

The CPI TWT *LIFEEXTENDER*[™] Advantage

Experience up to 50% longer TWT life with CPI's patented LifeExtender/LifePredictor technology.

CPI's *LIFEEXTENDER* technology is the most advanced method used in the satcom amplifier market to increase traveling wave tube (TWT) life. The superior results achieved through LifeExtender are obtained through a unique process whereby the heater voltage is adjusted in order to utilize the TWT's supply of barium more efficiently than has been done in the past.

Any TWT reaches end of life when its cathode barium reserve is exhausted. The rate of barium evaporation is determined by the cathode temperature, which is in turn determined by the cathode heater voltage setting. With *LIFEEXTENDER*, the cathode heater voltage is adjusted over time to minimize the rate of barium depletion, thereby maximizing the life of cathode, resulting in 30% to 50% longer TWT life.

An alternative method for extending useful tube life is in use today. Under this method, the amplifier ramps up the anode voltage to compensate for the loss of gain and beam current in the TWT that naturally occurs over time. While valid, anode voltage adjustment is not as effective in extending the life of the TWT as LifeExtender, primarily because, as in those amplifiers with no TWT life extending feature at all, the static setting of the heater voltage results in an inefficient use of barium reserves early in the life of the TWT.

TWT manufacturers acknowledge that CPI's method of dynamically adjusting the heater voltage over time will lengthen a TWT's cathode life. Anode voltage adjustment on its own only extends the operational life of the TWT for a limited time without extending the ultimate life of the cathode. With *LIFEEXTENDER*, the life of the TWT is actually extended by saving barium during the initial operational period so it can be used later to extend the TWT's cathode life.

An additional benefit of *LIFEEXTENDER* technology is derived from a feature called *LIFEPREDICTOR*, which monitors the evolution of the knee of the cathode emission curve over time. During the life of a TWT, the knee in the cathode emission curve moves to higher heater voltages and the curve changes shape. By analyzing the heater voltage setting and how much further voltage adjustment is available, a prediction of remaining TWT life can be made. This information is readily available through the HPA's M&C GUI interface, allowing the user to better plan for eventual TWT replacement.

CPI LIFEEXTENDER/LIFEPREDICTOR

CPI Dvnamic LIFEEXTENDER Svstem	Alternative Anode Adjustment/ Static Heater Voltage Method
1. Optimizes and sets cathode heater voltage on a per TWT basis (each TWT is slightly different); Finds a "value of the knee" that is optimal for the minimum rate of barium evaporation for each TWT.	1. Cathode heater voltage is fixed. A resistor or other methods can be used to set the voltage for a particular TWT but this voltage is static over the TWT lifetime and not automatically adjusted.
2. Adjusts cathode heater voltage over time as the TWT ages and as the cathode knee moves "to the right" to keep barium evaporation optimal over time.	2. Cathode heater voltage does not change over time, therefore barium evaporation is not optimized over time.
3. TWT suppliers acknowledge that CPI's method extends the cathode life by 30% to 50%.	3. Anode voltage adjustment does not extend cathode life. It only extends the operational life of the TWT while the cathode's barium is depleted prematurely.
4. Method utilizes heater voltage adjustment. Every TWT has a heater so it can be applied to all TWTs regardless of manufacturer.	4. Can only be used with TWTs that utilize adjustable anodes. Not all TWTs use anodes that can be adjusted, so this method only works with certain types of TWTs.
5. The cathode heater voltage is optimized from day one so that barium is never used up at a rate higher than necessary. The barium that is saved initially is used later to extend the life of the cathode.	5. The cathode heater voltage setting is static, so that barium depletion is higher than necessary at the beginning of TWT life. Once the barium is used it cannot be recovered so this method does not ultimately extend cathode life.

Table 1. Comparison of CPI's LifePredictor technology versus Anode Adjustment/Static heater voltage method.

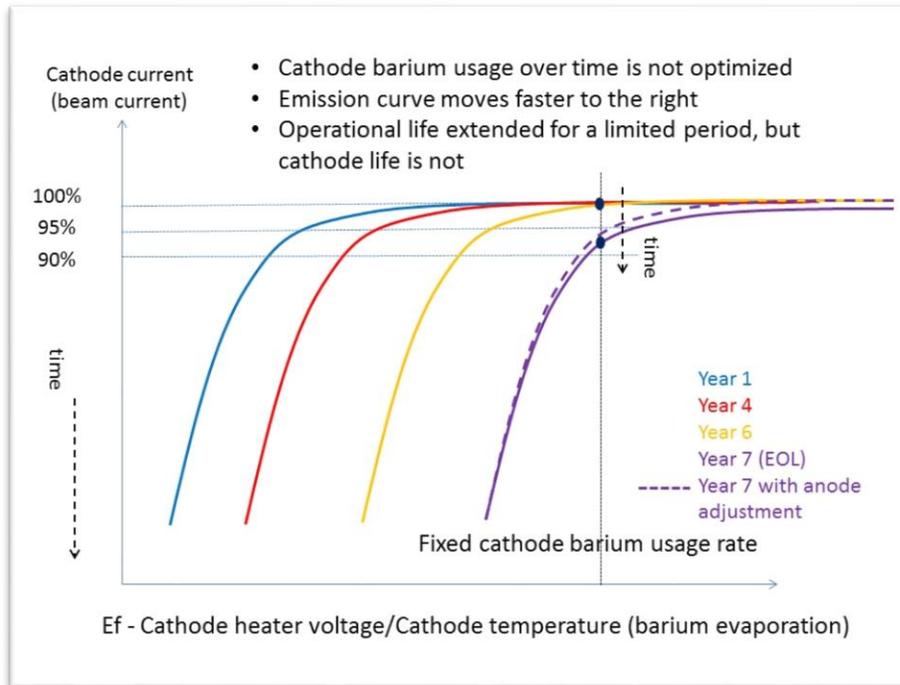


Figure 1. This graph shows barium usage when heater voltage is fixed over time, as represented by the vertical black line. Except for years six and seven, the cathode's barium coating is burned off without being utilized efficiently.

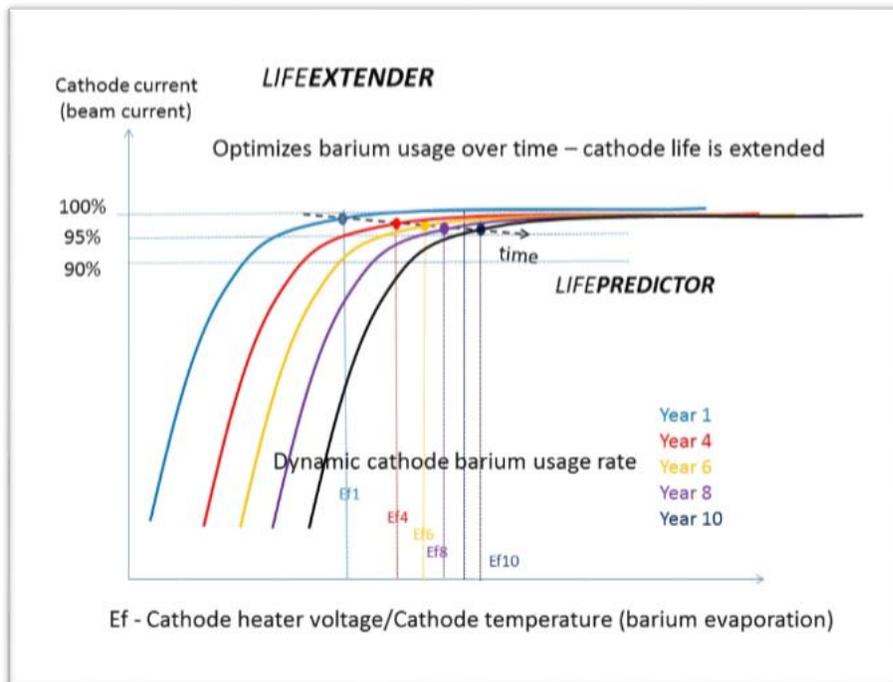


Figure 2. This graph shows the heater voltage increasing over time with LifeExtender, as shown by the six vertical lines, and is set dynamically in order to optimize barium use. This results in 50% longer TWT life.

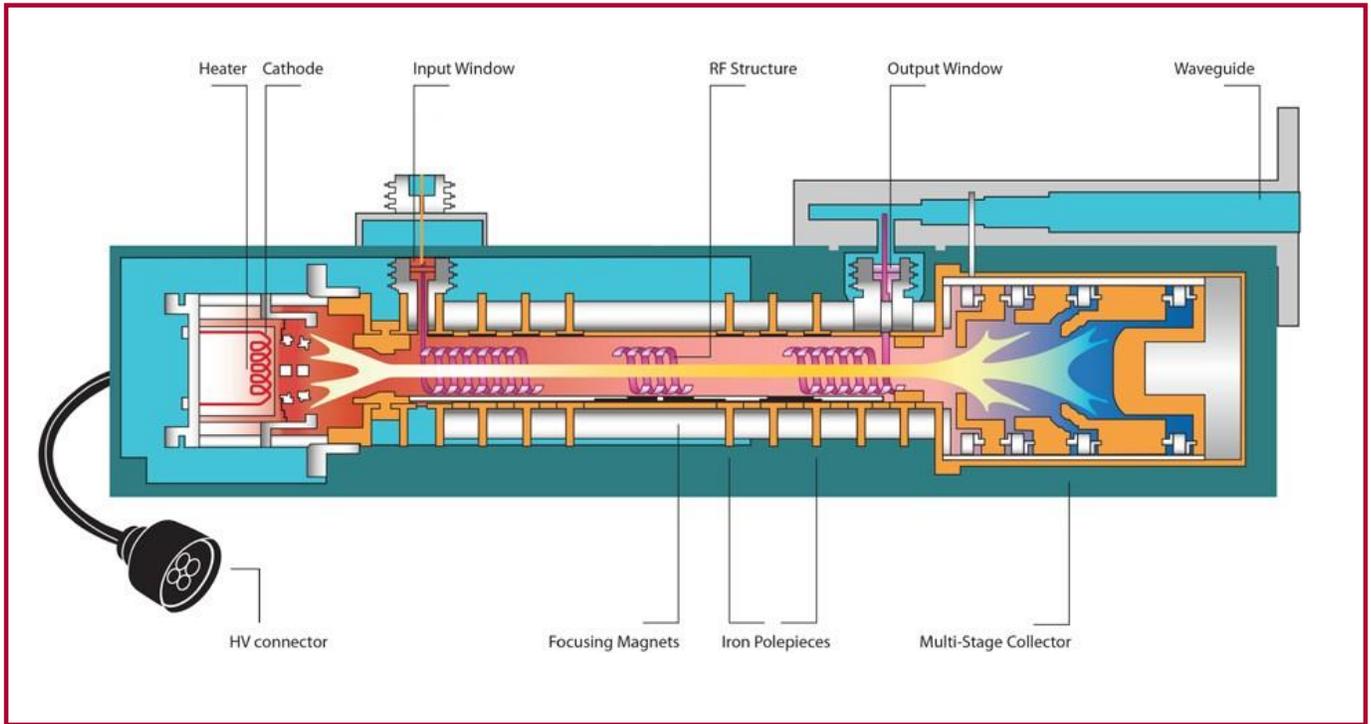


Figure 3. Cross section of traveling wave tube. The cathode and heater at the left.