Service Life

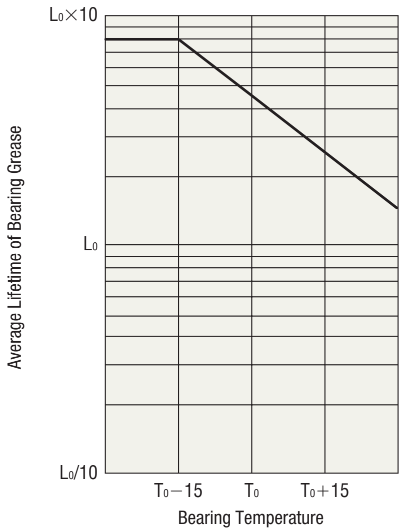
The service life of your Oriental Motor product is an important factor in determining the maintenance and inspection timings of your equipment. The following explains how we should approach the service life of each product. Note that the product life is not a guaranteed value. Please use this information only as a reference relating to maintenance and inspection.

■Service Life of Motors

The service life of a bearing greatly affects the service life of a motor.
The service life of a bearing can be expressed in two ways:

① The life of grease due to thermal deterioration
② Mechanical life affected by rolling fatigue

In most cases, it is the ruling idea that the service life of a motor is based on ① life of grease, because heat generation affects the life of grease more than the amount of bearing load affects the mechanical life.
Temperature is the greatest factor on the life of bearing grease, and consequently temperature has a significant impact on the motor's service life. It is shown in the graph below in a simple way.
The graph shows that the service life of bearing grease is halved after every 15˚C temperature rise of bearing.



To use the motor longer, it is effective to take measures to lower the motor temperature.
The table below shows the average bearing grease life for each motor as reference.

	Operating Condition	Estimated Average Lifetime of Bearing Grease [h]
Induction Motors	Operation : Continuous, One direction Torque : Rated Torque Load Type : Uniform load Speed : Rated Speed Ambient Temperature : 30˚C	30,000
Brushless Motors		40,000
Servo Motors	Surface Temperature of Motor Case Operation under 80˚C	50,000
Stepping Motors Frame Size 50 mm or more		
Stepping Motors Frame Size 42 mm or less		30,000

●Note that the service life of bearing grease is greatly affected by operating conditions and environment.

Standard AC Motors, Brushless Motors, Servo Motors

Be sure to keep the motor case surface temperature at 90˚C or less.

Stepping Motor

Be sure to keep the motor case surface temperature at 100˚C or less.

Due to the relationship of operating ambient temperature and operating duty, the lower the motor surface temperature, the longer the service life becomes. For your information, on rare occasions such as when the overhung load is large, the mechanical life will be shorter than the life of grease.

■Service Life of Gearheads

The service life of a gearhead is mostly determined by the mechanical life of its bearing. Gearheads can no longer transmit power when its service life has expired. Accordingly, the actual life changes according to the load size, how the load is applied, and service speed. At Oriental Motor, the rated life of each product is determined under a set of conditions and the service life of the product actually in use is calculated from the estimated life by also considering the load condition, etc. Take note that with Oriental Motor's gearheads, the tooth surface is lubricated with grease. Separate lubrication is not required.

●Rated Life

At Oriental Motor, the service life of a gearhead under the following conditions is defined as the rated life of the gearhead.
Condition
- Torque : Permissible Torque
- Load Type : Uniform load
- Input Speed : Reference input speed
- Overhung Load : Permissible Overhung Load
- Thrust Load : Permissible Thrust Load

Table 1: Rated Life of Each Gearhead Type

Series and Motor Type	Gearhead Type	Reference input speed	Rated Lifetime L1
Stepping Motors **AR** Series **ARL** Series **RK** Series **CRK** Series	**PS** Geared Type	3000 r/min	5000 hrs.
	TH Geared Type	1500 r/min	
	Harmonic Geared Type		
Stepping Motors **CMK** Series 2-Phase **PKP** Series 2-Phase **PK** Series	**SH** Geared Type		
Servo Motors **NX** Series	**PS** Geared Type	3000 r/min	5000 hrs.
	PJ Geared Type	3000 r/min	10000 hrs.
Standard AC Motors Brushless Motors	**GN-KF**, **GE-KBF**, **GU** Gearheads	1500 r/min	5000 hrs.
	Right-Angle Gearheads		
	BH Parallel Shaft Gearhead Type		
	BH Right-Angle Gearhead Type	1500 r/min	10000 hrs.
	GFS Gearheads **GFS** Hollow Shaft Flat Gearheads	3000 r/min	

●Estimating Lifetime

The lifetime in actual use is calculated using the formula below that considers the service speed, load and load type. Take note that this lifetime represents the actual driving time.

$$L \text{ (Life time)} = L_1 \frac{K_1}{(K_2)^3 \cdot f} \text{ [h]}$$

L_1: Rated lifetime [hours]

Determined for each gearhead type based on Table 1.

K_1: Speed coefficient

K_1 is calculated from the reference input speed specified in Table 1 and the actual input speed.

$$K_1 = \frac{\text{Reference input speed}}{\text{Actual Input Speed}}$$

K_2: Load factor

The load factor K_2 is calculated from the actual torque and the permissible torque of each gearhead.

$$K_2 = \frac{\text{Operating Torque}}{\text{Permissible Torque}}$$

If load is applied only at start and stop, as is the case when driving an inertial load, the average torque is used as the operating torque. The calculation method is explained later. The permissible torque corresponds to the specification value of each product stated in the catalogue.

f: Load-type factor

Determine the factor f based on the load type by referring to the examples of drive patterns shown below.

Load Type	Example	Load-type factor f
Uniform load	· Uni-directional continuous operation · Driving a belt conveyor or film reel with less load fluctuation	1.0
Slight Impact	· Frequent starting and stopping · Cam drive and positioning control of inertia body via stepping motor	1.5
Medium Impact	· Frequent instantaneous bi-directional operation, starting and stopping of reversible motors · Frequent instantaneous stopping of AC motors by brake pack · Frequent instantaneous starting and stopping of brushless motors and servo motors	2.0

Note

Effects of overhung load and thrust load

● In this estimation of lifetime, the overhung load and thrust load are also proportioned according to the load factor. When the load factor is 50%, for example, the overhung load and thrust load are also calculated as 50% of their respective ratings.

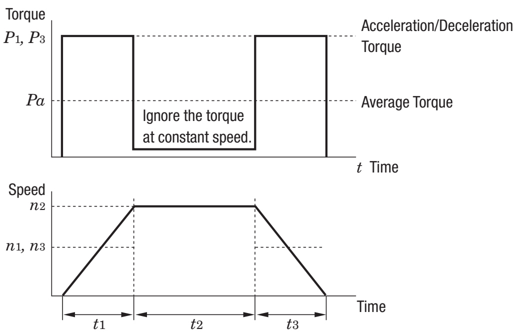
● If the load factor is low and overhung load or thrust load is high, the service life becomes shorter than the value calculated with this formula.

●How to Obtain the Average Torque

In applications where a stepping motor or servo motor is used, an index table or arm may be driven or other inertial load may be operated intermittently. In this case, the average torque is considered the service torque, as explained below. When an inertial load is driven by a standard AC motor or brushless motor, the load factor is deemed 1.0.

◇Driving Only an Inertial Load ①

When only an inertial load is driven and the operating cycle is long, torque is applied as shown in the figure below. Although the bearing, etc. may generate a frictional load at a constant speed, its effect is minor and therefore ignored.

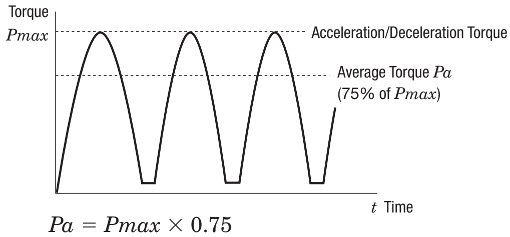


$$P_a = \sqrt[3]{\frac{(P_1{}^3 \times n_1 \times t_1) + (P_3{}^3 \times n_3 \times t_3)}{(n_1 \times t_1) + (n_2 \times t_2) + (n_3 \times t_3)}}$$

n_1 and n_3 indicate the average number of rotations in t_1 and t_3 zones, respectively.
In the above example, the following values apply: $n_1 = n_3 = \frac{1}{2} n_2$

◇Driving Only an Inertial Load ②: Driving an Arm, etc.

When driving an arm, etc., fluctuation load may apply as illustrated below. For example, this occurs when a two-joint arm is driven or an arm is driven in the vertical direction. In this case, use 75% of the maximum acceleration/deceleration as the average torque using the formula below:

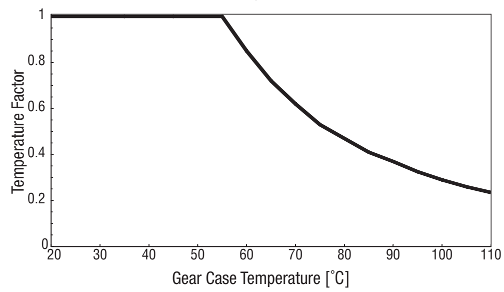


$$Pa = Pmax \times 0.75$$

●Operating Temperature

If the gearhead temperature rises, lubrication of the bearing is affected. The trend of how service life is affected by temperature varies depending on many factors including the condition of the load applied to the gearhead bearing and the frame size of the motor. Accordingly, it is difficult to consider the impact of temperature in the aforementioned lifetime estimation formula.
The data below shows how temperature affects the gearhead bearing. As you can see, the service life tends to be affected when the gear case surface temperature is 55˚C or more.

Gear Case Temperature Factor

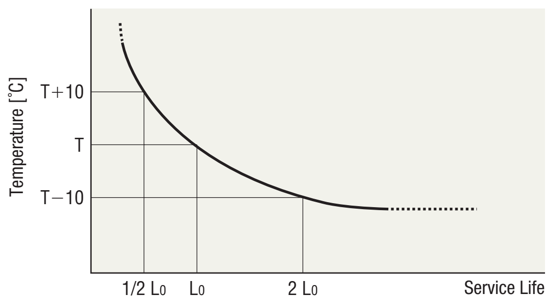


●Note

Although the calculated lifetime may be several tens of thousand hours long depending on the conditions, this is only a reference.
Service life estimation is based on bearing life.
If the driving conditions exceed the specification values, components other than the bearing may be affected. Make sure the specification values of your product stated in the catalogue are not exceeded.

■Service Life of Circuit Products

Oriental Motor's circuit products are designed so that their service life, determined by the aluminum electrolytic capacitor used in the circuit, will be 5 years or more under the operating condition: continuous power supply at an ambient temperature of 40˚C. (Some products are excluded.)
Also, note that in general, a characteristic of aluminum electrolytic capacitors is that their service life is halved when the temperature rises 10˚C, and doubled when the temperature drops 10˚C, according to the "Arrhenius' Equation" (as shown in the figure below).
With circuit products, their lifetime changes depending on the operating environment and operating conditions. Therefore, it is recommended that you use the curve in the figure below as a reference when determining a proper maintenance schedule of your system to prevent wear-induced failures.



Service Life of Aluminum Electrolytic Capacitors

Service Life of Motorized Linear Slides and Motorized Cylinders

The service life of a motorized linear slide and motorized cylinder is generally affected by the rolling fatigue life of its ball screw or linear guide. When stress is applied repeatedly to the raceways and rolling balls, flaking (a phenomenon in which the metal surface turns into small scale-like pieces that separate from the base metal) occurs due to material fatigue caused by rolling fatigue. The rolling fatigue life refers to the life time until flaking occurs.

Concept of Service Life

The service life of a motorized linear slide is determined from the maximum thrust applied to its ball screw, maximum transportable mass applied to its linear guide, and its moment load. The service life of a motorized cylinder is determined from the maximum thrust force applied to its ball screw.
Since the service life changes depending on the operating conditions, environment, and various other factors, use the calculated service life only as a reference.

Estimated Service Life of Each Series

Series	12 mm Lead	6 mm Lead	3 mm Lead
EZSII Series (Including Cleanroom Use)	5000 km	3000 km	–
EZCII Series	5000 km	3000 km	1500 km

Service Life of Cooling Fans

The service life of a cooling fan is reached when the cooling fan can no longer be used as a result of the loss of air flow capacity or an increase in noise due to continuous operation over a certain period of time.

Service Life of Cooling Fans

① Rotation life - Defined by a certain decrease in r/min
② Sound life - Defined by a certain increase in noise

The rotation life in ① can be clearly specified numerically and measurement is also easy. In general, the service life of a fan means the fan's rotation life.
The final judgment of the sound life in ②, which is defined by an increase in noise by XX dB, depends on the subjective feeling of the user and, depending on the operating conditions of the fan, it may still be usable after reaching its acoustic life. Generally the acoustic life is not used as a reference or to indicate a specific lifetime.
At Oriental Motor, the service life of each fan is defined by its rotation life in ①, where the fan is deemed to have reached the end of its service life when the speed has dropped to 70% of the rated speed.

Service Life of Cooling Fan Bearing

Our cooling fans use ball bearings. The following explains the service life of a ball bearing. Since the load applied to the cooling fan bearing itself is small, the life of a cooling fan is determined by the deterioration of grease applied to the bearing.
To begin with, compared to motors that are used as sources of power, the motors in cooling fans are subject to smaller operating torque and starting torque. When grease deteriorates and loses its lubricating function, the starting torque and operating torque of the bearing may rise significantly and the bearing may no longer function. When grease deteriorates and loses its lubricating function, the starting torque and operating torque of the bearing may rise significantly and the bearing may no longer function.
Deterioration of grease increases the noise generated from the fan bearing and therefore the life of grease affects the service life of the fan.

$$\log t = K_1 - K_2 \frac{n}{Nmax} - \left(K_3 - K_4 \frac{n}{Nmax}\right) T$$

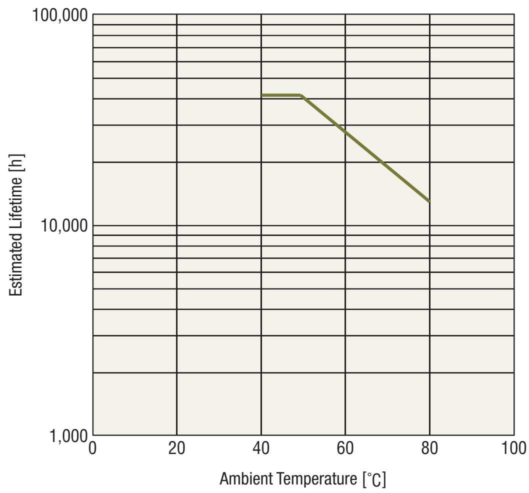
t: Average grease life
K_1, K_2, K_3, K_4: Constant determined by each grease
$Nmax$: Number of rotations allowed by grease lubrication
n: Bearing speed
T: Operating temperature of bearing

The formula below is a numerical expression of the life of grease. This formula shows that, since $Nmax$ is already determined by the bearing, the life of grease depends on the temperature and bearing speed. However, with Oriental Motor's products, bearing speeds are not high enough to affect the life of grease. Since $\frac{n}{Nmax}$ is constant, the life of grease is effectively determined by the temperature.

Estimated Life Characteristics

The figure below shows the estimated life characteristics of a cooling fan. These characteristics are those of the small AC cooling fan **MU1238A**.

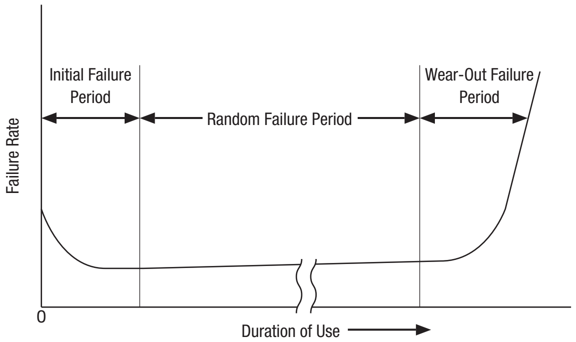
This graph estimates the service life of the bearing using the life-of-grease estimation formula for bearings based on actual measurements of temperature rise at the rated voltage.



Estimated Life Characteristics

Relationship between the Duration of Use and Failure Rate

In general, the failure rate of components are classified into three types according to the stage: initial failure, random failure and wear-out failure, as shown in the figure below.



Relationship between the Duration of Use and Failure Rate

Consideration has been given to eliminate initial failures in the manufacturing and inspection processes, but random failures are sudden failures that occur randomly and unexpectedly during the durable lifetime of the product before wear progresses, and implementing technical countermeasures is difficult. At the moment, all we can do is to take measures based on past statistics.
Wear-out failures occur near the end of the durability lifetime as a result of deterioration or wear, and the occurrence rate rises suddenly at a certain point in time. When specific components are replaced with new ones at this point, proper preventive maintenance can be ensured.
(Excerpts from "Recommendation for Periodic Inspection of General-Purpose Inverters" by the Japan Electrical Manufacturers' Association)