Section 8:
Oven Price vs Cost of Ownership

When multiple oven vendors pass the previous technical selection criteria listed, then a proper cost evaluation should be used to compare ovens. This is especially important when comparing ovens that utilize different heating technologies, as initial price and operating costs can be significantly different.

Often, the initial cost of the equipment is the only cost considered when comparing equipment. It is certainly important when companies have tight budgets, **BUT IT IS OFTEN FAR LESS SIGNIFICANT THAT THE OPERATING COSTS.** To make an informed comparison, all costs should be analyzed with a common basis based on an annual cost of ownership approach.

As an example, compare two ovens with a vast difference in sell price (Figure 8-2).

The expected oven life is 5 years, with a discount (interest) rate of 10%. Assume the oven is fully depreciated at the end of 5 years with no residual value (worth $0 – the worst case scenario).

The cost of ownership should reflect all the operational and opportunity costs of running the oven. Direct costs like electrical power usage and process gas requirements (such as nitrogen) are included. Indirect or lost opportunity costs related to lost production caused by maintenance downtime. Flux cleaning and chain lubrication are examples of machine downtime that will reduce board production. Figure 8-1 gives a real world example of these costs. When included in the Cost of Ownership model (Figure 8-1), it shows that when the impact of major cost of ownership factors is analyzed, the "cheaper" oven actually costs **TENS OF THOUSANDS OF DOLLARS MORE OVER JUST ONE YEAR OF OPERATION!**

<u>The next 2 pages describe how for a typical high-volume SMT line:</u>

- **Oven purchase price differences of 20-25% are INSIGNIFICANT when compared to increased cost of ownership**
- **Advanced ovens can payback 20-25% price premiums vs basic ovens IN THE FIRST 6 WEEKS of operation, based on reduced maintenance and downtime (opportunity) costs, even with a 10% cost of money factored in**
- **Advanced ovens improve profitability by NEARLY $170,000 PER YEAR based on the Real World example described by Figure 6-1 and Figure 6-2**
- ***Reflow oven downtime is the MOST SIGNIFICANT cost factor for high-volume machine evaluation***

Figure 8-1. Maintenance cost scenario.

Real World Case Study: Flux Cleaning Creates "Regularly Scheduled Bottlenecks"

A large contract manufacturer operates four SMT assembly lines in a plant that runs approximately 22 hours per day except for changeover and maintenance. The maintenance technician describes the reflow oven flux cleaning maintenance procedure:

> *Every three weeks, two technicians disassemble each reflow oven for flux cleaning. Reusable condensers collect flux in the cooling zones, and air jets require cleaning for the flux not collected by the heat exchanger. Newly cleaned flux condensers replace soiled units in the oven so that the latter's fins can be degreased off-line. The cleaning process requires 10 hours/month for EACH REFLOW OVEN.*

Based on its cost structure, the plant's per line annual maintenance expense for reflow oven is:

Labor: 2 people @ $40/hour (burdened) * (10 hours/month oven cleaning) * (12 months/year)
= $9600/year

Flux Condenser Defluxing Cost: $100/month covering degreasing solvent, using a commercially available degreaser (not degreased by hand scrubbing) = $1200/year

Direct Maintenance Cost per Line = $10,800 excluding the cost of replacement flux condensers

LOST BOARD THROUGHPUT MEANS LOST PROFIT

The cost is in lost production, however, is many times greater. For continuous board production, reflow oven maintenance creates "regularly scheduled bottlenecks", i.e. the capacity of the plant is equal to the capacity of the bottlenecks wherein each hour of reflow oven flux cleaning is a production hour lost for the entire plant (Goldratt, *The Goal*, p. 157).

For example, a typical production line might include:

Board Sell Price: $100
Board Cycle Time: 0.3 minutes (180 boards per hour)
Board Bill of Material Cost (PCB and components): $90
Labor Cost per board (direct and overhead): $1

SOURCE: Lasky, Baldwin, *Throughput: The Critical Cost Variable in DCA Assembly*, SMTA National Symposium, November 1996, p. 1.

Applying 10 maintenance hours per month imposes the following reductions in board production throughput (and profitability) per assembly line:

Board Production Rate * Maintenance Downtime = Lost Throughput per Line

(180 boards/hour) * (10 hours/month * 12 months/year) = 21,600 boards/year lost per line

Lost Line Throughput * (Board Sell Price - Board Cost [Material & Labor]) = Lost Line Profit

(21,600 boards lost/year) * ($100 - 91) = **$194,400 ANNUAL LOST PROFIT PER LINE**

Figure 8-2. Advanced reflow ovens cost more, but improve profitability by more than $847,000 over the five-year life of the oven.

Reflow Oven Cost of Ownership Model		
Assumptions (Figure 6-1)		
Number of assembly hours/year (2 shifts)	4160	4160
Board Cycle Time	180 boards/hour	180 boards/hour
	Oven A (Advanced)	Oven B (Average)
Purchase Price	$95,000	$75,000
Capital Recovery Factor (10% Interest for 5 Years (A/P, 10, 5))	0.2638	0.2638
Annual Oven Cost	*$ 25,061*	*$ 19,785*
Direct Costs		
Nitrogen Gas Consumption (cubic meters/hour)	30	54
Nitrogen Cost	$0.19/cubic meter	$0.19/cubic meter
Annual Nitrogen Cost	*$ 23,712*	*$ 42,682*
Power Consumption (KVA)	43	38
Electrical Power Cost	$0.16 KVA/hour	$0.16 KVA/hour
Annual Power Cost	*$ 28,442*	*$ 25,292*
Direct Maintenance Costs (See Figure 6-1 for calculations)		
Flux Cleaning Maintenance (hours/month)	1	8
General Maintenance (hours/month)	2	2
Annual Direct Maint. Costs (2 people @ $40 incl. Overhead)	*$ 1,440*	*$ 4,800*
ANNUAL DIRECT COST OF OWNERSHIP (Oven + Nitrogen + Power + Maintenance)	**$ 78,655**	**$ 92,559**
Opportunity Costs (See Figure 6-1 for calculations)		
Board Profitability ($100 board sell price @ 9% Gross Margin)	$ 9/board	$ 9/board
Annual Production Lost ($9/board x 180 bds/hour x Maint. Hours)	*$ 38,880*	*$ 194,400* (From Figure 6-1)
TOTAL ANNUAL COST OF OWNERSHIP (Direct cost + Opportunity Cost)	**$ 117,535**	**$ 286,959**