Grease name	Aluminum grease	Non-soap base grease Thickener	
Thickener	Al soap	Bentone, silica gel, urea, carbon black, fluorine compounds, etc.	
Base oil	Mineral oil	Mineral oil	Synthetic oil
Dropping poin °C	70 ~ 90	250 or above	250 or above
Operating temperature range °C	-10 ~ +80	-10 ~ +130	-50 ~ +200
Mechanical stability	Good ~ poor	Good	Good
Pressure resistance	Good	Good	Good
Water resistance	Good	Good	Good
Applications	Excellent viscosity characteristics. Suitable for bearings subjected to vibrations.	Can be used in a wide range of low to high temperatures. Shows excellent heat resistance, cold resistance, chemical resistance, and other characteristics when matched with a suitable base oil and thickener. Grease used in all types of rolling bearings.	

7. Load rating and life

7.1 Bearing life

Even in bearings operating under normal conditions, the surfaces of the raceway and rolling elements are constantly being subjected to repeated compressive stresses which causes flaking of these surfaces to occur. This flaking is due to material fatigue and will eventually cause the bearings to fail. The effective life of a bearing is usually defined in terms of the total number of revolutions a bearing can undergo before flaking of either the raceway surface or the olling element surfaces occurs.

Other causes of bearing failure are often attributed to problems such as seizing, abrasions, cracking, chipping, gnawing, rust, etc. However, these so called "causes" of bearing failure are usually themselves caused by improper installation, insufficient or improper lubrication, faulty sealing or inaccurate bearing selection. Since the above mentioned "causes" of bearing failure can be avoided by taking the proper precautions,and are not simply caused by material fatigue, they are considered separately from the flaking aspect.

7.2 Basic rating life and basic dynamic load rating

A group of seemingly identical bearings when subjected to identical load and operating conditions will exhibit a wide diversity in their durability.

This " life " disparity can be accounted for by the difference in the fatigue of the bearing material itself. This disparity is considered statistically when calculating bearing life, and the basic rating life is defined as follows.

The basic rating life is based on a 90% statistical model which is expressed as the total number of revolutions 90% of the bearings in an identical group of bearings subjected to identical operating conditions will attain or surpass before flaking due to material fatigue occurs. For bearings operating at fixed constant speeds, the basic rating life (90% reliability) is expressed in the total number of hours of operation.

The basic dynamic load rating is an expression of the load capacity of a bearing based on a constant load which the bearing can sustain for one million revolutions (the basic life rating). For radial bearings this rating applies to pure radial loads, and for thrust bearings it refers to pure axial loads. The basic dynamic load ratings given in the bearing tables of this catalog are for bearings constructed of NIKO standard bearing materials, using standard manufacturing techniques.Please consult NIKO engineering for basic load ratings of bearings constructed of special materialsor using special manufacturing techniques.

The relationship between the basic rating life, the basic dynamic load rating and the bearing load is given in formula (7.1).

$L_{10} = (\frac{C}{P})^{p}$ ....(7.1)

where,
$p = 3$ ················ For ball bearings
L_{10} : Basic rating life 106 revolutions
C : Basic dynamic rating load, n
(Cr: radial bearings)
P : Equivalent dynamic load, n
(Pr: radial bearings)

The basic rating life can also be expressed in terms of hours of operation (revolution), and is calculated as shown in formula (7.2).

$L_{10h} = 500 f_h^{\,p}$ ....(7.2)

$f_h = f_n \frac{C}{P}$ ....(7.3)

$f_n = (\frac{33.3}{n})^{1/p}$ ....(7.4)

where,
L_{10} : Basic rating life, h
f_h : Life factor
f_n : Speed factor
n : Rotational speed, r/min

BALL BEARINGS

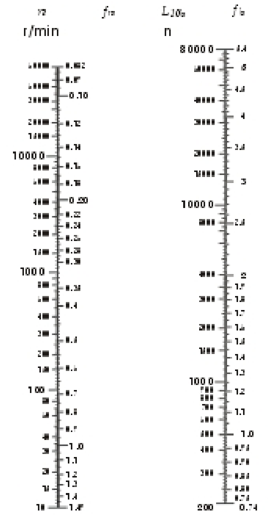

Fig.7.1 Bearing life rating scale

Formula (7.2) can also be expressed as shown in formula (7.5).

$L_{10h} = \frac{10^6}{60n} (\frac{C}{P})^{p}$ ....(7.5)

The relationship between rotational speed n and speed factor fn as well as the relation between the basic rating life L10h and the life factor fn is shown in Fig. 7.1. When several bearings are incorporated in machines or equipment as complete units, all the bearings in the unit are considered as a whole when computing bearing life (see formula 7.6). The total bearing life of the unit is a life rating based on the viable lifetime of the unit before even one of the bearings fails due to rolling contact fatigue.

$L = \frac{1}{(\frac{1}{L_1^{\,e}} + \frac{1}{L_2^{\,e}} + \dots \frac{1}{L_n^{\,e}})^{1/e}}$ ....(7.6)

where,
e = 10/9.......................For ball bearings
L = Total basic rating life or entire unit, h
$L_1, L_2...L_n$: Basic rating life or individual bearings, 1, 2....n, h

When the load conditions vary at regular intervals, the life can be given by formula (7.7).

$L_m = (\Sigma \phi_j / L_j)^{-1}$..............................(7.7)

where,
ϕ_j : Frequency of individual load conditions
L_j : Life under individual conditions

7.3 Machine applications and requisite life

When selecting a bearing, it is essential that the requisite life of the bearing be established in relation to the operating conditions.The requisite life of the bearing is usually determined by the type of machine in which the bearing will be used, and duration of service and operational reliability requirements. When determining bearing size, the fatigue life of the bearing is an important factor; however, besides bearing life, the strength and rigidity of the shaft and housing must also be taken into consideration.

7.4 Adjusted life rating factor

The basic bearing life rating (90% reliability factor) can be calculated through the formulas mentioned earlier in Section 7.2. However, in some applications a bearing fife factor of over 90% reliability may be required. To meet these requir ements, bearing life can be lengthened by the use of specially improved bearing materials or special construction techniques. Moreover, according to elastohydrodynamic lubrication theory, it is clear that the bearing operating conditions (lubrication, temperature, speed, etc.) all exert an effect on bearing life. All these adjustment factors are taken into consideration when calculating bearing life, the adjusted bearing life can be determined.

$L_{na} = a1 \cdot a2 \cdot a3 \cdot (C/P)^P$..........(7.8)

where,
L_{na} : Adjusted life rating in millions of revolutions (10^6)(adjusted for reliability, material and operating conditions)
$a1$: Reliability adjustment factor
$a2$: Material adjustment factor
$a3$: Operating condition adjustment factor

7.4.1 Life adjustment factor for reliability a_1

The values for the reliability adjustment factor ai (for a reliability factor higher than 90%) can be found in Table 7.1

Table 7.1 Reliability adjustment factor values a_1

Reliability %	L_n	Reliability factor a_1
90	L_{10}	1.00
95	L_5	0.62
96	L_4	0.53
97	L_3	0.44
98	L_2	0.33
99	L_1	0.21

7.4.2 Life adjustment factor for material a_2

The life of a bearing is affected by the material type and quality as well as the manufacturing process.In this regard, the life is adjusted by the use of an a_2 factor.

The basic dynamic load ratings listed in the catalog are based on NIKO's standard material and process, therefore, the adjustment factor a_2 =1. When special materials or processes are used the adjustment factor can be larger than 1.

NIKO bearings can generally be used up to 120°C. If bearings are operated at a higher temperature, the bearing must be specially heat treated (stabilized) so that inadmissible dimensional change does not occur due to changes in the micro-structure. This special heat treatment might cause the reduction of bearing life because of a hardness change.

7.4.3 Life adjustment factor a_3 for operating conditions

The operating conditions life adjustment factor a_3 is used to adjust for such conditions as lubrication, operating temperature, and other operation factors which have an effect on bearing life.

Generally speaking, when lubricating conditions are satisfactory, the a_3 factor has a value of one; and when lubricating conditions are exceptionally favorable, and all other operating conditions are normal, as can have a value greater than one.

However, when lubricating conditions are particularly unfavorable and the oil film formation on the contact surfaces of the raceway and rolling elements is insufficient, the value of a_3 becomes less than one. This Insufficient oil film formation can be caused, for example, by the lubricating oil viscosity being too low for the operating temperature (below13 mm^2/s for ball bearings or by exceptionally low rotational speed (nr/min x dpmm less than 10,000). For bearings used under special operating conditions, please consult NIKO engineering.

As the operating temperature of the bearing increases, the hardness of the bearing material decreases. Thus, the bearing life correspondingly decreases. The opera-ting temperature adjustment values are shown in Fig.7.2.

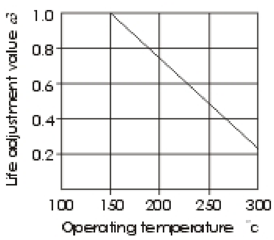

Fig. 7.2 Life adjustment value for operating temperature

7.5 Basic static load rating

When stationary rolling bearings are subjected to static loads, they suffer from partial permanent deformation of the contact surfaces at the contact point between the rolling elements and the raceway. The amount of deformity increases as the load increases, and if this increase in load exceeds certain limits, the subsequent smooth operation of the bearings is impaired.

It has been found through experience that a permanent deformity of 0.0001 times the diameter of the rolling element, occurring at the most heavily stressed contact point between the raceway and the rolling elements, can be tolerated without any impairment in running efficiency.

The basic rating static load refers to a fixed static load limit at which a specified amount of permanent deformation occurs. It applies to pure radial loads for radial bearings and to pure axial loads for thrust bearings. The maximum applied load values for contact stress occurring at the rolling element and raceway contact points are given below.

For ball bearings 4,200 Mpa
(except Self-aligning Ball Bearings)
For Self-aligning Ball Bearings 4,600 Mpa

7.6 Allowable static equivalent load

Generally the static equivalent load which can be permitted is limited by the basic static load rating. However, depending on requirements regarding friction and smooth operation, these limits may be greater or lesser than the basic static rating load In the following formula (3.9) and Table 7.3 the safety factor So can be determined considering the maximum static equivalent load.

$So = Co/Po$ .... (3.9)

where,
So : Safety factor
Co : Basic static rating load, N (radial bearings: Cor)
$Po\ max$: Maximum static equivalent load, N (radial: Por max)

Table 7.3 Minimum safety factor values So

Operating conditions	Ball Bearings
High rotational accuracy demand	2
Normal rotating accuracy demand (Universal application)	1
Slight rotational accuracy deterioration permitted (Low speed, heavy loading, etc.)	0.5

8. Bearing handling

Bearing storage

Most rolling bearings are coated with a rust preventative before being packed and shipped, and they should be stored at room temperature with a relative humidity of less than 60%.

9. Allowable speed

As bearing speed increases, the temperature of the bearing also increases due to friction heat generated in the bearing interior. If the temperature continues to rise and exceeds certain limits, the efficiency of the lubricant start to fail down drastically, and the bearing can no longercontinue to operate in a stable manner. Therefore, the maximum speed at which it is possible for the bearing to continuously operate without the generation of excessive heat beyond specified limits, is called the allowable speed (r/min). The allowable speed of a bearing depends on the type of bearing, bearing dimensions, type of cage, load, lubricating conditions, and cooling conditions.

The allowable speeds listed in the bearing tables for grease and oil lubrication are for standard NIKO bearings under normal operating conditions, correctly installed, using the suitable lubricants with adequate supply and proper maintenance. Moreover, these values are based on normal load conditions ($P \leq 0.09C$, $Fa/Fr \leq 0.3$). For ball bearings with contact seals (LLU type), the allowable speed is determined by the peripheral lip speed of the seal.