

## Mean Time Between Failure (MTBF)

NOTE: The following calculations are for the components as received from our vendors, and represent a best effort on our part. They are subject to change as updated by our vendors.

### Motors

The dominating component in the MTBF calculation is the bearings. Our bearing calculations are based on the standard ANSI-AFBMA Standard 9 – 1990 “Load Rating and Fatigue Life for Ball Bearing”. This standard specifies the life of the bearing in number of revolutions as follows:

$$L = (C/P)^3$$

$$L == \text{Revs} \times 10^7$$

C == Load Rating (Estimated from standard and vendor datasheets)

P == Actual Load

Bearing Life (L) is inversely proportional to the cube of the load. For example, L will go up by a factor of 8 if the load is halved.

Actual Load (P) is the combination of Axial and Radial load. Axial is along the axis of the shaft and Radial is perpendicular to the shaft. For our calculations, we assume minimal Axial load and therefore set P to the Radial load.

The following equation can be used to calculate MTBF for a particular application.

$$L_y = \text{Revs/Year}$$

$$\text{MTBF(years)} = L * 10^7 / L_y$$

NOTE: For any given motor, MTBF can be greatly increased by reducing the shaft load and or decreasing the speed, with shaft load being the dominate term.

The following table shows some example MTBFs. The chosen  $L_y$  (rev/yr) is equivalent to a motor going 1500RPM continuously for the entire year. The loads were chosen to achieve approximately a 20yr MTBF. Since MTBF is inversely proportional to the shaft load cubed, the MTBF will go up by 8 times if the shaft load is cut in half.

Motor	P (lbs)	C(lbs)	Ly (rev/yr)	Bearing MTBF(yr)
17, 17H	1.75	20	750,000	20
23	8	90	750,000	19
23H	17	200	750,000	22
34N, 34H	50	600	750,000	23
34HC-1,2	50	600	750,000	23
34HC-3,4	60	650	750,000	17

### SilverNugget and SilverDust Controller/Drivers

The dominating component in the MTBF calculation is the capacitors. The main factor affecting capacitors is temperature.

Our Aluminum Electrolytic caps are rated for 7000 hour at 105C. Their life doubles for every 10C reduction.

Temp C	Hours	Years
45	448000	51.2
55	224000	25.6
65	112000	12.8
75	56000	6.4
86	28000	3.2
95	14000	1.6
105	7000	0.8