Brüel & Kjær application notes

Six weeks' advance warning of breakdown!

by *Ray Brett*
Brüel & Kjær

A motor driving a pump at an oil refinery burnt out its bearings. Regular recordings were being made of the motor's vibration. The overall vibration level gave no indication of impending failure. However, retrospective comparison of the constant-percentage-bandwidth (CPB) spectrum of the vibration measured *six weeks* before the actual breakdown, with one measured when the machine was in good condition, clearly showed a large increase in a band of high frequencies—the classic symptom of a faulty rolling-element bearing.

When measurements from other machines were reviewed, the maintenance engineer found similar indications for another pump motor and for a compressor. By acting on the results of the CPB spectrum comparison, the maintenance team prevented two breakdowns, which would have stopped production of LPG and petrol respectively.

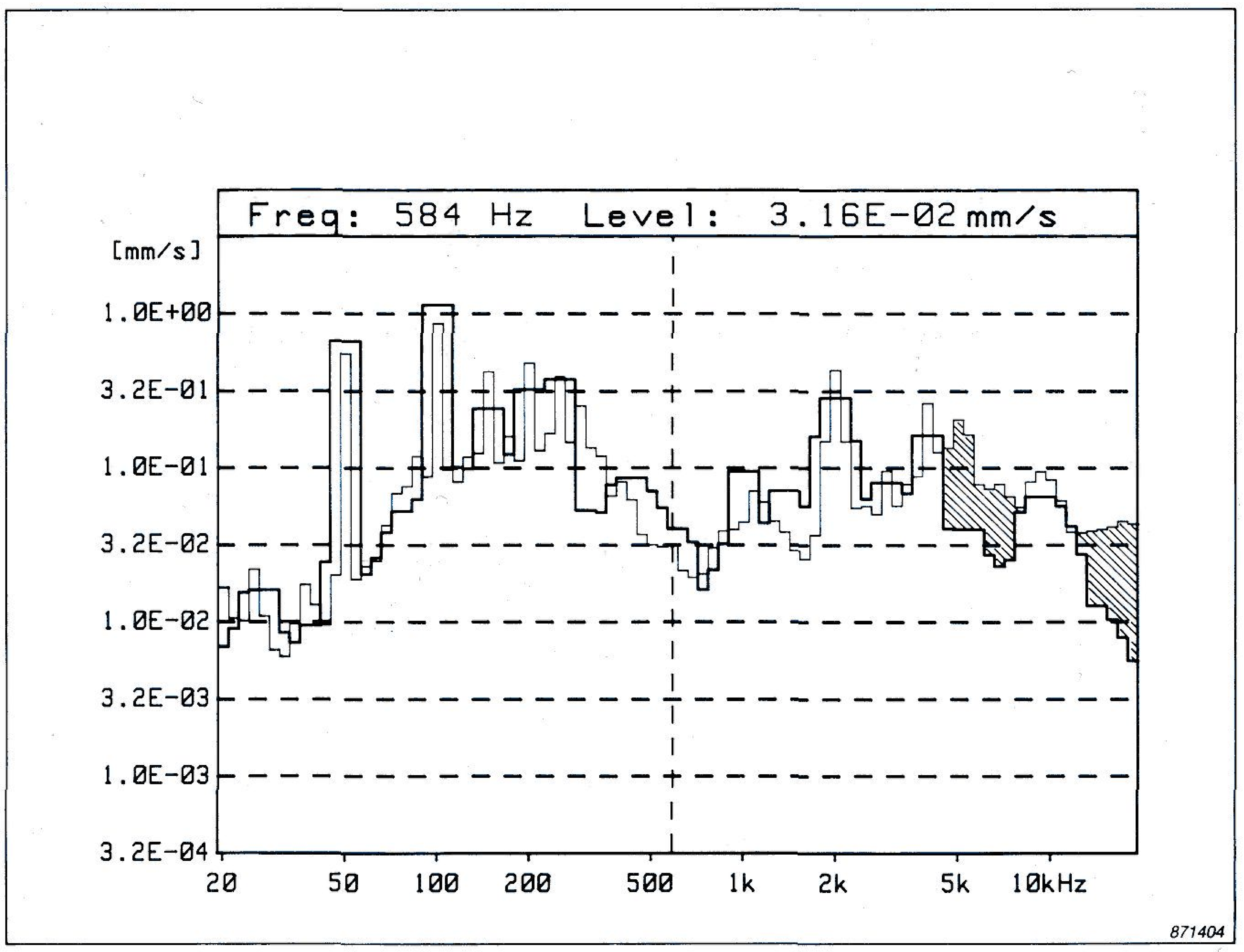

Fig. 1. CPB spectrum comparison for the vibration at the non-drive-end of the 55kW motor. The dark line is the "good-condition" reference mask against which the current spectrum (light line) is compared. Significant increases in two bands of high-frequencies (shaded) indicated a damaged rolling-element bearing

The maintenance team at the Statoil oil refinery at Kalundborg, Denmark were regularly recording the vibration of a 55kW motor. The motor was driving a single-stage, centrifugal pump that was draining bitumen from a distillation tower. The motor had rolling-element bearings with an inner diameter of 2½″ (64mm). The overall vibration level showed no development but 6 weeks after the last measurement the motor burnt out its bearings.

Later, using Machine-Monitoring Software Package WT 9114, the maintenance engineer compared the CPB spectrum of the vibration for the last measurement, with a reference CPB spectrum made when the machine was in good condition. See Fig. 1. The spectrum comparison clearly showed very large increases in two bands of high frequencies. The amplitude of vibration in both frequency bands had increased by up to a factor of 8 (i.e. 18dB). This is a classic symptom of a faulty rolling-element bearing.

This increase was not reflected in the overall vibration level because the overall vibration level is largely determined by the level of the highest peak in the spectrum. The highest peak in Fig. 1 is at 100Hz and this frequency corresponds to the second harmonic of the rotation speed of the motor.

Stoppage in petrol production averted

After this experience, the maintenance engineer reviewed all recordings to see if any other machine showed a similar vibration pattern. Comparison of the latest CPB spectrum with its reference CPB spectrum, for motor P301A, also showed an increase in a band of high frequencies. See Fig. 2.

This 110kW motor was directly driving a 4-stage, centrifugal pump. The pump was pumping naptha and if the pump broke down, the production of petrol would stop.

The increase showed up in measurements made at the drive-end measur-

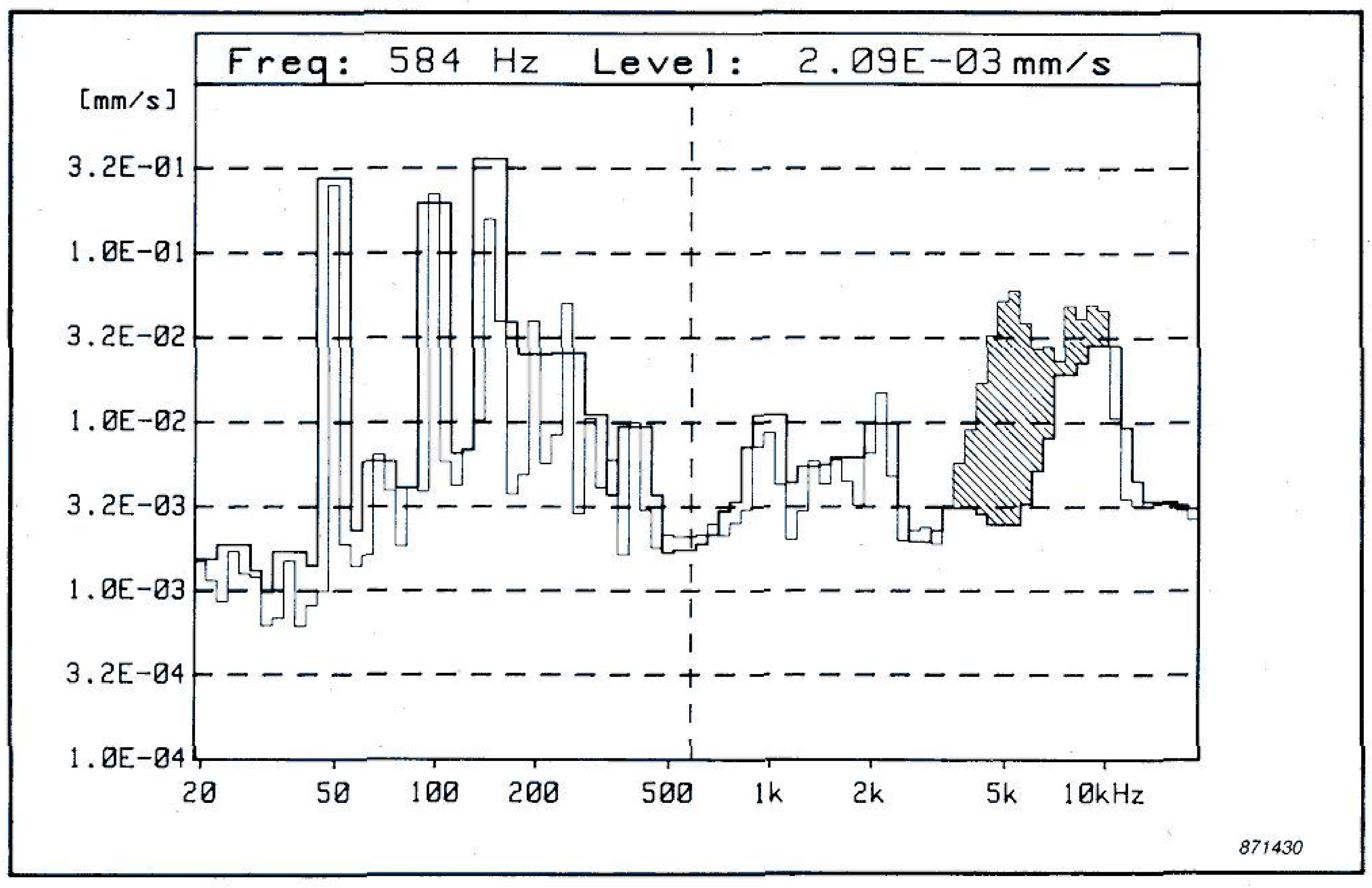

Fig. 2. CPB spectrum comparison for the vibration at the drive-end of the 110 kW motor. Significant increases in a band of high-frequencies (shaded) indicated a damaged rolling-element bearing

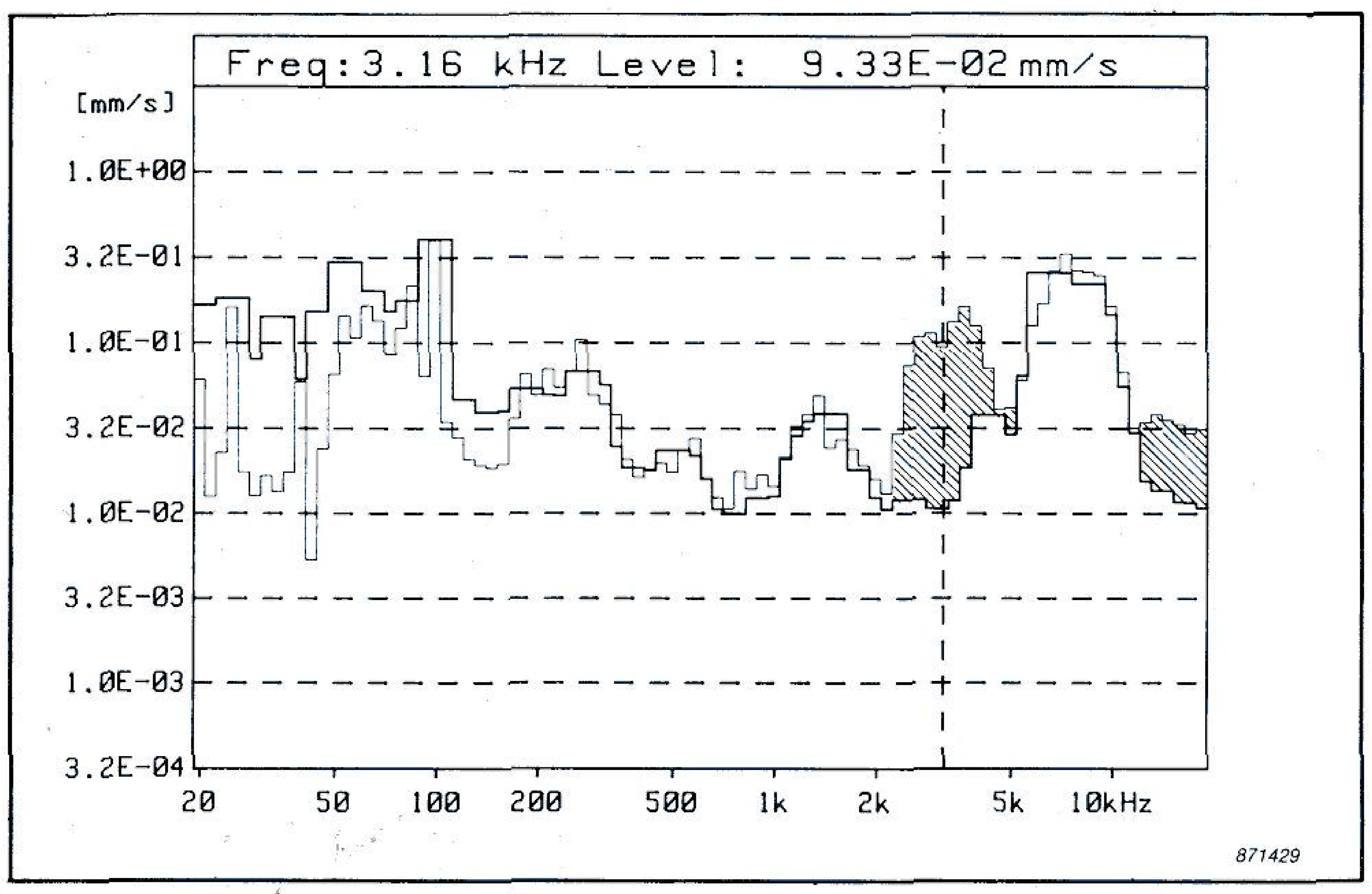

Fig. 3. CPB spectrum comparison for the vibration at the drive-end of the compressor motor. Significant increases in two bands of high-frequencies (shaded) indicated a damaged rolling-element bearing

ing point, indicating that the drive-end bearing was the problem. This bearing was a roller bearing with an inner diameter of 65 mm.

This time the motor was saved by acting on the results of the CPB spectrum comparison.

Maintenance personnel injected grease into the bearing at the drive end. The vibration level over the whole frequency range dropped to the normal level. The maintenance team then kept a close eye on the machine, measuring its vibration every week. These measurements showed a steep increase in the same band of high frequencies indicating that the bearing was damaged. Because of this, it was decided to strip down the motor at the first opportunity and replace it with a standby unit.

When the motor was stripped down, marks on the races and on the bearing housing showed that the bearing had slipped and rubbed, both on the shaft and in the housing. Furthermore, the new bearing grease had not mixed properly with the old grease, thus hindering the rolling motion of the balls. Apparently, two different greases had been used, which did not mix readily.

Compressor breakdown prevented

Recordings made at the drive end of a compressor motor (K651) showed the same symptom: a steep increase in the 2 to 6 kHz region. See Fig. 3.

The drive-end bearing was a roller bearing (SKF N320) with an inner diameter of 100 mm. The motor was a 200 kW motor driving a reciprocating compressor used to liquidize process gases. If it broke down, production of LPG would stop.

Injection of grease had an immediate soothing effect but, as in the previous case, the vibrations gradually increased afterwards. It was therefore decided to repair the machine during the next plant shutdown. Here it was found that the bearing had the same lubrication problem as the others and that there was a distinct wear track on the inner race.

No doubt the bearing could have lasted longer, as, after lubrication, the predicted lead time to failure was 5 months. However, the decision to use the shutdown as an opportunity to change the bearing was also meant as an extra precaution, as this particular motor had no backup, and the next regular general shutdown was several months ahead.

Conclusions

These incidents show how damaged, rolling-element bearings can be detected through comparison of CPB spectra. The same monitoring philosophy that is built into the WT 9114 software (used by Statoil) is built into the newer, machine-condition, monitoring software Type 7616.

Without the wide frequency-range of the Brüel & Kjær accelerometer used (Type 4391) the telling increases in high-frequency vibration would not have been detected.

These case histories suggest that when using such a system and a new type of grease is introduced, a vibration measurement should be made immediately after greasing and again one week later. If high-frequency vibrations increase after using the new grease, this is an indication of a lubrication problem and, possibly, of the beginning of damage to the bearing.

It would appear that when increases in high-frequency vibration are detected, even with increases as large as 20 dB (i.e. a factor of 10), the first reaction should not be to shut down the machine. If no other indications of impending bearing breakdown are present, add grease to the bearing or check the lubrication system. If the level of vibration decreases after adding grease, then the machine should be regularly checked by making weekly vibration measurements. Should the level of vibration remain high, or begin to increase again, after the addition of grease, then it is probable that the bearing is damaged and needs to be overhauled.

Special thanks to Arnold Mikkelsen, Mechanical Engineer, Statoil.

Brüel & Kjær

WORLD HEADQUARTERS: DK-2850 Nærum · Denmark · Telephone: +45 2 80 05 00 · Telex: 37316 bruka dk

Australia (02) 450-2066 · Austria 02235/7550*0 · Belgium 02 · 242-97 45 · Brazil 246 8149 · Canada (514) 695-8225 · Finland (90) 80 17 044 · France (1) 64 57 20 10
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Printed in Denmark by Nærum Offset