



## Applied Motion Products Step Motor Life & Reliability

Applied Motion Products step motors are brushless motors with excellent bearings. As such, they can have a phenomenal life. Factors that determine motor life include: bearing life, insulation system temperature, shaft strength, and environmental conditions. The goal of this paper is to help you understand these, avoid motor life problems, and provide solutions if a standard motor does not meet your needs.

Most life factors are rated in hours. This is the time the motor is actually running at its operating temperature. As a guide, life of 20,000 hours running is suitable for many applications. This typically represents 10+ years of field use (8 hours / day, 5 days / week, and 50 weeks / year). With good design motor life can be much longer; once the actual working cycle, shaft loads, and motor temperatures are accounted for.

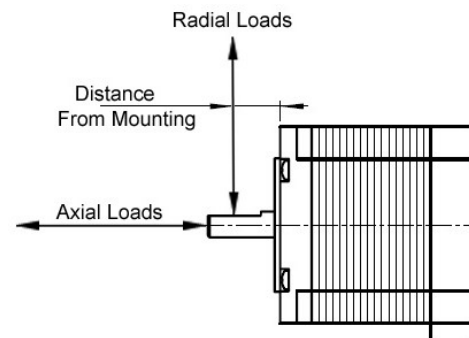
### Shaft Life:

When a motor shaft is subjected to large radial loads it can break after many hours of use. This is due to the radial load causing the shaft material to fatigue as it rotates. Shaft life is a function of the magnitude and location of the radial load, as well as the shaft material and shaft size. As the radial load is moved further from the motor mounting face, the maximum radial force the shaft can withstand drops.

**Shaft Strength - Maximum Radial Load - Standard Shafts**

Motor Size	Series	Shaft Diameter		Radial Force Location From Motor Mounting			Max. Radial Force	
		mm	Inch		mm	Inch	N	Lbs.
8	HT08-220/221	4	0.157	End of shaft	20	0.79	18	4
11, 14	HT08-020/021	5	0.197	Center of Flat	16.5	0.65	30	6.7
	End of shaft			24	0.94	21	4.7	
17	HT17-268/269/270	5	0.197	Center of Flat	16.5	0.65	30	6.7
	HT17-271/272/273/274 HT17-275/276/277/278			End of shaft	24	0.94	21	4.7
23, 24	HT23-560/593/594/595	6.35	0.25	Center of Flat	13.1	0.52	62	13.9
	HT23-559/596/597/598 HT23-599/600/601 HW23-598/601			End of shaft	20.6	0.81	44	9.9
34	HT34-504/505/506	12.7	0.50	Center of Key	20.8	0.82	300	67
	HW34-506 HT34-495/496/497			End of shaft	31.8	1.25	200	45

A common cause for shaft (and bearing) failure, is high radial loads that are created when a pulley is attached to the motor shaft at a large distance from the motor mounting face, and the belt has high tension. To avoid this condition mount pulleys and gears as close to the face of the motor as possible, and avoid over tightening belts. This dramatically reduces the shaft stress, and increases the life of the bearings.



## Bearing Life:

Bearing life depends on several factors including: axial and radial loads, motor speed, temperature, and the bearing ratings. Because the front bearing is positioned closest to the motor shaft, it usually carries a higher load and has the shortest life.

There are two sets of bearing life curves below. The first set shows the maximum axial and radial shaft loads for 20,000 hours L10 bearing life at various speeds. These curves are for the radial load applied at the distance from the mounting face shown on the curve (usually the center of the flat / keyway). These curves are for the shortest motor in the series. Longer motors have a somewhat higher rating.

Additional life curves are shown for larger motors, (size 17, 23, 34, 42) They show bearing life, at various speeds and radial loads. These curves are for the radial load applied at the distance from the mounting face shown on the curve (usually the center of the flat / keyway). Each page has six graphs for one motor size and length. There are multiple graphs for different axial loads, and separate graphs for English and metric units.

Another limiting factor for bearing life can be the bearing grease life. Applied Motion Products uses special high-grade bearing grease. Normally Applied Motion Products motors operate for years without the grease being an issue. Typical grease life is 40,000 hours of operation.

## Insulation Life:

Applied Motion Products standard insulation is class B, rated for 130° C. By industry definition, insulation life is rated for 20,000 hours, at rated temperature. For every 10°C temperature reduction, insulation life approximately doubles. If the motor internal temperature is actually running at 120° C insulation life is 40,000 hours; at 110°C the life is 80,000 hours, etc. Because it's rare for Applied Motion Products motors to be operated so that internal motor temperatures are continuously above 90 C, insulation life is usually not a limiting factor.

Insulation and bearing temperature can be confirmed in the application by measuring the surface temperature of the motor, after running the machine under worse case conditions for several hours. The maximum internal temperature is about 15°C hotter than the surface temperature of the motor. Thus, maximum temperature equals the measured motor body temperature, plus 15°C, plus the difference between the maximum rated machine ambient and the test ambient.



## MTBF - Mean Time Between Failures:

MTBF is a number that represents failure rate. It is combined with other component MTBF numbers to estimate the reliability of a system. The method for estimating reliability is defined in MILITARY HANDBOOK MIL-HDBK217F (notice 2).

For motors, MTBF is mostly influenced by the bearing and insulation life. The factors included in the MTBF calculations are operating motor temperature, and the motor design life. Most applications for step motors fall into one of two different situations.

**Typical Commercial:** The motor is actually operated at infrequent at random times throughout the day. Examples of this type of application include: 3 D printers, antenna positioning, solar systems, ATM machines, vending machines, and performance lighting.

**Typical Industrial:** The motor is used for production equipment and operates a high percentage of the time throughout the work day. Examples of this type of application include: production equipment, medical analysis equipment used in commercial laboratories, packaging equipment, and industrial robots.

Application		Typical Industrial	Typical Commercial
Operating Conditions		10 years, 1 shift High duty cycle	5 years 24/7 Low duty cycle
LC = design life	Hours	20,000	43,800
TA = Motor Temperature	°C	65	45
MTBF	Hours	406,500	1,123,600
lp = Failure Rate	per 1,000,000 Hours	3.44	1.21

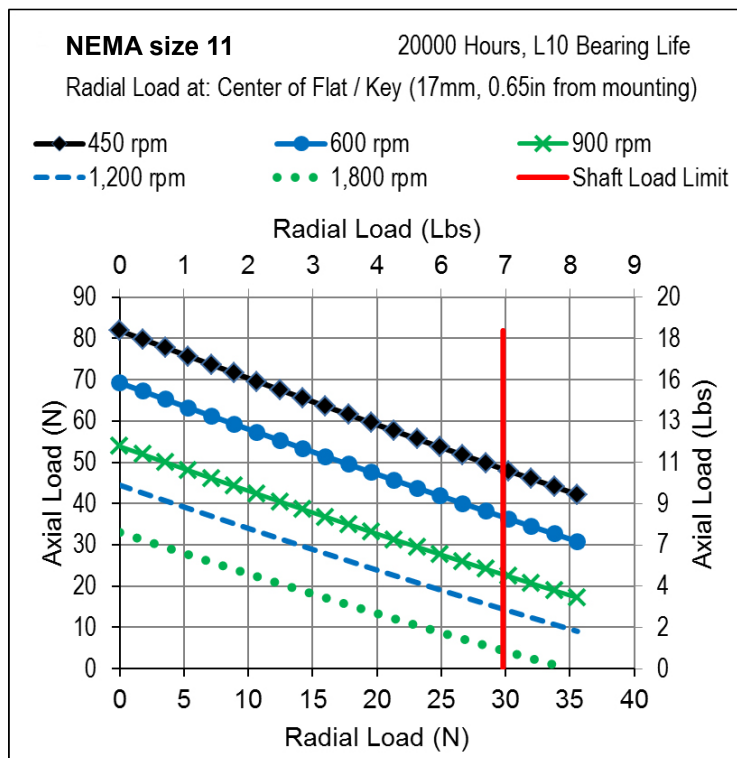
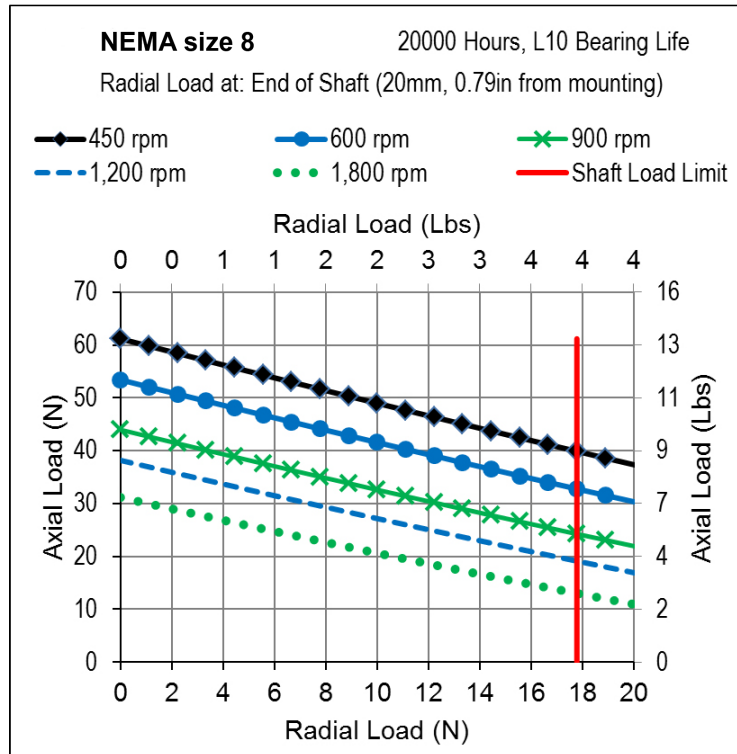
## Other Life Factors:

Other application specific conditions that can lead to early motor failure include:

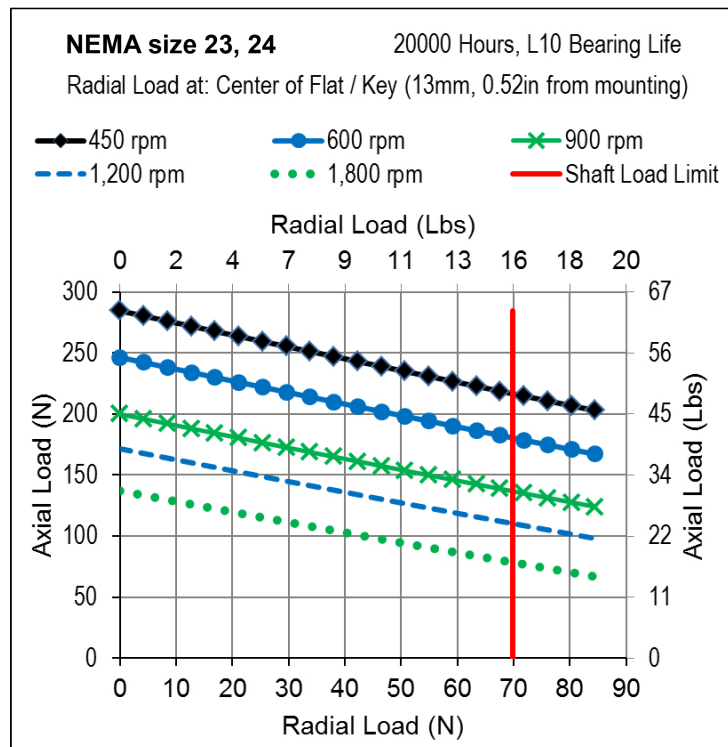
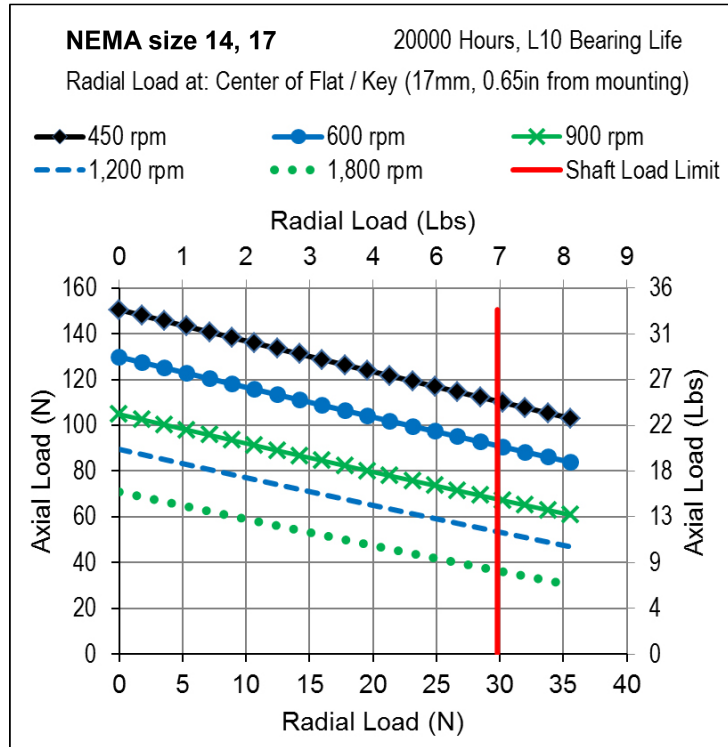
- The presence of water or humidity that causes corrosion inside the motor. This can then bind the rotor or damage the bearings.  
***Applied Motion Products anti-rust treatment can eliminate this problem.***
- Dust that may get inside the motor and cause binding or damage the bearings.  
***Sealed motors and shaft seals are available from Applied Motion Products.***
- High shock and vibration can cause a variety of failures.  
***Larger bearings, magnet wire lead loops, & varnished windings can all be solutions.***
- High shaft loads or longer life may be required.  
***Applied Motion Products can supply motors with over size bearings and shafts to meet your needs.***
- Excessive temperatures may be present, and shorten the life of the insulation or bearing grease.  
***Low temperature rise motors are available from Applied Motion Products.***

***Applied Motion Products also has encapsulated motor designs that can be especially effective for solving many of these problems.*** If you want assistance with your motor application, please contact Applied Motion Products. We can help with analysis of your application, and recommendations for your specific needs.

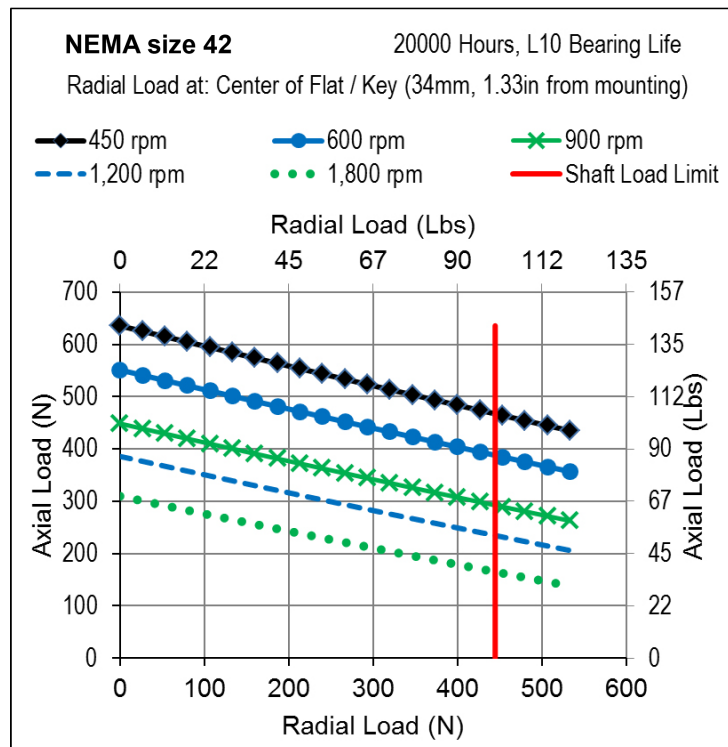
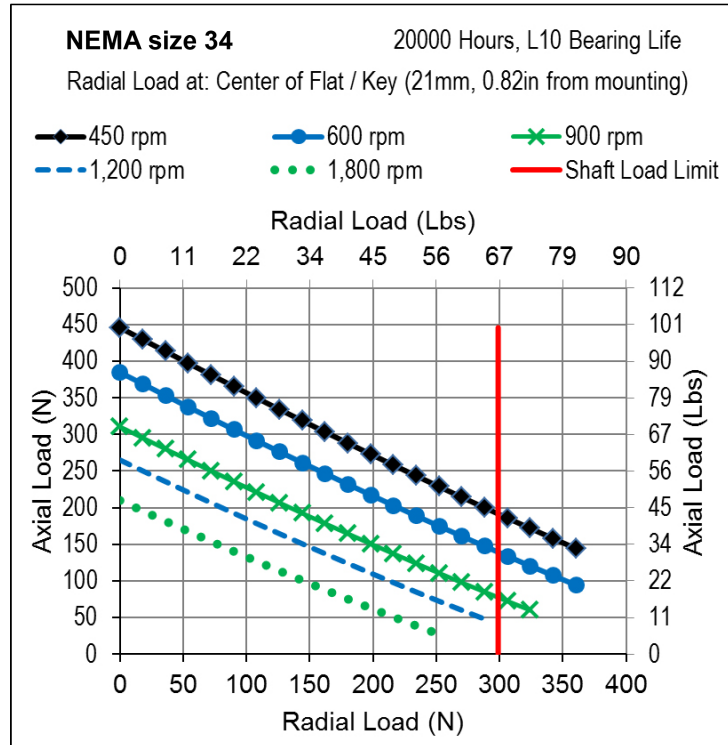
## Maximum Shaft Loads for: 20,000 Hour L<sub>10</sub> Bearing Life



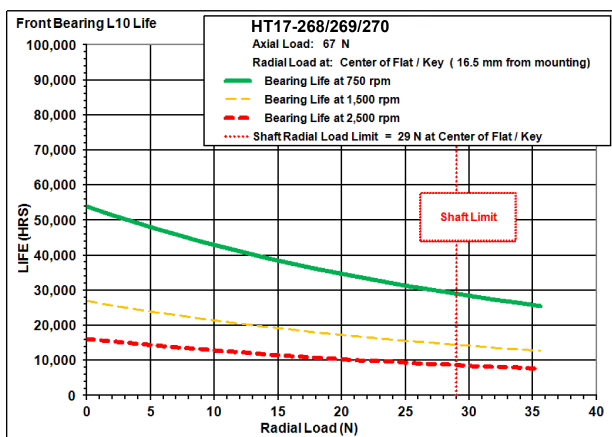
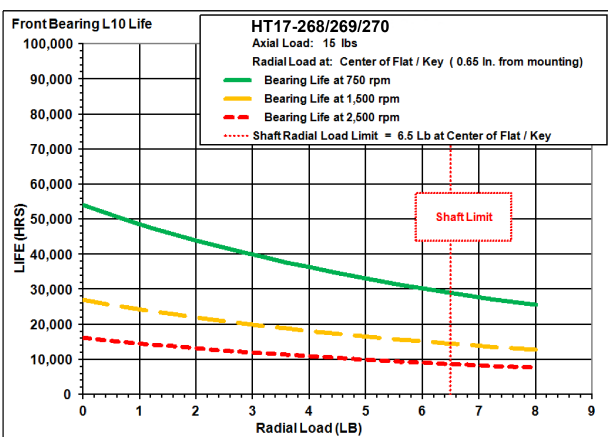
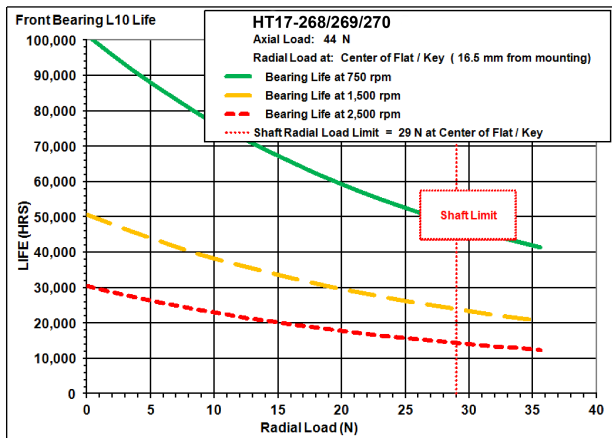
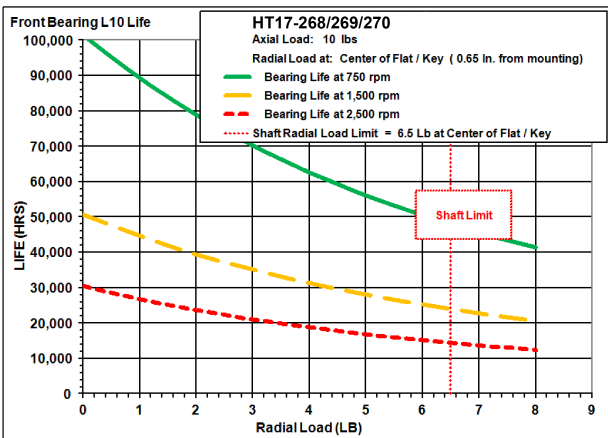
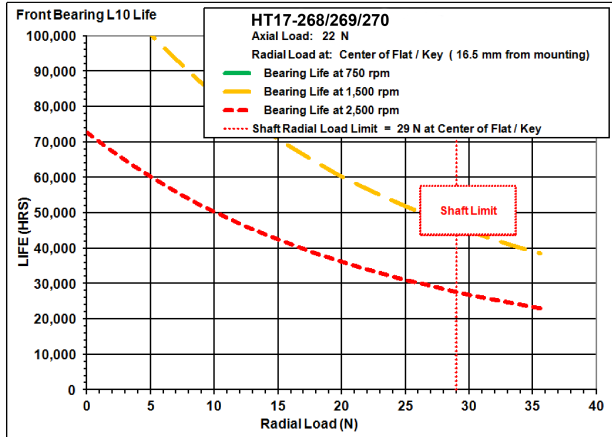
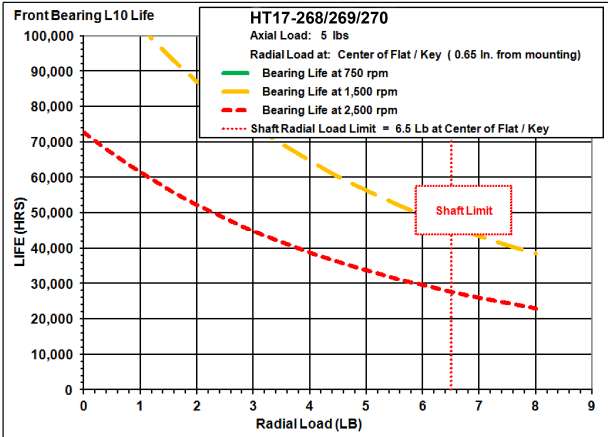
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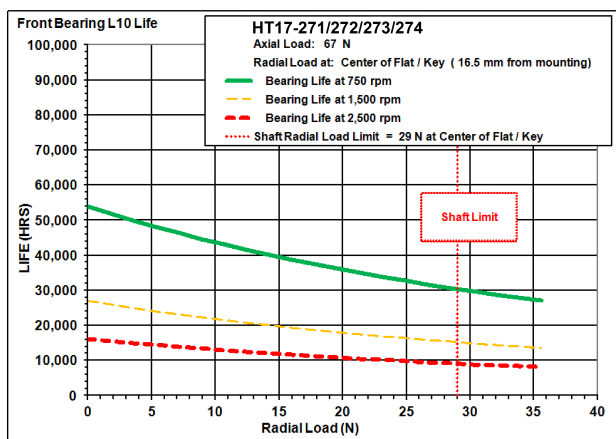
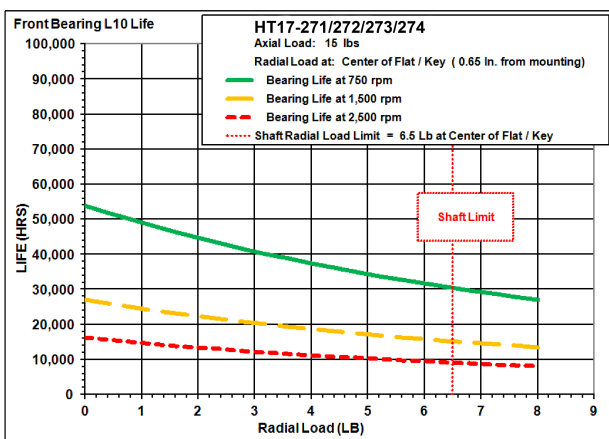
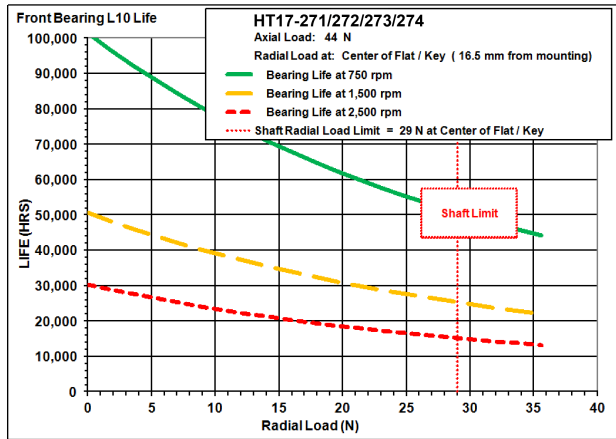
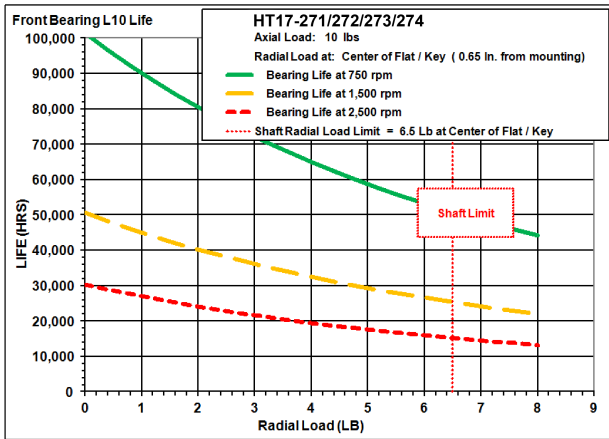
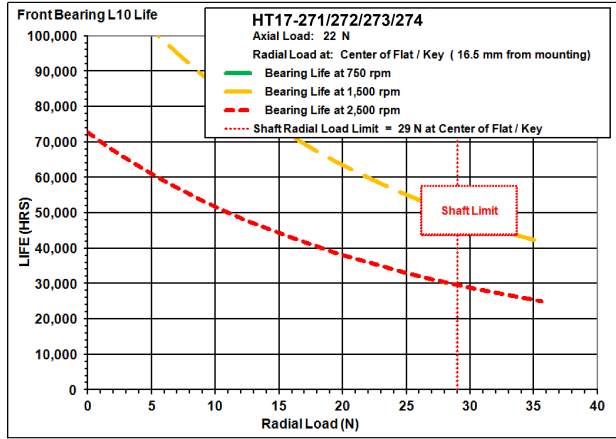
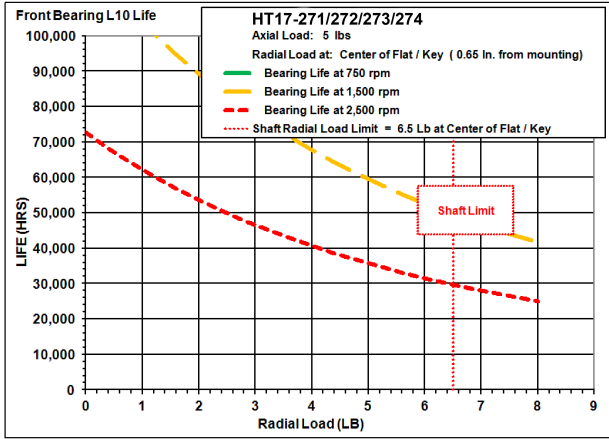
## Maximum Shaft Loads for: 20,000 Hour L<sub>10</sub> Bearing Life



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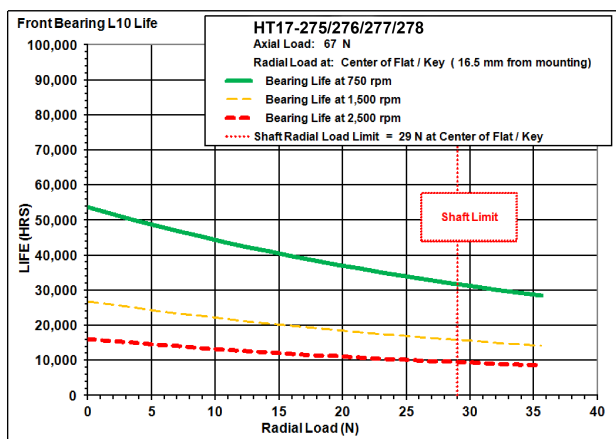
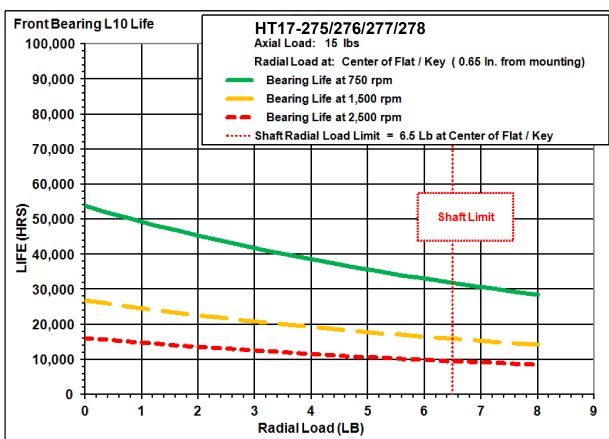
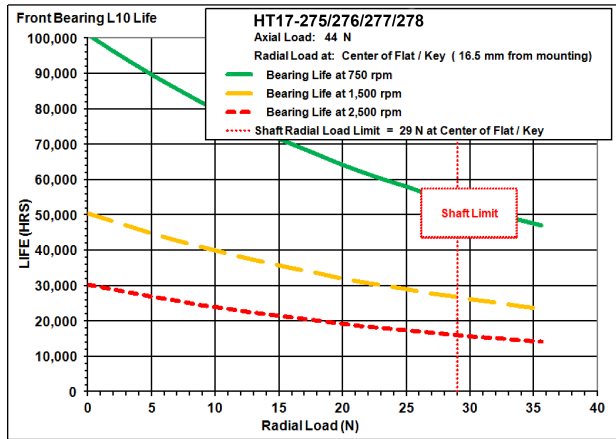
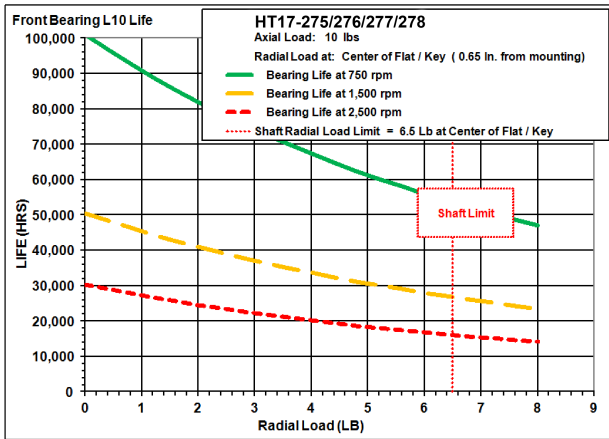
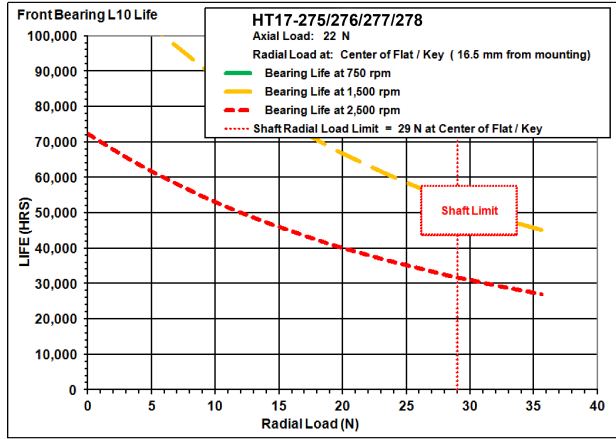
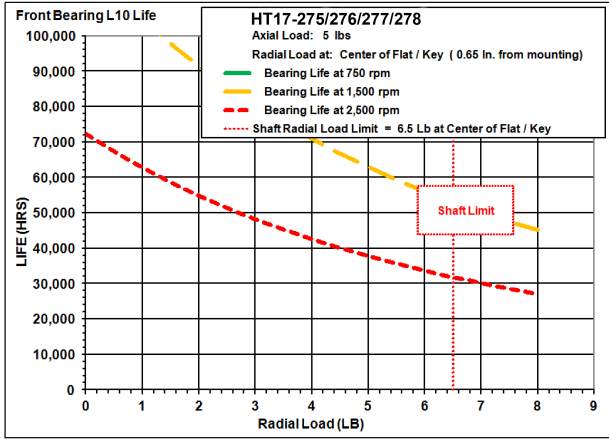


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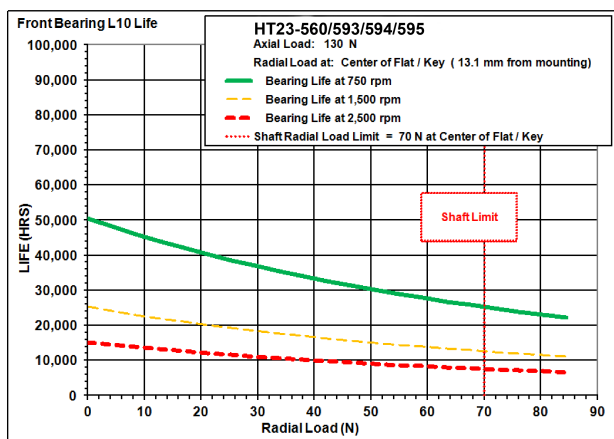
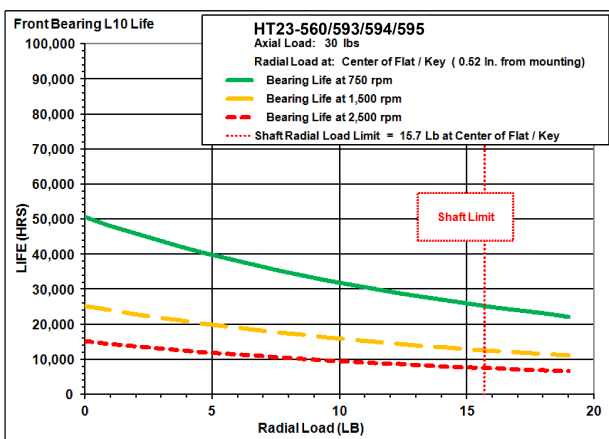
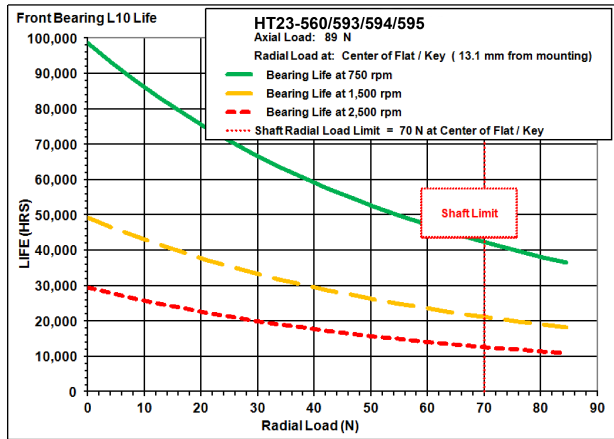
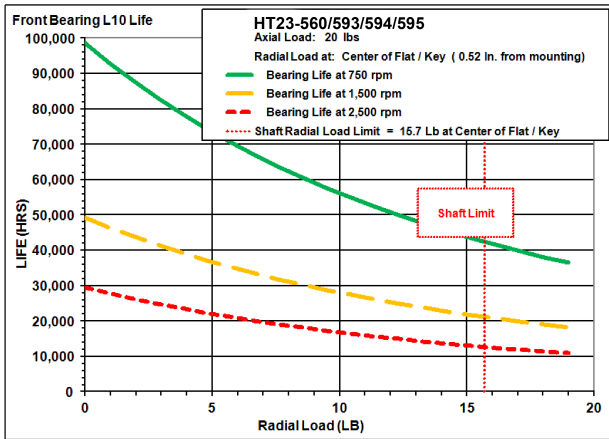
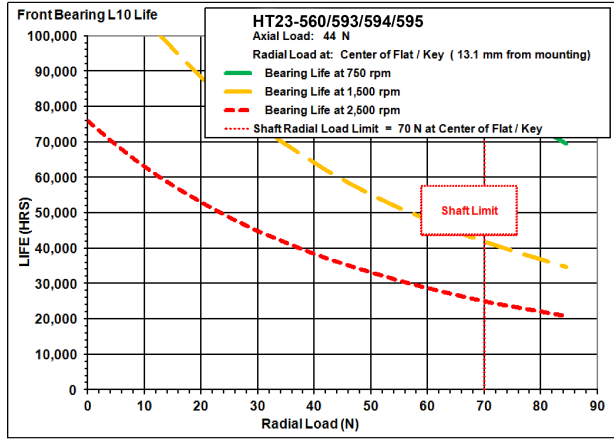
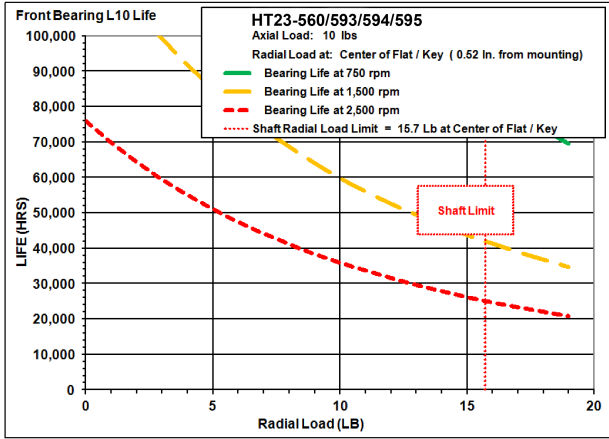




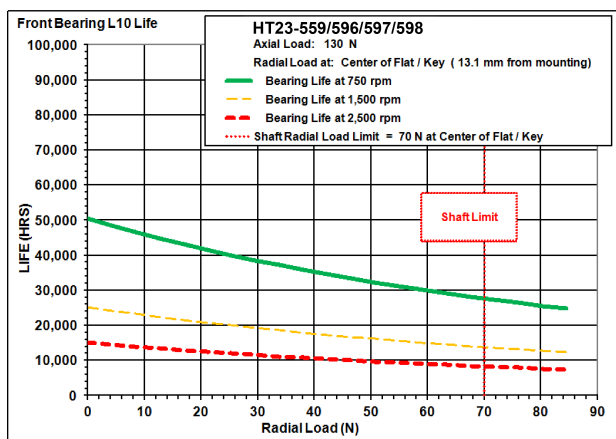
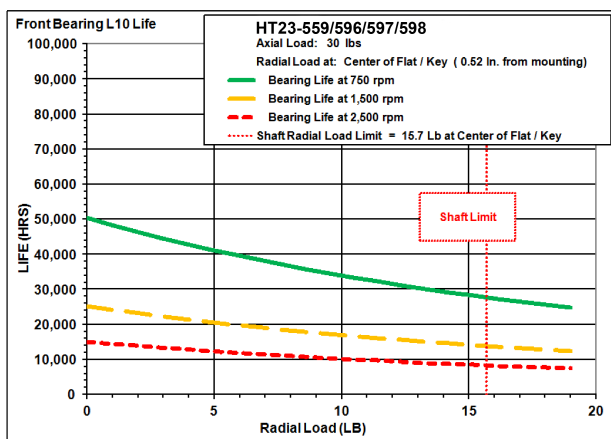
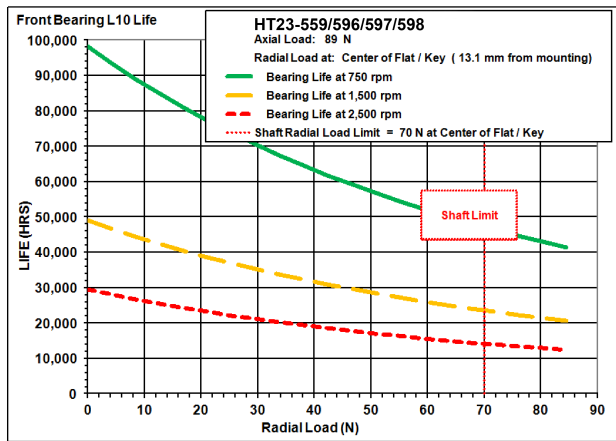
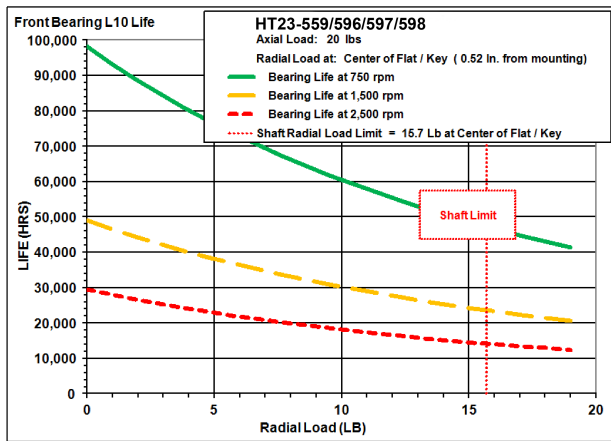
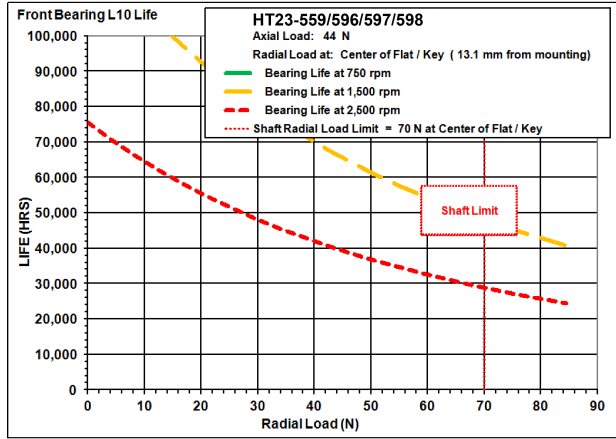
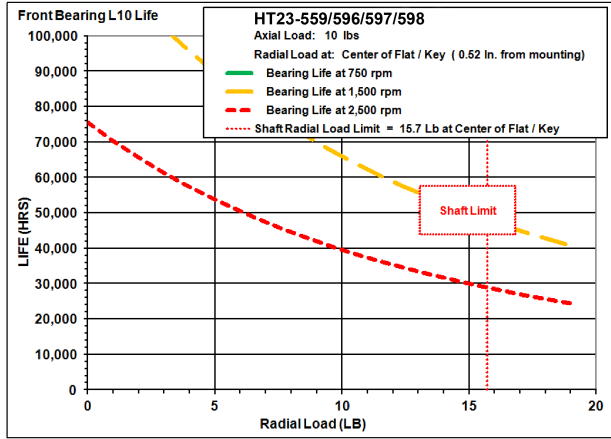
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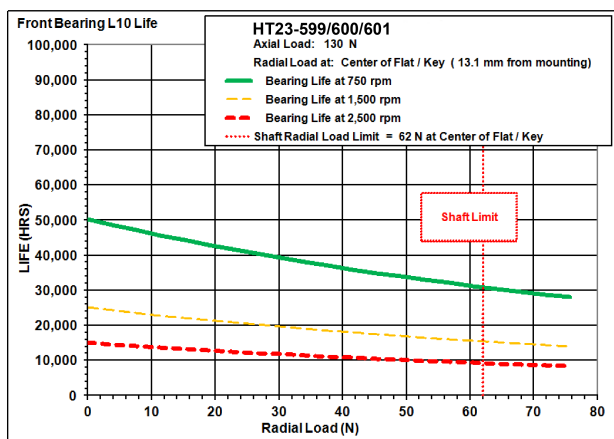
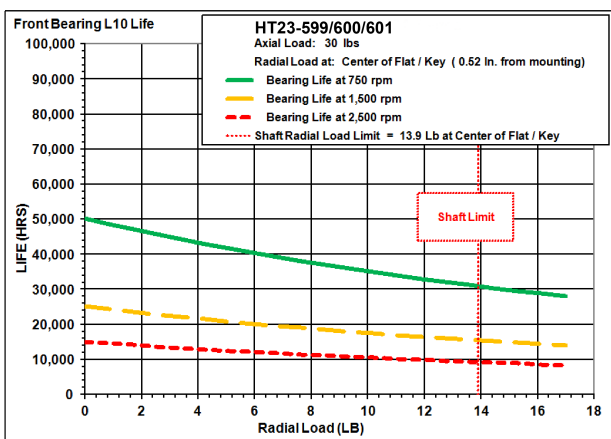
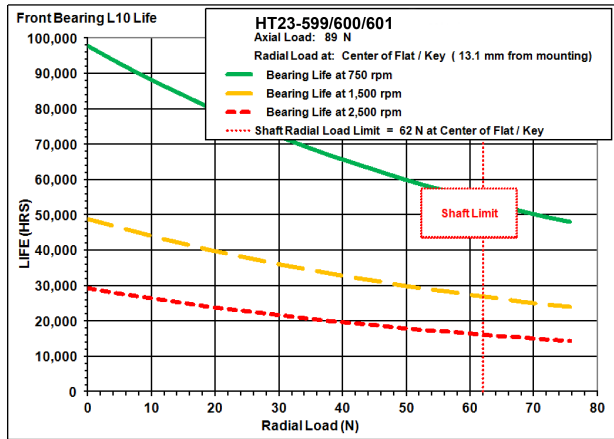
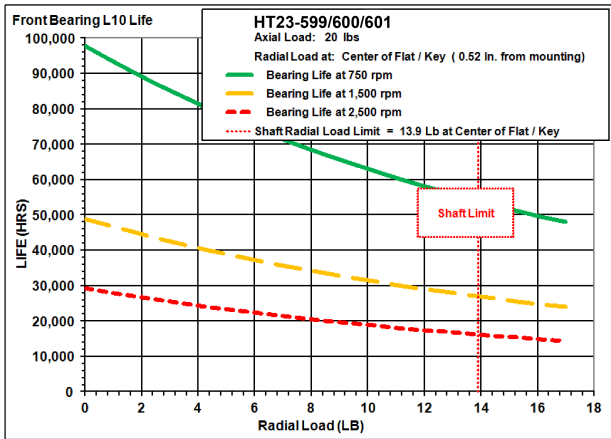
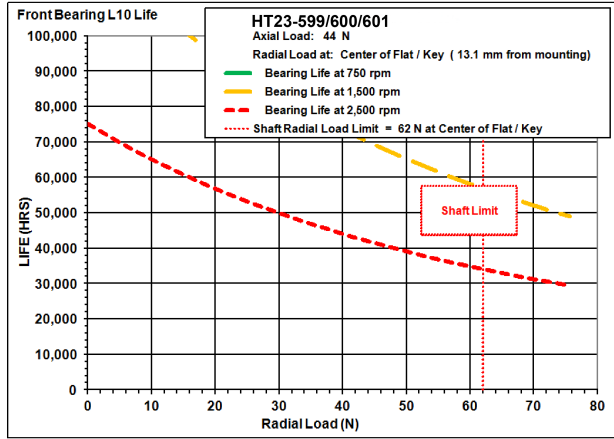
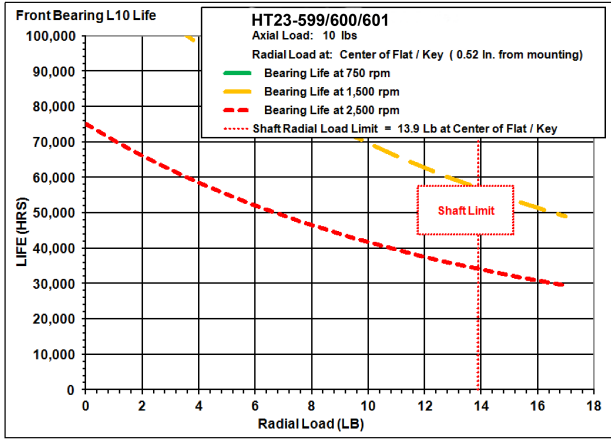
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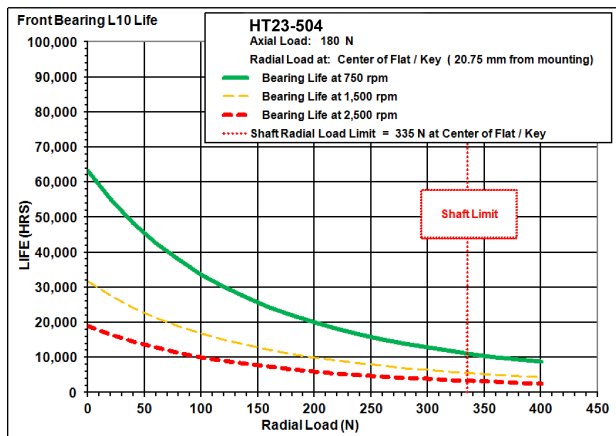
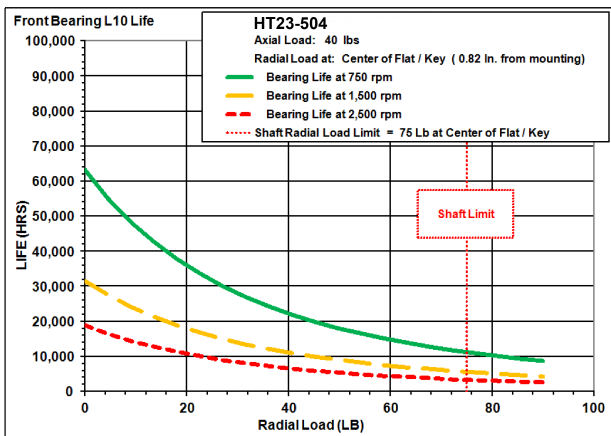
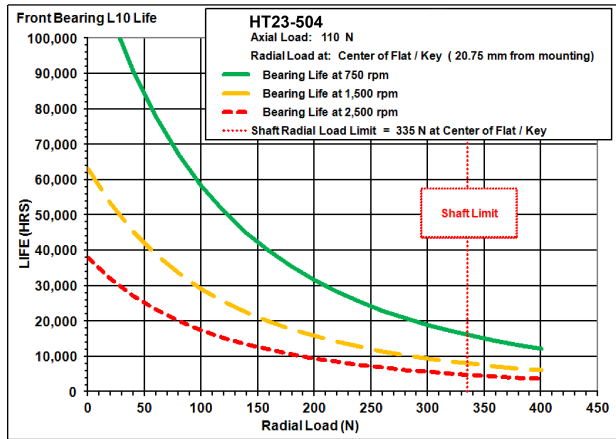
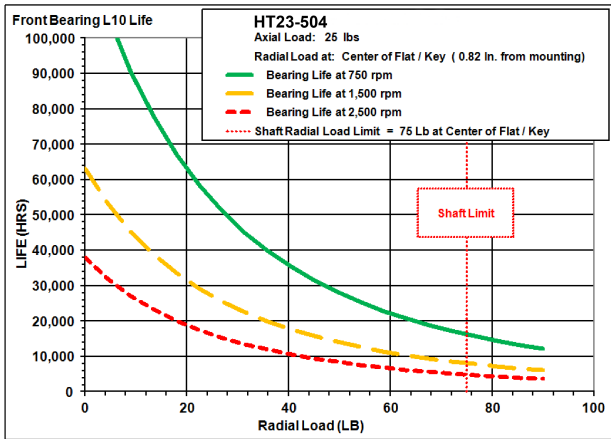
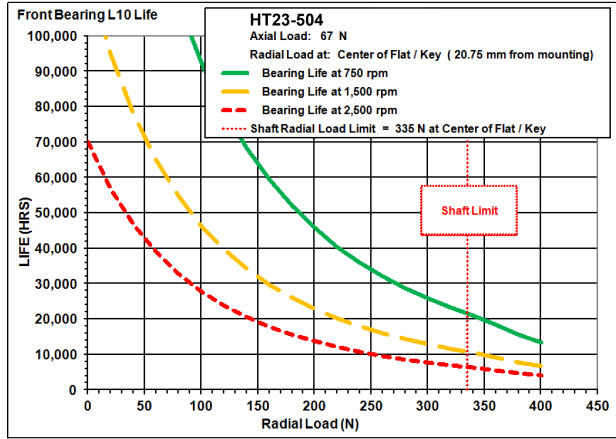
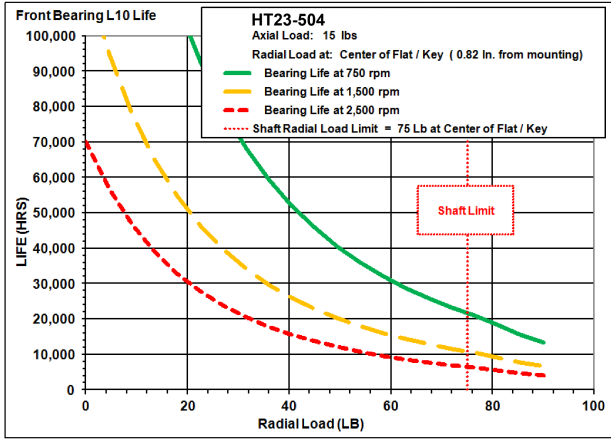
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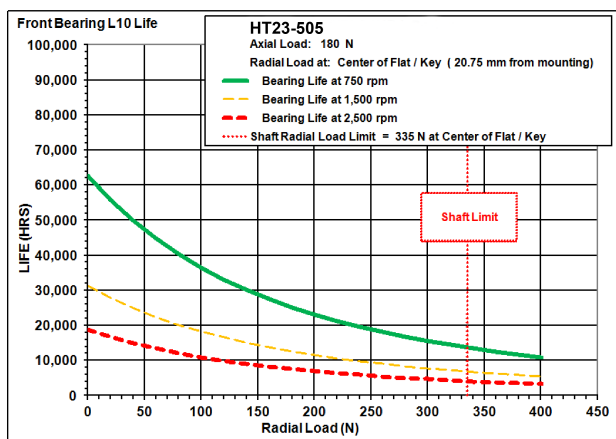
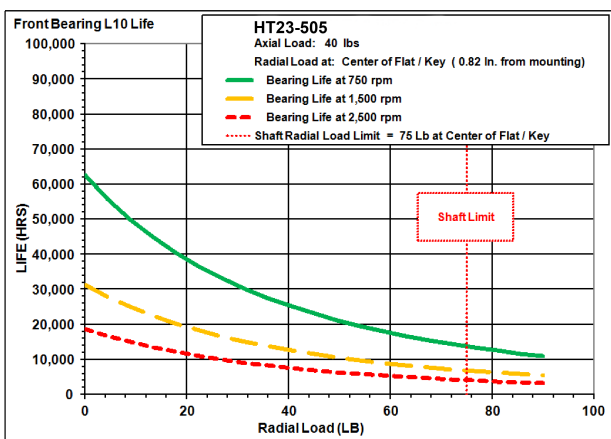
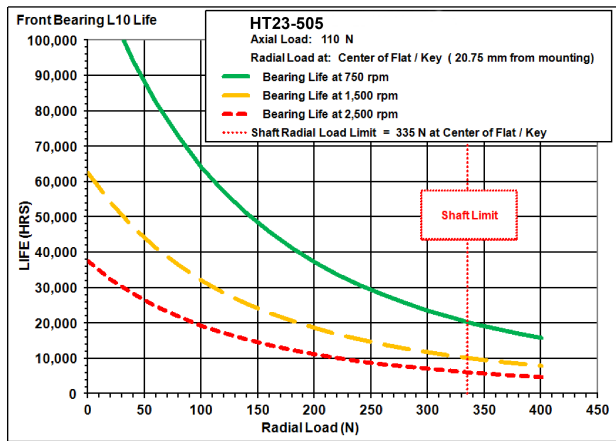
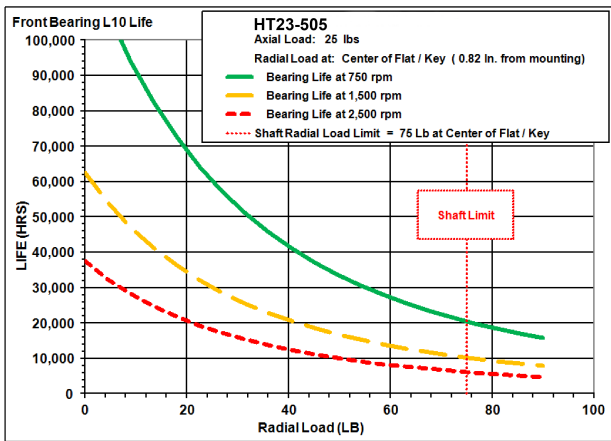
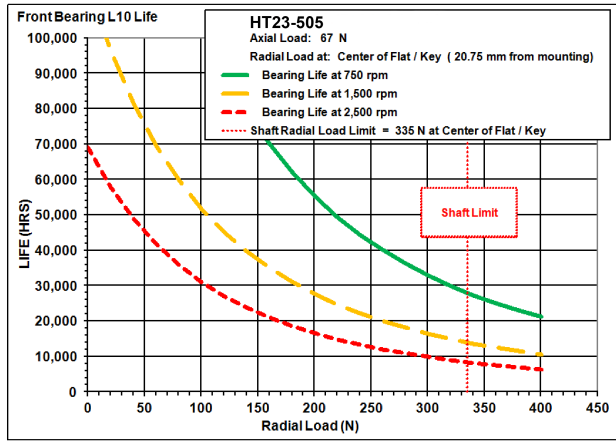
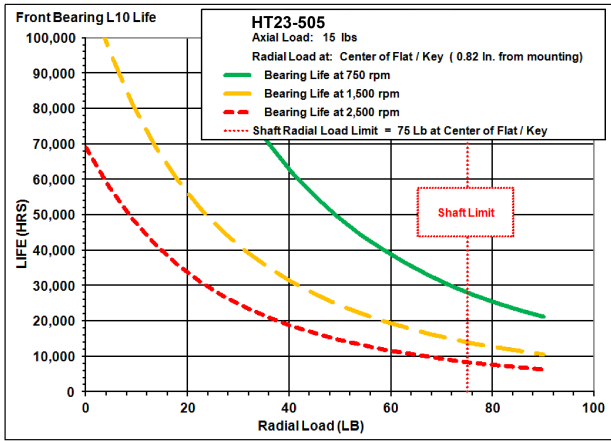
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## HT34-504 – Bearing Life



## HT34-505 – Bearing Life



## HT34-506, HW34-506 – Bearing Life

