Precision Regreasing of Element Bearings:

Listen Carefully!

Mark Barnes

Regreasing of element bearings is one of the most common lubrication tasks any maintenance team needs to perform. Unfortunately, it's also one of the most poorly executed!

While the preferred method for simple plain bearings (bushing), in most circumstances, is pumping grease into the bearing until grease purges out, applying a similar approach to rolling element bearings - particularly in high-speed applications such as motors and fans – can result in a 70% to 90% reduction in bearing life. In fact, more high-speed bearings fail due to over lubrication than under lubrication. The old adage that if a little bit of grease is good for a bearing, a whole lot of grease must be better is certainly not true!

Figure 1: More bearings fail due to over greasing than under greasing

But it doesn't have to be that way. Precision grease lubrication of element bearings is actually fairly straightforward with a little care and attention.

To properly grease a rolling element bearing, there are three things we need to know:

- which grease to use;
- how much (how many shots) of grease should we apply;
- how often to apply the grease (regrease interval).

Let's examine these three factors individually.

Which grease should I use?

Like any other lubricant selection decision, the starting point for grease selection is viscosity. Viscosity selection is based on the applied load and speed of the bearing. Generally speaking, high unit loads require higher base oil viscosities, while higher speeds require lower viscosities. Perhaps the most common mistake with grease selection is to confuse grease consistency and base oil viscosity. Consistency refers to the stiffness or thickness of a grease and is related to how much grease thickener is used in the formulation process. Grease consistency is given by the grease's NLGI grade number (for example, EP 2 or AW 1) and is important in determining a grease's ability to flow and be pumped. The consistency of a grease has little effect on lubricant film thickness, which is almost entirely due to the viscosity of the base oil contained within the grease.

For high-speed applications, such as electric motors and fans, it's common to use greases with base oil viscosities in the 80 to 120 cSt range, while for slow-turning, heavily loaded bearings, base oil viscosities in the 600 to 1000 cSt range are not uncommon. Most multipurpose greases have base oil viscosities in the 220 to 460 cSt range and should not be used in most high-speed applications.

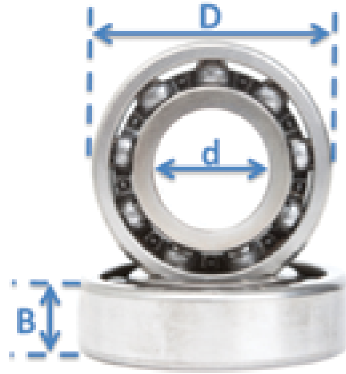
How much grease should I apply?

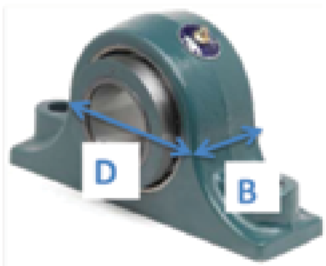
Determining the correct volume of grease for a bearing is largely a matter of bearing dimensions. Put simply, the bigger the bearing, the more grease we need to apply! Figure 2 shows a simple way of estimating how much grease should be reapplied during each re-grease interval. It uses two basic dimensions, the outside diameter (OD) of the bearing (desig-

G (grams) = 0.005 x D x B
(note: D & B in mm)

Gp (ounces) = 0.114 x D x B
(note: D & B in inches)

G = grease replenishment amount
D = bearing outside diameter
B = bearing width





When actual bearing dimensions are unknown, use the diameter and width of the bearing housing and divide the product by 3: Gp = $\frac{.114 \times D \times B}{3}$

(note: D & B in inches)

Figure 2: Regrease volume calculations (Reference - Des-Case Corporation Practical Machinery Lubrication Training Course Manual)

nated as D in Figure 2) and bearing width (shown as B in Figure 2), to estimate the replenishment volume in either ounces or grams. Where bearing dimensions are not readily available, housing dimensions can be used with a correction factor of 1/3 to account for the difference in D and B of the housing versus the bearing. These calculations should not be considered exact engineering calculations; they are simply designed to give an order of magnitude estimate that is adequate in even the most demanding and critical applications.

How often should I apply grease?

Once the correct grease volume has been established, the final step is to determine how often to reapply grease. Again, this is relatively straight forward, with the right information. Bearing regrease intervals are dependent on four basic factors: bearing size, bearing type, load and speed. There are several methodologies used to estimate regrease intervals, though perhaps the most reliable is given by the SKF Group as shown in Figure 3. In this method, we first calculate the so-called bearing speed factor (A), which is the product of the mean bearing diameter (D_m) and the rotational speed RPM. D_m is simply the arithmetic average of the bearing OD and inside diameter (ID) or bore diameter. This is then used in conjunction with a bearing type factor to read off the correct regrease interval in operating hours based on light and average or high unit loads relative to the rated load capacity of the bearing. Calculated regrease intervals should be adjusted up or down based on operating temperature, vibrations, degree of contamination and shaft orientation.

Adding Precision to Regreasing: Listen Up!

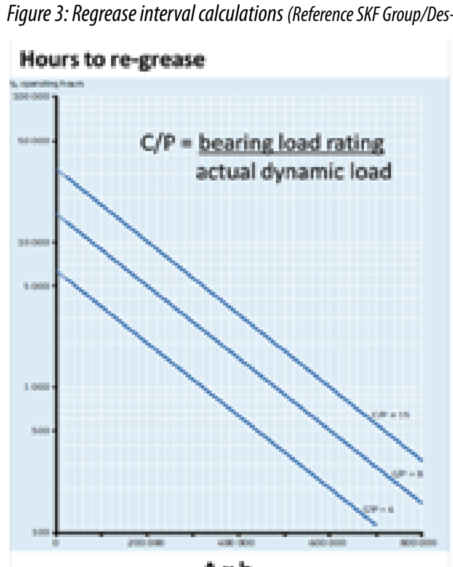
Increasingly, companies are starting to explore the use of ultrasonics to add precision to regreasing. Traditionally used for other predictive maintenance activities, such as checking for air leaks, steam trap integrity, or stray electrical discharges, ultrasonic monitoring has proven to be a very valuable tool for adding precision to regreasing activities. There are numerous articles on ultrasonic assisted regreasing, but on a basic level, ultrasonic bearing diagnostics work by measuring high frequency sound emissions caused by friction.

This applies to both under and over lubricated bearings. While under lubrication can result in high friction and ultrasonic emissions due to metal-to-metal contact, so too can over lubrication. Particularly in high-speed bearings, over lubrication causes churning and internal friction within the grease, resulting in higher ultrasonic emissions. So by measuring high frequency emissions and plotting time-based energy emissions, the exact quantity of grease required by the bearings can be determined empirically simply by looking for the "sweet spot" or the amount of grease that results in the lowest ultrasonic energy emission over time. Figures 4a and 4b show the time-based energy plot for an under lubricated bearing versus a properly lubricated bearing.

Over the past five to 10 years, I've been asked many times for my opinion on using ultrasonics in this manner and my answer is always the same. I believe with a few simple precautions, an ultrasonic gun is a very valuable addition to any lube tech's toolbox. So what are those precautions?

First, ultrasonic monitoring is only really useful for regreasing higher speed bearings. From a practical standpoint, that means 200 to 300 RPM and greater. That's not to say that ultrasonics cannot pick up incipient bearing problems at lower speeds – it most certainly can - but to evaluate and regulate regrease volumes, 200 RPM is a pragmatic limit that most practitioners agree on. Secondly, don't over-rely on ultrasonics. I have seen several instances where blindly looking at a decibel meter hoping to see a drop in overall ultrasonic emissions has led to significant and serious over greasing due to well-intentioned but misguided technicians who continue to add grease to try to make a high dB reading drop, when in reality, they are picking up ultrasonic energy from another source.

Figure 3: Regrease interval calculations (Reference SKF Group/Des-Case Corporation Practical Machinery Lubrication Training Course Manual)



The speed factor (A) multiplied by the relevant bearing factor (bf) where:

$$A = N \times D_m$$

N = rotational speed (rpm)
D_m = 0.5 x [d(mm) + D(mm)]
b_f = bearing factor depending on bearing type and load condition

	b_f
Ball bearings	1.0
Cylindrical roller bearings (light/no axial load)	1.5
Spherical/tapper roller bearings	2.0
Spherical roller thrust bearings	4.0
Cylindrical roller thrust bearings	10.0

Figure 4a: Energy-based time plot for an under lubricated bearing (Image courtesy of UE Systems, Inc.)

Figure 4b: Energy-based time plot for a properly lubricated bearing (Image courtesy of UE Systems, Inc.)

Conversely, I've also seen technicians who elect to add no grease at all since they have not seen any increase in the dB level since the last reading, when in actuality, attenuation effects are diluting the true ultrasonic emissions from the load zone of the bearing below the level to which it can be detected.

So how can we be sure we're doing it right? Figure 5 shows a simple procedure for adding precision to the act of regreasing using an ultrasonic gun. This procedure, which has been referred to as a "hybrid" approach, uses a combination of engineering calculations, such as those shown in Figures 2 and 3, coupled with an ultrasonic gun to add a level of precision to the process. In essence, the hybrid approach uses the ultrasonic device to ensure the calculations – which are, after all, just estimates – have not seriously under- or over-estimated the correct regrease interval or volume.

So if you're interested in doing a better job of lubricating motors, fans and other high-speed bearings, I strongly encourage you to look at ultrasonic monitoring as a very effective tool and a great investment. But don't just proceed on blind faith without applying common sense. Use a combination of tried and tested engineering calculations with state-of-the-art instrumentation to transform your regrease practices to best-in-class.

Hybrid procedure for high-speed bearing regreasing

1. Attach the ultrasonic detector to the grease fitting and record the baseline dB reading
2. Remove the drain port plug (if fitted) and ensure vent port is free from contamination and spent grease
3. Wipe grease fitting and grease gun nozzle with a clean (lint free) cloth
4. Slowly apply grease, ½ stroke at a time while monitoring the dB reading
5. If dB reading increases and fails to drop after 30 seconds, discontinue lubricating – the bearing is likely over lubricated
6. If the dB readings remains unchanged or drops, continue to apply grease ½ stroke at a time, while monitoring the dB levels
7. Discontinue greasing when either:
   a. an additional ½ shot of grease causes the dB reading to increase and remain high
   b. the maximum calculated quantity of grease has been added. This bearing has been calculated to require 1.2 oz (equivalent to 10 shots from a model ABC grease gun)

   Do not add more than the maximum calculated quantity of grease
8. Record the final dB reading
9. Allow 10-15 mins for new grease to become distributed throughout the bearing and housing, then replace drain port plug

Figure 5: Hybrid procedure for high-speed bearing regreasing

Mark Barnes, CMRP, is the Vice President of the newly formed Equipment Reliability Services team at Des-Case Corporation. Mark has been an active consultant and educator in the maintenance and reliability field for over 17 years. Mark holds a PhD in Analytical Chemistry. www.descase.com