See Table A17, "Used Solvent Disposal Costs". (This figure would be entered as a positive number if the installation must pay to dispose of the waste solvent; it would be a negative number if the solvent can be sold.)				

Table A25. Recurring Costs - Full-Service Contract; Corresponds to Tables A1-A5, Column (C)

Line	Item	Unit	Example	Result
1	Quantity of solvent purchased under contract*	Gal	1000	
2	Monthly parts cleaner service charge per unit of 22-gal capacity	$	81.75	
3	Number of units needed (1000/22 =45.45;then 45.45/12 =3.79)	No.	4	
4	Monthly service cost(line 2 x line 3)**	$		327.00
5	Yearly total cost (line 4 x 12 months)	$ 3924.00 Enter this amount in column C for each year of operation.		
*Service contractor brings new solvent, takes away old solvent, and supplies solvent-washing containers. **Service contractor furnishes the unit(s). (Source: Mr. Dan Mendoza, Manager, Safety Kleen Corp., Urbana, Il. August 1995.)				

Table A26. Mixing Labor; Corresponds to Tables A1-A5, Column (C).

Line	Item	Unit	Example	Result
1	Drums of used solvent per year (Option 5,column C, Table A24, line 2)	Drum	12.73	
2	Time per drum to transfer used solvent and mix with fuel	Hr	½	
3	Base cost of labor per hour*	$	21.00	
4	Labor burden*	%	25	
5	Labor overhead*	%	40	
6	Total labor rate per hour [line 3 + line 3 x(line 4 + line 5) / 100]	$		34.65
7	Mixing labor cost per year(line 6 x line 1 x line 2)	$ 110.27 Enter this amount in column C for each year of operation.		
*See Table A9, "Labor Hourly Wage Rates."				

Table A27. Boiler Maintenance & Operation Cost; Corresponds to Tables A1-A5, Column (C)

Line	Item	Unit	Example	Result
1	Average monthly time for cleaning the system (assumed)	hr	4	
2	Average time for residue disposal per month (assumed)	hr	1	
3	Total monthly labor time (line 1 + line 2)	hr	5	
4	Base cost of labor per hour*	$	21.00	
5	Labor burden*	%	25	
6	Labor overhead*	%	40	
7	Total monthly labor cost [(line 3 x line 4) + (line 3 x line 4) x (line 5 + line 6)/100]	$		173.25
8	Total annual labor cost (line 7 x 12 months)	$ 2079.00 Enter this amount in column C for each year of operation.		
*See Table A9, "Labor Hourly Wage Rates."				

Table A28. Credit for Heating Value; Corresponds to Tables A1-A5, Column (C).

Line	Item	Unit	Example	Result
1	Gallons of used solvent (Table A6, line 6)	gal	700	
2	Btu value per gallon of used solvent PD 680	Btu	60,000	
3	Btu value per gallon of No. 2 fuel oil*	Btu	145,000	
4	Cost per gallon of No.2 (regular) fuel oil*	$	0.50	
5	Total credit [(line 1 x line 2 x line 4) / line 3]	$ 144.83 Enter this amount as a negative number in column D of Table A5.		
*See Table A16, "Utilities and Operating Data."				

*Physical Data

Item	Boiling Point(F)	Density (lb/gal)	Heat Value
1,1,1-TCE	158 - 190	11.04	-
PD 680 Type 1	300 - 410	6.47	-
Type 2	350 - 415		
Freon	199	13.69	-
MEK	174 - 177	6.71	-
Xylene 261 - 318	7.17		-
Methanol	147 - 151	6.71	-
Fuel Oil	-	-	135,800 to 152,000 Btu/gal
Wood	-	-	4,799 to 9,000 Btu/gal
Rubber	-	-	10,500 to 15,000 Btu/gal