LUBE-TECH

NO.44

SKF NEW TOOL FOR ESTIMATING GREASE LIFE IN LUBRICATED-FOR-LIFE DEEP GROOVE BALL BEARINGS

Advanced grease-life estimates for lubricated-for-life ball bearings can be made with a new diagram that includes operating temperature and grease type *by* **BEN HUISKAMP**, *SKF Engineering and Research Centre (ERC), Nieuwegein, the Netherlands.*

In many grease-lubricated bearing applications, the service life of the grease is such that no grease needs to be added during the bearing life. For such applications SKF provides ready-greased bearings and bearing units with integral seals or shields, which are suitable for maintenance-free operation.

In order to judge if a maintenance-free solution is possible, the grease service life is estimated from operating parameters. The main factors that determine the grease service life are bearing type and size, speed, operating temperature, grease type and the bearing environment.

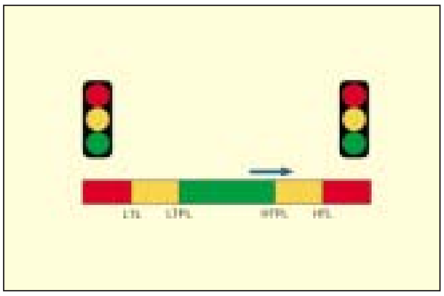
In principle, the new relubrication interval diagram that is published in the new *SKF General Catalogue 5000* can also be used to estimate grease life in lubricated-for-life bearings, but the outcome may be conservative. The calculation rules and corresponding limitations specified in the "Lubrication" section in the *SKF General Catalogue* are primarily focusing on applications with relubricated bearings.

More detailed calculations that would be desirable for lubricated-for-life bearings; for example, calculations exceeding 30,000 hours and usage of special greases and unusual operating temperatures - are not covered there. For advanced grease-life calculations for lubricated-for-life bearings, SKF has developed a new tool, which is further explained in this article.

Grease-life calculations and models

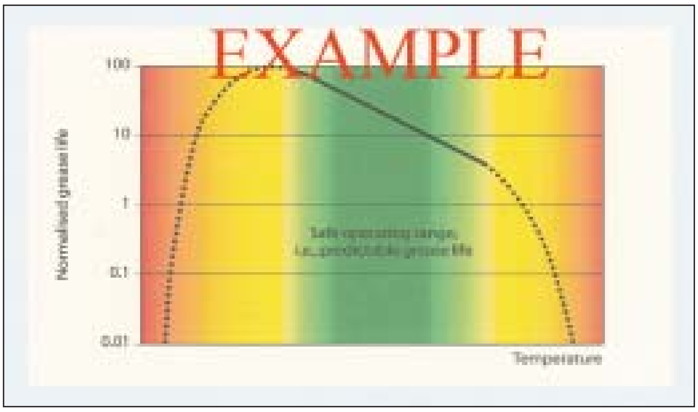
Current grease-life calculation tools are mainly based on empirical models. But many diagrams show all sorts of distortions, which are apparently caused by insufficient separation between normal and exceptional data points used for the curve fitting. By further analysis of available field data and by running many grease-life tests in the laboratories, SKF engineers have managed to better understand grease-life phenomena and to improve existing models.

An important step was made by recognising different grease failures as a function of operating temperature. This understanding resulted in the formulation of the SKF "traffic light" concept, which is published now in the *SKF General Catalogue 5000*. This concept is summarised in **Figure 1**.



The SKF "traffic light" concept

With the identification of the low-temperature performance limit (LTPL) and the high-temperature performance limit (HTPL), a temperature range can be defined where grease will function reliably and grease life can be determined accurately: the green zone. For this green zone more neat correlations could be derived for the primary grease life parameters, resulting in a type of Arrhenius equation, which is typical for a chemical reaction rate as a function of temperature.



Outside the green zone, below LTPL or above HTPL, grease life declines relatively rapidly because of deviating failure mechanisms.

Figure 2 shows schematically the predictable behaviour of the grease life in the green zone. Bearing applications running outside the green zone must be treated as exceptions, as grease-failure mechanisms are abnormal (more complex, with a large spread) and more difficult to predict.

Also for the speed parameter A = n x d_m, where n is the rotational speed in r/min and d_m is the bearing mean diameter in mm, existing grease-life data have been rearranged. Above a particular speed, conventional greases tend to fail in an early stage, whereas modern, specifically designed greases can have a normal failure mechanism up to much higher speeds. Restrictions on speeds should not lead to distortion of curves in a general model, but must be defined per individual grease.

Finally, the effect of load on grease life was introduced as a separate correction factor. At low loads (i.e., C/P = 15) grease life is independent of the load, but for higher loads (C/P<15), a correction factor is required. In some older models, larger bearings were apparently treated more conservatively, as these were often involved in applications with relatively high loads.

The above analysis has resulted in the new relubrication interval diagram in the *SKF General Catalogue 5000*, which is valid for an operating temperature of 70°C, using good quality lithium thickener/mineral oil greases. Recommendations on how to account for the accelerated ageing of the grease with increasing temperatures and related limitations are given separately. The equations behind this relubrication interval diagram are also used for the development of the dedicated diagram for lubricated-for-life bearings.

Lubricated-for-life

Recommendations for grease life are always based on statistical rules. The SKF relubrication intervals are defined as the time period at the end of which 99% of the bearings are still reliably lubricated. This represents the L_{01} grease life. For lubricated-for-life bearings, the grease life is preferably defined as L_{10}, which is in line with definitions for bearing fatigue life. For a typical grease life distribution, the correlation between L_{01} and L_{10} is $L_{10} \tilde{} 2.7 L_{01}$.

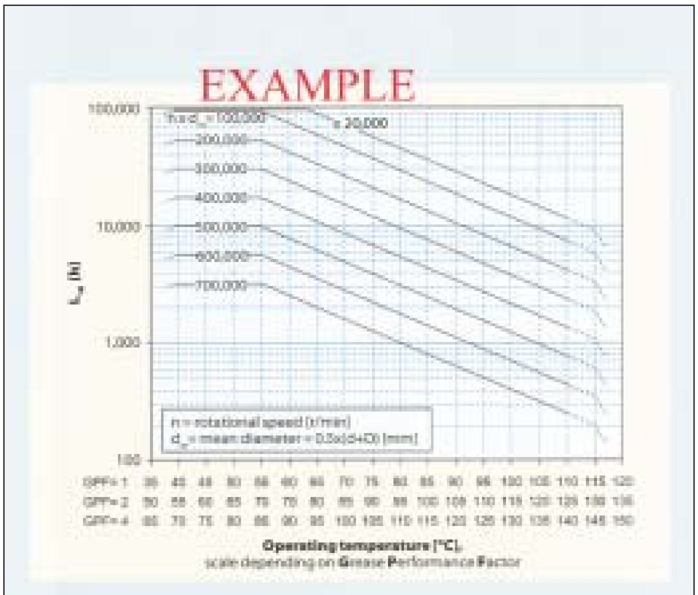
For relubrication, intervals in excess of 30,000 hours (~3+ years) are not advised, but there is no reason to maintain this limit for grease-life estimates for lubricated-for-life bearings. In real life, many pre-greased and sealed bearings in simple applications run much longer than predicted with the existing tools. As there is more certainty for

(Continued on Page II)

(Continued from Page I)

lubricated-for-life ball bearings, which are filled in the SKF factories with a grease of known quality with proper cleanliness and an optimal fill quantity, it is justified to have an extended tool for grease-life calculations for such bearings.

A first step towards an improved grease-life calculation tool was already made for SKF Y-bearings, with a new diagram published in 2003. A more universal diagram is now presented for a wider speed range and with extra features.



Grease life in lubricated-for-life radial ball bearings running at low loads (C/P = 15). L_{10} as function of n x d_m, temperature and grease type (GPF=1, 2, 4, respectively.)

New diagram

A new sophisticated diagram **(diagram 1)** was developed for lubricated-for-life deep groove ball bearings using the same model as for the relubrication diagram. In this diagram, grease life L_{10} can directly be read as a function of the speed parameter A, operating temperature and grease type. Differentiation between greases is achieved with a grease performance factor (GPF). For three different GPF values (GPF= 1, 2 or 4, respectively), there is a different horizontal temperature scale in the diagram. In table 1 GPF values are specified for factory-fill greases applied by SKF, together with speed limitations for the life calculation for each of the greases.

EXAMPLE

Factor	Grease suffixes	Maximum A (=n x d_m)
GPF=1	MT or no suffix	500,000
GPF=1	LT20, LT	700,000
GPF=2	HT22, GJN, LHT23, HT	500,000
GPF=4	GWB, WT	700,000

Table 1. Specification of grease performance factors for SKF bearings with factory fill.

The adjustment for temperature is the same procedure as explained in the *SKF General Catalogue* for the relurication interval. In the shape of the curves, one can recognise the interval where the grease ageing follows the rule of a factor of 2 for every 15°C increase (inclined part) and a horizontal part at the lower temperature range. The solid parts of the curves are in the green zone, delimited by the LTPL and the HTPL.

The diagram nicely assists in choosing grease with optimum GPF value. The following examples show that a higher GPF is not always an improvement.

In a sealed deep groove ball bearing operating at n x d_m=300,000 and 55°C, a grease with GPF=1 is the best solution, giving L_{10}=30,000 hours. For GPF=2 the estimated life is the same, whereas a grease with GPF=4 is not recommended, due to a shorter life.

In a shielded 6302-2Z deep groove ball bearing operating at 15,000 rpm (A=428,000), at C/P=8 and 90 °C, the L_{10} is estimated at 1,500 hours for a grease with GPF=1 (including a correction factor of 0.5 for the load (table 2). A grease with GPF=2 would give a grease life L_{10} ˜3,000 hours. However, there is only partial advantage for this increase, as the estimate for the bearing fatigue life under these conditions is L_{10} ˜ 2,100 hours (calculated with the SKF rating-life method). Application of a grease with higher GPF is often more expensive, so the extra costs must be justified.

Table 2.

EXAMPLE

Load, as C/P	Approximate factor
≥15	1.0
10	0.7
8	0.5
4	0.2

Table 2. Correction factor for increased load.

The visualisation of the effect of temperature on grease life in the new diagram is very useful when designing a bearing application. In case the grease life is the bottleneck for the life of the system due to internal heat generation, it is worthwhile to consider design improvements, focusing on better heat transfer and lower bearing operating temperature. Selection of a grease with higher GPF value can then be avoided, if feasible, which can have a positive effect on costs.

Correction factors

Outside the green zone, below LTPL or above HTPL (represented by the dotted lines in **figure 2** and **diagram 1**) the grease life declines relatively rapidly, caused by deviating failure mechanisms. In these ranges it is not possible to predict grease life accurately on the basis of the general model.

The value estimated from the diagram is the minimum grease life (L10) that can be attained in SKF lubricated-for-life deep groove ball bearings running under optimal operating conditions with inner-ring rotation at low loads. This base line is representative for bearings with steel cages and metal shields (2Z bearings). For special bearing executions it is possible to achieve longer life under certain conditions, for example with special cages, advanced sealing systems (2RS1, 2RSL, 2RZ, etc.), ceramic components, etc. The diagram can also be used as a baseline for other sealed radial ball bearing types, such as angular contact ball bearings and self-aligning ball bearings.

At increased loads (C/P<15) the life must be adjusted with a factor as specified in table 2. For additional adverse operating conditions, such as vertical shafts, vibrations, etc., correction factors are specified in the "Lubrication" section in the SKF General Catalogue. Life calculations for exotic greases (e.g., with silicone or fluorinated ingredients) cannot be made with the new diagrams, as the ageing for such greases follows different rules.

The grease life calculations in the SKF interactive tool LubeSelect (www.aptitudexchange.com) now follow the same rules as in the new SKF diagrams described here. The validity of the new diagram and the GPF values for the standard greases listed in table 1 have been confirmed through extensive grease-life testing at the SKF Engineering & Research Centre in Nieuwegein, the Netherlands.

BASE OIL REPORT

There is little cheer in the Base Oil market after the festive season. It was known some time in advance that it was going to be tough to secure product, due in no small part to scheduled turnarounds at Livorno, Petit Couronne, Port Jerome-Gravenchon and Europoort in the first Quarter of 2006, and compounded by the final closure of Coryton in December and Huelva in February. However, plant problems and unscheduled downtime at Stanlow and Pernis cut into Shell's already meagre stocks, turning Shell into a spot purchaser. All these plant stoppages forced a large number of blenders onto the spot market too. Cargoes were snapped up from the Baltic, Mediterranean, Black Sea, Caribbean and North America. There was even a Chinese cargo of SN 150 that was booked into NWE.

All this spot activity caused spot market prices to jump up immediately. Supplies are so tight throughout the entire European system that any seller who possesses oil can expect to secure a premium for it. A rush of Russian Base Oils from different origins was booked for January and February delivery, often at prices that were scarcely different from those of mainstream European oil. Only two or three years ago most blenders would have shunned any contact with Russian Base Oil. Nowadays, if it were not for this additional supply source the situation would be even more dire.

Traditionally, Europe is a net exporter of Base Oils, and usually such exports would be conducted at discounted prices. This year however, typical Export sellers have found better returns by selling any excess into NWE, or to oil company affiliates either locally or for deep-sea destinations. However, Export demand remains quite high presently. Asia is fundamentally short of Base Oils and we are running into the usual season of refinery turnarounds in the East. As with India, local prices are more competitive than paying for imports from Europe, but there simply is insufficient Base Oil of a high enough quality available locally. Several larger companies tendered to import large cargoes, but the majority of these tenders have foundered due to a lack of offers. The squeeze is on worldwide as well. In the States, the Hurricanes took their toll on Base Oil output, and not every refinery is back up at the time of writing.

Some European blenders have pinned their hopes on North American Base Oils during 2006. Not the usual Group I material, but Group II Base Oils. It is understood that a large volume of Group II material will come across, and may eventually displace some Group I production in Europe that in turn could help bolster the European market. Total too is progressing with its construction of a hydrocracker in France which is due on-stream mid 2006, although a decision has yet to be reached whether Group II Base Oil capacity will be added. Not all users are familiar with Group II oils, nor are they ideal for all applications, But as with the Russian Base Oil, blenders may find themselves adapting to the supply conditions.

So it can be seen that supplies are tight and demand is picking up as buyers wish to replenish stocks. But what of the other driver in Base Oil pricing, namely crude and products pricing? After all, this was one of the main reasons why refiners jacked prices up so swiftly during the last Quarter of 2005. How does it look now?

Compounders argue that margins on Base Oil must be huge. Gas Oil prices have been reduced from the heady days of October and November. But Crude remains strong. There is a nervousness about the Crude Oil market. The recent debacle over natural gas prices reinforced just how fragile the whole energy sector is. The price of fuels is at the whim of the weather. A cold spells higher energy costs, whilst milder weather could bring about lower oil prices. Base Oil margins today certainly make much more sense to a refiner, but the priority is still fuels.

All in all, it is a gloomy picture for anyone wanting to buy Base Oil. Just about the only sign of hope is towards the middle of the year when the series of plant closures hopefully comes to an end and the flow of Group II imports kicks in. And the recent increase in the price of finished lubricants helps ease the agony until that moment. But a lot can happen between now and then.

Adrian Brown
Senior Base Oils Editor, ICIS

HSC/E HEALTH AND SAFETY STATISTICS FOR 2004/2005

The Health and Safety Commission (HSC) latest statistics on workplace injury and work-related ill-health in Great Britain, 'Health and Safety Statistics 2004/05', presents the top-level statistics, including reports on progress against the targets set in the 'Revitalising Health and Safety' strategy

Workplace fatal and non-fatal injury

For workplace injuries, the new figures include 2004/05 data on non-fatal injuries reported by employers and others under RIDDOR (the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations), supplemented by self-reported injury statistics from the Labour Force Survey (LFS).

The main features of the injury statistics are as follows:

Fatal injuries to workers

- There were 220 fatal injuries to workers in 2004/05, a decrease of 7% on the 2003/04 figure of 236.
- Around half occurred in two industries, construction (71) and agriculture, forestry and fishing (42).
- The rate of fatal injury to employees declined throughout the 1980s and 1990s. The rate rose by 30% in 2000/01 and has dropped since then.

Reported non-fatal injuries

30 213 major injuries to employees were reported in 2004/05, a rate of 117.7 per 100 000. This was down 2% on the previous year. Over a third were caused by slipping and tripping.

There were 120,346 other injuries to employees causing them to be off work for over 3 days, down 8% on 2003/04. Two fifths were caused by handling, lifting or carrying.

Labour Force Survey and reporting of injuries

The rate of reportable injury estimated from the Labour Force Survey (LFS) was 1330 per 100,000 workers in 2003/04 (3-year average) , down by 7% on the previous year.

Comparing this with the RIDDOR rate of reported major and over-3-day injury, the level of reporting by employers was 47.6%, up from 43.0% in 2002/03.

Injuries to members of the public

There were 361 fatal injuries to members of the public in 2004/05, down by 3% on the previous year with around two-thirds due to acts of suicide or trespass on the railways.

There were 14 321 reported non-fatal injuries to members of the public, an increase of 5% on 2003/04.

Work-related ill health

For work-related ill health, there are new results from the Self-reported Work-related Illness (SWI) Survey 2004/05. The statistics also

(Continued from Page III

draw on surveillance data from specialist doctors in The Health and Occupation Reporting network (THOR), claims for disablement benefit under the Department for Work and Pensions' Industrial Injuries Disablement Benefit (IIDB) Scheme, and deaths from mesothelioma and other occupational diseases.

The main features of the ill health statistics are as follows:

Self-reported ill health

In 2004/05 an estimated 2.0 million people suffered from ill health which they thought was work-related, lower than the level in 2003/04 (2.2 million).

Around three-quarters of the cases were musculoskeletal disorders (eg upper limb or back problems) or stress, depression or anxiety.

Ill health seen by specialist doctors

Each year between 2002 and 2004, an estimated 23,000 new cases of occupational or work-related illness were seen by disease specialist doctors and occupational physicians who reported to the THOR surveillance scheme.

Asbestos-related and other fatal diseases

Several thousand people die each year from diseases caused by past work exposures, including nearly 1900 deaths in 2003 from mesothelioma, a cancer related to asbestos exposure.

Revitalising Health and Safety targets

The statistics on health and safety at work inform the measurement of progress against the targets for reducing work-related injuries, ill health and working days lost set in the 'Revitalising Health and Safety' strategy. HSE's approach to progress measurement is detailed in a Statistical Note published in June 2001; annual progress reports have been published each Autumn since then. All these documents are on the HSE website.

LINK
www.hse.gov.uk/statistics/targets.htm
.

HSE & SAFE OPERATION OF VEHICLES IN THE WORKPLACE

Comprehensive guidance, *Workplace Transport Safety: An Employers' Guide* (HSG136) provides advice on all aspects of workplace transport operations. Although primarily aimed at managers and supervisors, it is equally useful for safety and union representatives, contractors, the self-employed and employees.

- Workplace transport means any vehicle that is used in a work setting. It specifically excludes transport on the public highway; air, rail or water transport, and specialised transport used in underground mining.
- The four main types of workplace transport accidents which employers and the self employed need to prevent are:
  - moving vehicles hitting or running over people;
  - people falling off vehicles;
  - vehicles overturning; and
  - objects falling off vehicles

Announcing its publication Carol Grainger, head of HSE's Workplace Transport Team, said: "Workplace transport is the second biggest cause of incidents in the workplace, accounting for about 70 fatalities each year." The majority of these accidents are preventable. Reducing these casualties is an important priority in the HSE's work programme.

"The guide gives detailed advice on the key risks surrounding transport use in today's workplaces, and how to get to grips with controlling them. There's also a free booklet which provides an extensive overview of the subject, enabling those responsible for workplace transport to identify any areas of their operations where further help might be required".

The guide tackles general workplace transport safety issues and provides an introduction to workplace transport risk management. In particular, it offers information on assessing transport risks relating to site safety, vehicles themselves, and the people working with and around them and implementing a safe system of work. Later chapters offer specific guidance on typical workplace transport operations and common risks. Throughout, the book provides practical examples of risk control.

HSE has also published a revised version of *Workplace Transport: An Overview*. This is a free booklet that provides employers with a brief summary of the main issues that should be considered when planning workplace transport operations. Arranged similarly to *An Employers' Guide*, the 27-page booklet also includes specific sections about workplace organisation and operations. The booklet can be downloaded from the HSE website below.

LINK
www.hse.gov.uk/pubns/tranindx.htm

HSC REPORT SHOWS PROGRESS ON ILL HEALTH, BUT MORE NEEDS TO BE DONE

The Health and Safety Executive has published the national statistics on work related injuries and ill health for 2004/2005. These figures show progress on occupational ill health and the number of RIDDOR reportable injuries. However, fatal and major injuries remain a concern.

Chair of the Health and Safety Commission (HSC) Bill Callaghan said, " I am pleased to see the reduction in cases of occupational ill health and the continuing reduction in the rate of fatal and major injuries in the production industries, especially in construction, but the overall picture is mixed. I am concerned at the increase of reported major injuries within the service sector, which is one reason the midpoint target for fatal and major injuries has not been met. We are making progress in meeting the days lost target, but in spite of the improvement last year it would be complacent to think we had cracked the problem of health at work. Today's figures suggest that our strategy is beginning to bear fruit but an even greater focus is needed." The full report can be viewed using the link below.

LINK
www.hse.gov.uk/statistics/overall/hssh0405.pdf