Increased Productivity through ULTRASOUND

LUBRICATION HANDBOOK

Ultrasonic Condition-Based Lubrication

14 Hayes Street, Elmsford NY 10523-2536 USA • Tel: 914-592-1220

Toll Free USA & Canada	24 Hour Fax	Email:	Internet
800-223-1325	914-347-2181	info@uesystems.com	http://www.uesystems.com

Ultrasound Condition Based Lubrication

Traditionally, lubrication scheduling has been “time-based.” Equipment suppliers often recommend lubrication schedules based on hours of operation. In addition, they frequently provide instructions as to the amount of lubricant to be applied during these scheduled maintenance procedures.

The problem is that not every bearing needs to be lubricated when they are scheduled for lubrication. Or if they do need to be lubricated, they might not need as much lubricant to be added as stated in the scheduled work order. The lubrication level might be fine and adding more might result in an over lubricated bearing.

The concept of establishing lubrication intervals is based on a simple premise: to keep equipment running optimally by preventing a bearing from running dry and causing catastrophic damage. It is a solid “preventive” concept. However, there is a balance that must be struck between preventing lubrication starvation and the extreme of over lubrication. In fact, one of the most common causes of bearing failure is over lubrication, not lubrication starvation.

To accomplish the goal of equipment optimization, it is best to know when to lubricate and when to stop applying lubricants to a bearing. This can be accomplished with a condition-based lubrication strategy. Simply put, the *condition* of the bearing determines when to lubricate. If a bearing is working properly and does not demonstrate any changes that warrant lubrication, the bearing should be left alone. Should conditions change and a bearing demonstrates a lessening of lubricant, then lubrication should be applied. Monitoring the lubricant as it is applied will also determine how much lubricant to add and when to stop the application.

Ultrasound technology is ideally suited for condition-based lubrication methods. With ultrasonic inspection instruments a program can be established that will inform inspectors which bearings need to be lubricated and help lubrication technicians know exactly how much lubrication to apply.

To understand how these instruments can work effectively in the loud environments of a typical plant, one must understand the technology of ultrasound, how ultrasound is produced by bearings, and how ultrasound monitoring instruments can help maintain optimal lubrication levels in bearings.

The technology is based on the sensing of high-frequency sounds. Ultrasound is considered to start at 20,000 cycles per second, or 20 kilohertz (kHz). This is considered the high-frequency threshold at which human hearing stops. Most ultrasonic instruments employed to monitor equipment will sense from 20 kHz up to 100 kHz. The range of human hearing covers frequencies of from 20 cycles per second (20 Hz) up to 20 kHz. The average human will often hear up to 16.5 kHz and no more.

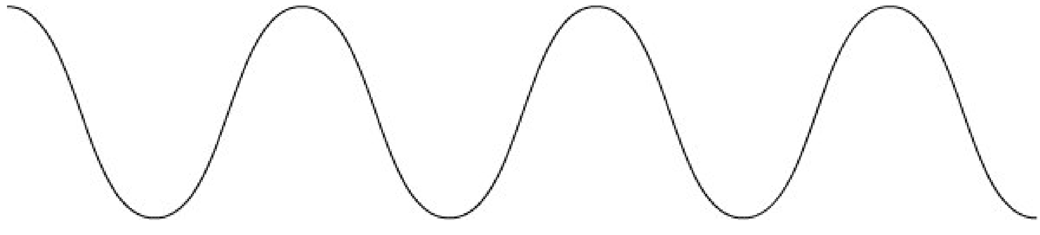
These frequency comparisons are important to note because there are differences in the way low-frequency and high-frequency sounds travel, which help us understand why ultrasound can be effectively instituted in bearing monitoring and lubrication programs.

<u>Size Differences.</u>

There are substantial differences in the size of low-frequency, or audible sound waves, and the size of high-frequency/ultrasound waves. The size of audible or low- frequency sound waves will range from ¾" (1.9 cm) to as large as 56' (17 m). Ultrasound waves range from 1/8" (.3 cm) to maximally 5/8" (1.6 cm). These physical differences in wavelength help us understand why ultrasound has an advantage in condition monitoring. Low-frequency sounds, being large, tend to maintain a high intensity of sound volume over greater distances than high-frequency sounds. High-frequency sounds, being magnitudes smaller than low-frequency sounds, will not travel as far. Therefore, the amplitude will fall off rapidly as the high-frequency sound waves move away from the sound source.

Low frequency sound waves will tend to travel large distances and working in these low frequency environments often makes identification of a sound source difficult. In addition these gross signals can produce confusing "cross-talk" effects in which a sound can travel from one part of a machine to another producing confusing inaccurate test results.

Ultrasound wavelengths range from 1/8" (.32 cm) to 5/8" (1.6 cm)



Low Frequency wavelengths range from ¾" (1.9 cm) to 56' (17 M)

Instruments based on the technology of Airborne/Structure-Borne Ultrasound are referred to as ultrasonic translators. They receive the inaudible high-frequency sounds and electronically translate them down into the audible range through a process called heterodyning. The heterodyning method works in a similar fashion to an AM radio. While we cannot hear radio waves, this method helps us easily identify different voices and musical instruments when we listen to the radio. Similarly this heterodyning process provides an accurate translation of ultrasound produced by operating equipment and enables users to readily identify one sound component from another. Most ultrasonic translators provide feedback two ways: through headphones and on a meter where the amplitude of these sounds can be viewed as intensity increments or as decibels.

Lubrication Procedures

It is imperative to consider two elements of potential failure: lack of lubrication and over lubrication.

Normal bearing loads cause an elastic deformation of the elements in the contact area providing a smooth elliptical distribution. But bearing surfaces are not perfectly smooth. For this reason, the actual stress distribution in the contact area will be affected by a random surface roughness. In the presence of a lubricant film on a bearing surface, there is a dampening effect on the stress distribution, and the acoustic energy produced will be low. Should lubrication be reduced to a point where the stress distribution is no longer present, the normal rough spots will make contact with the face surfaces and increase the acoustic energy. These normal microscopic deformities will begin to produce wear and the possibilities of small fissures may develop which contributes to the "pre-failure" condition. Therefore, aside from normal wear, the fatigue or service life of a bearing is strongly influenced by the relative film thickness provided by an appropriate lubricant.

Avoiding Over Lubrication

When too much lubricant is put into the bearing housing, pressure builds up and can lead to an increase of heat, which can create stress and deformity of the bearing. Or it can break or "pop" the bearing seal allowing lubricant to spill out into unwanted areas (such as a motor winding), or allow contaminants to enter the raceway. All of which can lead to bearing failure.

The appropriate amount of lubrication is very important. If a bearing is over lubricated the bearing can be pushed excessively by the lubricant causing additional wear of the bearing. On the other hand, if there is not enough lubricant, the bearing will rub on the solid surface, again causing friction and wear on the bearings. Either case is detrimental to the life of the bearing. Using airborne/ structure borne ultrasound takes the guess out of lubrication.

Ultrasound Monitoring

Ultrasound instruments detect changes related to friction. A properly lubricated bearing will have very little friction. The lubricant evens out any stress the bearing encounters as it rolls around the raceway thereby reducing the potential for destructive friction. As the bearing rolls, it produces a recognizable "rushing" sound akin to the sound of air leaking out of a tire. This rushing sound is referred to as "white noise." It includes all sounds, both low and high frequencies. The high-frequency waves generated by this white noise are more localized than those of the lower frequencies. Using an ultrasonic translator, these signals can be detected with little or no interference from other mechanical noises generated by other components, such as a shaft or another bearing close by.

As the lubrication level in a bearing falls or deteriorates, the potential for friction increases. There will be a corresponding rise in the ultrasound amplitude level that can be noted and heard. The method to determine when to lubricate and when to stop applying lubrication with ultrasound instruments is as simple as: setting a base line, setting inspection schedules and monitoring as you lubricate.

Setting a Baseline:
A baseline for a bearing reflects in decibels the level at which it is operating under normal conditions with no observable defects and with adequate lubrication.

There are three methods for setting a baseline.

1. Comparison: when there is more than one bearing of the same type, load and rpm, multiple bearings can be compared one to the other. Each bearing is inspected at the same test point and angle. The decibel levels and sound quality are compared. If there are no substantial differences, (less than 8dB) a baseline dB level is set for each bearing. This is usually performed with a portable ultrasonic translator.

2. Set while lubricating. While lubrication is being applied, listen until the sound level drops down and begins to rise. At that point no more lubricant is added and the dB value is used as the baseline.

3. Historical: bearing dB levels are obtained from an initial survey. Thirty days later the bearing dB levels are taken and compared. If there is little (less than 8dB) to no change in dB than the base line levels are set and will be used for comparison for subsequent inspections.

Baselines are usually set with a portable ultrasonic translator

Setting Inspection Schedules:
The criticality of equipment as it relates to production, environmental or operational consequences is the primary factor as to which equipment to test and how often to test it. After the baseline inspection has been performed, most often a schedule of once per month will prove adequate. For bearings that have had high levels and have been subsequently lubricated, it might be necessary to test more frequently to note any possible changes. If a bearing is in a failure mode, the lubricant will temporarily mask the fault. However the fault will quickly produce a rise in the dB level. In some instances this will happen in minutes, in others, days.

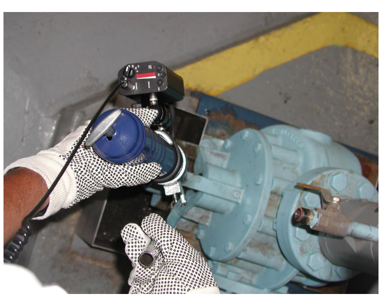
Monitoring as you lubricate:
If a bearing exceeds 8 dB over a set baseline it can be presumed to need lubrication. Once a bearing has been identified for lubrication, to prevent over lubrication, a technician must know when to stop applying the lubricant. This is accomplished in one of two ways:

Lubricate until the dB level drops to the baseline.

1. The lubrication technician monitors the bearing with an ultrasonic instrument as the lubricant is being applied. But be cautious! Some lubricants will need time to uniformly cover the bearing's surface. Lubricate a little at a time until the decibel level drops to the baseline dB level.

2. If it is not possible to use a dB level as a guide, the lubricant is applied until the sound drops off and begins to rise. At that exact moment, the technician stops applying the lubricant.

If readings do not go back to original levels and remain high, consider that the bearing is on the way to the failure mode and recheck frequently.



Accessibility issues: there may be situations in which it may be difficult to gain access to some bearings. For example, there may be a complex machine where a bearing is embedded in an area where only a lube tube is extended outside the casing. If the lube tube is a conductive metal such as copper, the bearing can still be tested and a lubrication action level set. If the fitting is of a non-sound conductive material such as plastic, a separate conductive metallic wave guide can be installed so that the bearing can be monitored. The wave guide can be isolated from structure borne noise of the machine (the mounting point) via rubber isolation material.

Auto Lubrication Devices

There are debates about the use of automatic lubrication devices. In some instances a permanently installed ultrasonic sensor could be used to turn an auto greaser on and off instead of having it operate with a constant flow. When the sound level goes up 8 dB, the bearing is lubricated automatically. Otherwise no lubricant is released. This method can assure adequate lubrication is being applied since no other technology is as comprehensive for monitoring lubrication and friction changes.

Conclusion

Ultrasound technology is ideally suited for effective condition-based lubrication programs. The short wave nature of the signal reduces interference from competing noises and allows inspectors to accurately monitor bearing condition. By establishing an alarm level of 8 dB over a given baseline, inspectors will know when and when not to lubricate. Over lubrication can be avoided by applying only enough lubricant to achieve baseline levels or listen to a drop in the sound level should no dB reference be available.

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