Noise Characteristics of Rolling Bearing Greases

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INTRODUCTION
In many technical fields, ultra-pure and low-noise greases are required for rolling bearings in order to reduce the noise level and air-borne sound emission. Special lubricating greases contribute to comply with the noise limits and narrow operating tolerances in precision rolling bearings and ensure an economic as well as energy-saving operation.

High and maximum speeds as well as low and high temperatures and lifetime lubrication are the requirements to be met. The author's employer accepted this challenge by developing and manufacturing high-purity special lubricating greases which improve the noise characteristics of rolling bearing greases and are suitable for high/low speeds and temperatures.

REQUIREMENTS TO BE MET BY LOW-NOISE ROLLING BEARING GREASES

1. Noise reduction.
2. Shortening of the final quality control time.
3. Lifetime extension of rolling bearings (Figs. 10-14).

APPLICATION EXAMPLES FOR LOW-NOISE ROLLING BEARINGS

Integrated Bearings
1. Disk storage drives, linear and swivel drives for read/write heads and printers in the computer industry.
2. Audio and video equipment.
3. Textile machines.
4. Precision equipment.

Fig. 1—The tribo-system "rolling bearing" lubricant and rolling bearing as factors influencing the noise characteristics.

Fig. 2—Principle of a solid-borne sound measurement, SKF, Schweinfurt, Germany.

Miniature and Small Bearings
1. Domestic appliances: electric motors, oven fans, pumps etc.
2. Automotive components: electric motors, compact generators, fans, air conditioning equipment, etc.

WHAT IS "LOW NOISE?"
1. Reduction of the solid-borne sound generated by the rolling bearing.
2. Reduction of external solid-borne sound.
3. Reduction of the solid-borne sound originating "outside" (Figs. 1 and 6).

NOISE MEASUREMENT
Measuring Principle
Before testing at the author's company the noise characteristics of a bearing with a grease, the test bearings are tested using a small quantity of reference oil. The measurements primarily reveal the noise generated by the bearing itself. As the oil used does not contain any particles with a diameter exceeding 1.2 μm, the noise generated by the oil can be neglected.

The average of the measurements of slightly oiler test bearings is used as the reference value for the grease tests and is defined as the 100 % value (Fig. 2).

Noise Measurement with the GMN Noise Tester KGE-4-11
The GMN equipment (Fig. 3) mainly tests deep groove ball bearings type 608 at a speed of n = 3000 rpm. The solid-borne sound is measured at the outer bearing ring for a period of 60 s. Figure 4 shows the silencing tendency of an ultra-pure, low-noise rolling bearing grease in comparison with the reference run. The minimum of visible "peaks" indicates slight contamination. The lithium-soap grease on a mineral oil base shows clear noise peaks and a high noise level as compared to the reference run. The initial noise values drop at the end of the measurement.

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The noise class comprises the noise peak evaluation and the damping factor. The starting value is assessed independent of the noise class.

Figure 7 shows the noise test of an ultra-pure, low-noise rolling bearing grease with a base oil viscosity at 40°C of approximately 25 mm²/s and its classification according to noise class II/1 and I/1 resp. or 70 mm²/s. Starting value "1" is evaluated independent of the noise class. A comparison was made with a lithium-soap grease on a mineral oil base, \( V_o \) approximately 15 mm²/s, which resulted in noise class III/4.

**Noise Measurement with the SKF Noise Tester MVH 90 B**

The oscillation speed of the solid-borne sound is measured at the outer ring of 20 deep groove ball bearings type 608 at a speed of \( n = 1800 \text{ rpm} \) by means of an acceleration transducer.

By filtering the measuring signals into the frequency bands:

- **Low**: 50 - 300 Hz
- **Medium**: 300 - 1800 Hz
- **High**: 1800 - 10000 Hz

the oscillation speeds of a 30s measurement are shown. The High band responds to short-wave disturbances, which can be caused by lubricant particles, for example. The registration of such disturbances during a 30 second test run is only possible if they take place at short and rather periodic intervals. The measurements are made subsequent to a non-evaluated running-in period of 15 s. Furthermore, a peak value is recorded in all frequency bands during the measuring period. In order to record unique, rare or irregular disturbances, mainly those which are due to the lubricant. Each fault occurring within the measurement period may lead to the maximum oscillation speed which is recorded (Fig. 8).

Figure 9 shows the noise tests of ultra-pure, low-noise rolling bearing greases, \( V_o \) approximately 25 mm²/s or 70 mm²/s, in comparison with lithium-soap grease on a mineral oil base, \( V_o \) approximately 15 mm²/s. Low peak values and standard deviations indicate a low degree of contamination of the lubricating grease. A higher viscosity also contributes to the lubricant’s damping effect within the High band.

**WHICH EFFECT DOES AN ULTRA-PURE, LOW-NOISE ROLLING BEARING GREASE HAVE ON THE ROLLING BEARING LIFE?**

**Determination of the Purity Degree in Accordance with DIN 51 813**

As defined in DIN 51 825, 1 kg of lubricating grease must contain not more than 20 mg of solid particles larger than 25 \( \mu \)m.

The content of solid substances in lubricating greases according to DIN 51 813 is determined by means of the author’s employer purity test-method as follows.

A 500 g sample of the lubricating grease is pressed through a filter screen having a 25 \( \mu \)m mesh. The grease and the solid foreign particles remaining, in the filter screen are dissolved and filtered using a sifted glass filter which retains only the solid particles. The filter is weighed before and after the filtration process: thus, the content of solid foreign matter in the grease sample (indicated in mg/kg) can be determined. This value is called the degree of purity.

However, the method according to DIN 51 813 does not meet the high demands of the author’s employer makes on a grease of high purity and quality. Thus, the above method was considerably tightened in terms of a more precise determination of the solid particle content. The special grease manufacturer determines the purity degree of the ultra-pure low-noise greases as follows.

A 20 g sample of the grease is dissolved and filtered through a membrane filter having a pore size of 1.2 \( \mu \)m, its mesh size thus being smaller than 1/20 of the standard mesh of 25 \( \mu \)m. Weighing of the filter before and after the test shows that an ultra pure grease contains less than 100 mg/kg (ppm) of solid particles larger than 1.2 \( \mu \)m. Most of the lubricating greases for low-noise rolling bearings that have tested so far contain more than 300 mg of solid particles of this size per kilogram.

**Effect of Ultra-Pure Greases on the Rolling Bearing Life**

Figure 12 takes the example of iron oxide (Fe₃O₄) to show how solid contamination in the lubricant increase wear and thus reduce the bearing life.

Tests carried out by the rolling bearing manufacturers have lead to the “adjusted rating life calculation” in SKF, FAG...
Fig. 10—Low-noise axial fan, lubricated with ultra pure low noise grease. Lₙ, rating life at 75°C approximately 25,000 operating hours. Papst Motoren GmbH % CoKoG, St. Georgen, Germany.

Fig. 11—Comparison of the solid particle content.
(a) low-noise rolling bearing grease
(b) ultra pure low-noise grease

general catalog for rolling bearings. One aspect of this calculation is that as little contamination as possible may enter the rolling bearing via the lubricant.

The rating Lₙ of a deep groove ball bearing 6204 according to the SKF calculation can be extended as follows, if purity is increased.

With "normal purity" which is typical of grease-filled bearings with shields on both sides: Lₙ = 3645 h.

With "high purity" which is typical of grease-filled bearings with seals on both sides: Lₙ = 8505 h.

Calculation according to SKF: SKF general catalog Bearing type: deep groove ball bearing 6204

R = 9
P = 1400 N
n = 10,000 min⁻¹
C = 12.7 kN
Pₑ = 280N
X = 1.5
Lₙ = aₙ₋ₙₙ * 1ₙₙ
Lₙ = 1.08 * 7 = 8505 h

ηC₅ = 0.5 normal purity (bearings with shields)

ηC₅ = 0.10

aₙ = 3

Lₙ = 1 * 1.2 / 0.016 = 3 * 9³ = 3645 h

SUMMARY

Ultra-pure and low-noise special rolling bearing greases are necessary in order to comply with the requirements of silent-running rolling bearings as to running precision, low starting and running friction as well as a long service life (lifetime lubrication). Noise testers are used for the evaluation and classification of rolling bearing greases.