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.

(Continued on Page II)
(Continued from Page 1)

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 \( A = 2 \pi n d_m \), 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.

The adjustment for temperature is the same procedure as explained in the SKF General Catalogue for the relubrication interval. If 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 \( n \times d_m = 100,000 \) 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 higher GPF is not recommended, due to a shorter life.

In a shielded 6302-2Z deep groove ball bearing operating at 15,000 rpm (\( A = 288,000 \)), at GPF=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

<table>
<thead>
<tr>
<th>GPF</th>
<th>Estimated Life (Hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2,100</td>
</tr>
<tr>
<td>2</td>
<td>3,000</td>
</tr>
</tbody>
</table>

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 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.

### Table 1: GPF values for the standard greases listed in table 1 and temperature range and with extra features.

<table>
<thead>
<tr>
<th>Grease Type</th>
<th>GPF</th>
<th>Temperature Range (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>L10</td>
<td>1</td>
<td>0-40</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>0-40</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>0-40</td>
</tr>
</tbody>
</table>

**Table 2. Correction factors for increased load.**

<table>
<thead>
<tr>
<th>Load Constant</th>
<th>Correction Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>2</td>
<td>0.7</td>
</tr>
<tr>
<td>3</td>
<td>0.9</td>
</tr>
</tbody>
</table>

**Table 3. Effect of temperature.**

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Correction Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.0</td>
</tr>
<tr>
<td>10</td>
<td>0.9</td>
</tr>
<tr>
<td>20</td>
<td>0.8</td>
</tr>
<tr>
<td>30</td>
<td>0.7</td>
</tr>
</tbody>
</table>

The main legal instrument is the Russian Code of Labour. In the European Union, the main legal sources are the European Union Treaties and the EU Directives. The main sources of national labour law are the national constitutions, the national labour codes, the national labour department, the national social security and the national accident compensation systems.
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, Pétit Couronné, 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 Pensik 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 exports would be conducted at discounted prices. This year however, typical Export sellers have found better returns by selling any excess

HSCIE 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 230 fatal injuries to workers in 2004/05, a decrease of 7% from 2003/04 figure of 248.

• A round 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 35% in 2000/01 and has dropped since then.

Reported non-fatal injuries

20-213 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...
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 (IIB) 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 1,900 deaths in 2003 from mesothelioma, a cancer related to asbestos exposure.

**Revitalising Health and Safety targets**

The focus 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.

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**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 employers and managers, 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.

**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 2004/05. 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.

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