Appendix E-1

Trimester Approach

In order to calculate the model savings to an institution after one year of use of our program, with two shipments for recertification, we defined the total number of components, new or used, per trimester as N and our recertification rate as R.

For the first trimester, all components, N, are new. For the second trimester, RN components are those that are reused after original use in the first trimester and $(1-R)N$ are new components purchased to replace the components from the first trimester that failed to be recertified. In the third trimester, *R(RN)* components have been reused twice, $R(1-R)N$ components have been reused once, and $(1-R)N$ components have been purchased new to replace the uncertified components.

The cost of components in each trimester was then calculated by multiplying the above distributions by the cost of new components, C_{new}, for the new components and by the discounted cost, $S \cdot C_{new}$, for the components being reused. The total savings is the difference between the total cost of all new components, $3NC_{new}$, and the total cost with reuse, $1+2(RS+(1-R))$. The corresponding total savings is 25%, which is slightly less than potential savings over time as no components in this model were reused three times.

Appendix E-2

Specific Equations for Three Reuses

For our specific study, we limited our reuses to three. The average number of uses of a new component with a limit of three reuses, N_3, was calculated with the following equation:

$$N_3 = 1 + R + R^2 + R^3 = \sum_{n=0}^{3} R^n$$

With an R of 0.75, the average number of total uses of a new component in our program was found to be 2.73.

The average cost per use of a component with up to three reuses is the average total cost for all uses of the component divided by the average total number of uses.

$$C_3 = C_{new}\left(\frac{1 + S\sum_{n=1}^{3} R^n}{\sum_{n=0}^{3} R^n}\right) = C_{new}\left(\frac{1 + S\left(R + R^2 + R^3\right)}{1 + R + R^2 + R^3}\right)$$

In our study, with a limit of four total uses (new plus three recertifications), the average cost per use of a component was 0.683 C_{new}, or 68.3% of the cost of a new component.

Appendix E-3

General Equations

Here, we derive general expressions for the average number of reuses, N, and average per-use cost of reusable components, C, if there is no limit placed on the number of reuses. If N is the average total number of uses per component and R is the reusability pass rate, then we can write:

$$N_{\infty} = 1 + R + R^2 + R^3 + \ldots = \sum_{n=0}^{\infty} R^n = \frac{1}{1-R}$$

where the first term is the initial use, the second is the average number of second uses, the third is the average number of third uses, etc. Using 0.75 for R as we did yields a theoretical upper limit to the average number of total uses of four.

The general expression for the average per-use cost of components, C, is the total average cost of the component divided by the average number of reuses:

$$C_{\infty} = C_{new}\left(\frac{1 + S\sum_{n=1}^{\infty} R^n}{\sum_{n=0}^{\infty} R^n}\right) = C_{new}\left(1 - R(1-S)\right)$$

The full price of a new component is C_{new}, and the fractional cost of a reused component is $S \cdot C_{new}$. With use of 0.75 for R and 0.5 for S as in our program, the theoretical average per-use cost of each component, if no limit is placed on reuses, was found to be 0.625 C_{new}, or 62.5% of the cost of a new component.