



PLAYING THE NUMBERS GAME

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Introduction

Most people do not have an innate ability to win at numbers games. The odds tend to be stacked against those who try, resulting in far more games lost than won. Yet, when it comes to purchasing gear lubricants, many people in both sales and purchasing decide to play the numbers game. The person with the most numbers, or the biggest numbers, or the lowest numbers, must have the best product – right? Wrong. Gear oil selection is not a game, and numbers alone cannot determine the right product for an application. Too much information can be just as much of a problem as too little. A purchaser can be tricked into selecting the wrong oil if he does not completely understand what the numbers on a technical sheet or price list really mean. An attempt will be made here to explain what factors should be considered when choosing a gear lubricant for a specific application, and why a choice based solely on numbers is not the best bet.

Background

Gear teeth, unlike most other lubricant applications, experience a simultaneous rolling and sliding motion. The formulator has numerous ingredients available to build a gear lubricant that provides proper protection. It is the job of the lubricant formulator to choose the proper ingredients to provide synergistic performance in a given application.

To understand how a formulator chooses the proper ingredients for gear oil applications, it might help to define how gear oils are categorised. As indicated in Figure 1, gear oils are first categorised by application as either an open gear lubricant or an enclosed gear lubricant. Open gear lubricants are not enclosed in a gearbox or oil sump, so they are generally formulated as either high viscosity fluids or greases. The focus of this article will be enclosed gears.

Enclosed gears are generally contained within a gearbox or some other device in which the gears can be bathed or showered with a coating of fluid lubricant. Enclosed gear oils are categorised next as either automotive or industrial gear

John Sander, Vice President of Technology, Lubrication Engineers Inc., USA, warns against basing the decision to purchase gear lubricants solely on price.

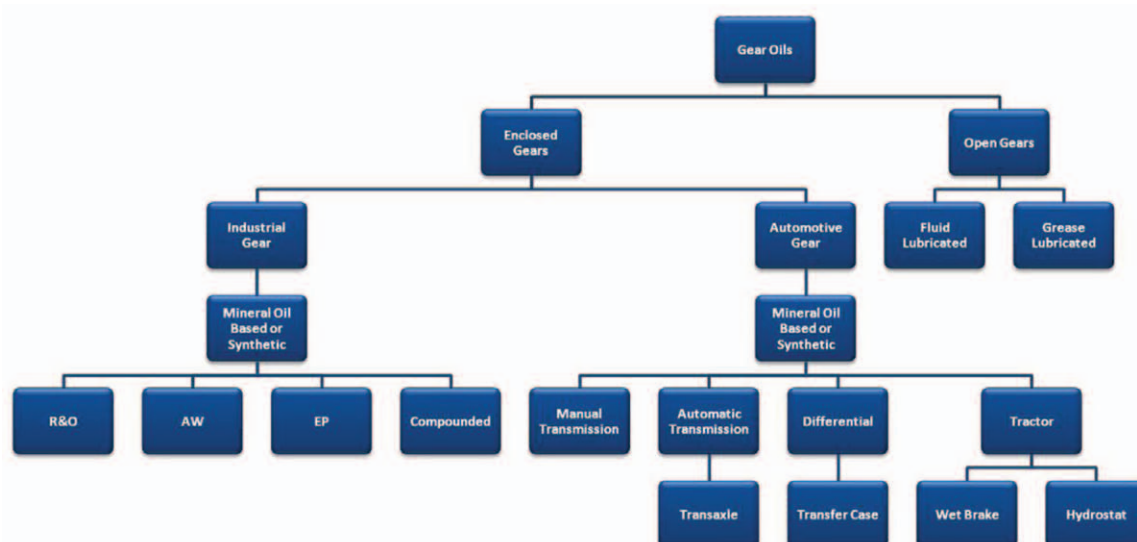


Figure 1. Gear oil categories.

oils. Both types are then subcategorised by base fluid type as synthetic or mineral oil. Automotive gear oils are then broken down into a final set of subcategories describing the application in which it will be used, while industrial oils are subcategorised by the type of additives used in the formula.

10 step gear oil selection process

It has often been stated that for lubricant selection, one must consider only temperature, speed and load. More recently, this advice has been expanded to include environment. An easy way to remember this is through the acronym LETS (load, environment, temperature and speed). While this advice is simple and memorable, it is insufficient for making a completely educated decision. Instead, the following 10 step process is recommended when purchasing enclosed gear lubricants.

1. Set lubrication goals.
2. Seek professional advice and consultation.
3. Review OEM recommendations and compatibility.
4. Determine type of load.
5. Know gearbox construction and capacity.
6. Minimise effects of operating environment.
7. Identify viscosity recommendation.
8. Consider gear speed.
9. Ensure fluid durability for extended drains.
10. Evaluate price.

Step 1: set lubrication goals

Goal setting is important when it comes to selecting a gear lubricant for use in a specific piece of equipment. Many maintenance individuals would like to improve equipment reliability, increase uptime and reduce the amount of time spent on lubricant-related maintenance projects. High-performance lubricants are available that can be used to help improve reliability. Today, many are looking to lubrication to improve energy efficiency. Improved heat removal and friction reduction in gear applications can result in decreased energy consumption.

So the question remains, how does one set goals when selecting a gear lubricant? This can vary from user to user. One must ask questions such as: is the lubricant currently in use not

performing as needed? Is there a desire to change from one supplier to another? Is it a new piece of equipment that needs to be filled for the first time? Are there availability issues with the lubricant currently in use? Does the company have an edict to reduce energy consumption? Is there a desire to increase the maintenance intervals? Goals must be personalised and they must be specific. Without specific goals, there is little reason to push ahead to steps 2 – 10.

Step 2: seek professional advice and consultation

Many companies used to employ a lubrication engineer or, at the very least, a person whose job was focused on equipment lubrication. Today, having a lubrication specialist on staff is considered a luxury as most maintenance departments have been forced to work with fewer people. Lubrication duties have often been added to the existing workload of maintenance staff.

After goals have been set, the gear oil purchasing process should start by evaluating the experience, knowledge and services offered by the individual or companies under consideration for providing the lubricants. Today, groups like the International Council for Machinery Lubrication and the Society of Tribologists and Lubrication Engineers offer certification programmes for lubrication professionals. Check with a potential lubrication provider that they, or somebody on their support staff, have been certified by one of these organisations. If the potential gear lubricant supplier can only provide a price list and specification sheet, it should raise an immediate red flag. The price for the lubricant should not only include the lubricant but also professional services to go along with it.

Step 3: review OEM recommendations and compatibility

The next step is to review the original manufacturer recommendations for the equipment to be lubricated. A potential gear oil supplier should be asked to provide evidence that their products are either approved by, or meet the requirements of, the OEM. Many OEMs determine, through field experience or extensive testing, what the lubricant requirements are for their equipment. Aside from lubricating the equipment, many of the OEM requirements are also to ensure that the lubricant is compatible with seals,

Table 1. Effect of gear type on lubricant chemistry selection					
Lubricant chemistry	Gear geometry type				
	Spur	Helical	Worm	Bevel	Hypoid
R&O inhibited	Normal loads	Normal loads	Light loads and slow speeds only	Normal loads	Not recommended
EP gear lube	Heavy or shock loading	Heavy or shock loading	Satisfactory for use in most applications	Heavy or shock loading	Specified for most applications
Compounded	Not normally used	Not normally used	Preferred by most OEMs	Not normally used	Lightly loaded applications
Synthetic	Heavy or shock loading and/or extreme temperatures	Heavy or shock loading and/or extreme temperatures	Heavy or shock loading and/or extreme temperatures	Heavy or shock loading and/or extreme temperatures	Heavy or shock loading and/or extreme temperatures

paint and other components of their equipment. Some publish a specification that lists the physical and performance requirements for gear lubricants. Some gear OEMs even take it a step further by creating their own approval system, including the publication of a list of approved products. It is advisable to become familiar with these specifications or approval lists so as not to void any warranties provided by the OEM and to maximise the reliability of the equipment. It is important to consult the professional advisor mentioned in step 2. Their advice should provide recommendations on approvals, establish proper testing programs and define drain, flush and refill procedures to ensure a successful change to a new, better-performing product.

Step 4: determine type of load

Figure 1 illustrates how gear oils are characterised according to their formulation and/or usage application. In particular, it indicates how industrial gear oils are characterised according to their additive type, specifically the wear-related chemistry used. For example, a gear lubricant may be described as R&O, EP or AW. Certain enclosed gear applications have little to no load applied. The appropriate oil in this case might be R&O oil only. As the amount of loading increases, so will the amount of metal-to-metal contact between the gears. For gears operating in the mixed film wear regime, AW oil may be needed, while for those operating in the boundary regime, EP oil may be needed.

So how does a user know? Sometimes the OEM describes the type of oil needed either in the equipment user's manual or on a plate attached directly to the gearbox itself. If not, then the user must determine whether the gearbox is subjected to either heavy loads or shock loads during operation. In that case, an EP oil that contains active sulfur and phosphorous compounds will be needed to form a protective chemical layer on the gear surfaces. In extreme loading cases, a gear lubricant that contains solid EP additives might be beneficial. However, some OEMs advise against the use of solid additives, so it is important to know this so no warranties are voided.

Step 5: know gearbox construction and capacity

A gearbox contains various components including, but not limited to, the case, gears, bearings, shafts and seals. The construction and geometric configuration of the gearbox is contingent upon how it is required to transmit power within the given application. According to Tim Cooper, Luzibrol, "Today's gearboxes often are smaller and made from new

materials [...] they are getting pushed to produce more power and at the same time be more durable and reliable than before. To meet these increasing demands, today's industrial gear oil must contain high performance additive chemistry".¹

The construction of the gearbox, including the metallurgies, gear geometries and the cuts of the gears (rough or smooth) must be considered as part of the lubricant selection process (Table 1).

Gearbox capacity is a subcategory of construction that merits its own discussion. As many gearboxes are getting smaller, less oil is present. As such, the oil could run hotter, be sheared more by the gears and be affected more dramatically by contamination. The corollary is that in a large box, the oil may circulate less, run much cooler and last much longer. Although this sounds like an endorsement for larger gearboxes, it may not be possible for certain applications. As an example, a lubricant containing the wrong additive system employed in a small, hot gearbox could cause premature activation resulting in the formation of oxidised deposits.

Step 6: minimise effects of operating environment

Gearboxes are installed in equipment operating environments that are hot, cold, dusty, wet or various combinations of these conditions. To minimise the effects of these environmental conditions, precautions such as installing air breathers, sight glasses and filtration devices can be taken. However, the lubricant may still be required to compensate for some of the challenges caused by the operating conditions.

Extreme temperatures

For an application operating at either extremely high or low temperatures, it may be necessary to choose a synthetic-based lubricant instead of a mineral-oil-based lubricant. For low temperatures, oil should have a pour point that is 5 °C (9 °F) below the start-up temperature. Operating temperatures can also determine the chemistry needed in the gear oil. Very aggressive EP gear oils used at too high a temperature might result in heavy deposit formation in the gearbox during operation. Non-EP oil used in an EP oil application can result in high oil temperatures due to excess frictional heating of the oil.

Particulate contamination

In an aggregate crushing plant, it is inevitable that dust and dirt will be in the air, and it is very difficult to keep the particles from finding their way into the gear oil. Filterable gear oil

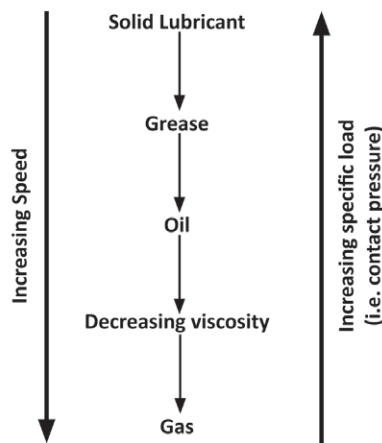


Figure 2. Effect of speed and load on lubricant selection.²

would allow filtration to remove harmful contaminants without removing valuable additives. Gear oils that contain solid additives might not be filterable.

Water contamination

In high water contamination applications, it is nearly impossible to keep water out of some gearboxes. It is vital to choose a gear lubricant with excellent water separation properties.

Step 7: identify viscosity recommendation

The viscosity of a gear lubricant is a measurement of its ability to flow in an application. This is a very important consideration in selecting gear oil. If the oil is too thick, it will not flow into the gear contact zones. If the oil is too thin, it will be compressed out of the contact zones or fling off the gears while they are in motion. In either case, lubricant starvation occurs, which can result in premature wear-related failures. With regard to viscosity, the primary means of gear lubricant selection is to use the OEM recommendation. When an OEM recommendation is not available, there are two other methods to obtain viscosity recommendations. The first is to use the viscosity ranges recommended by the American Gear Manufacturers Association, per its 9005-E02 standard.³

The second method is attributed to renowned gear expert Robert Erricello,⁴ and is based upon a calculation method that employs the following equation:

$$V/40 = 7000 / \sqrt{V1}$$

Where $V/40$ is the viscosity at 40 °C, in cSt

$V1$ = pitchline velocity of the lowest speed gear in the gearbox in ft./min = $0.262 \times \text{speed (pinion rpm)} \times \text{pinion diameter (in.)}$

If there is no oil cooler on the industrial gear drive, it is best to determine the maximum expected ambient temperature during operation and to adhere to the following points.

- Increase one ISO viscosity grade if the ambient temperature exceeds 35 °C (95 °F).
- Increase two ISO viscosity grades if the ambient temperature exceeds 50 °C (122 °F).

If there is an oil cooler, the maximum ambient temperature is less important because the oil's temperature can be controlled. Therefore, the oil's temperature should determine the viscosity.

- Increase one ISO viscosity grade if the oil temperature exceeds 65 °C (150 °F).

- Increase two ISO viscosity grades if the oil temperature exceeds 85 °C (185 °F).

If the oil temperature exceeds 90 °C (194 °F), use a cooler such as a fan or a heat exchanger.⁵

Step 8: consider gear speed

Often, viscosity is proportionately related to the speed at which the gearbox is operating. In general, high-speed applications require low-viscosity lubricants, and low-speed applications require high-viscosity lubricants. AGMA provided a general guideline in its 9005 – 94 specification, which can serve as a good rule of thumb when referring to its viscosity grades: “These guidelines are directly applicable to [...] gears that operate at or below 3600 rpm, or a pitchline velocity of not more than 40 m/sec. (8000 ft./min) [...] and worm gears that operate at or below 2400 rpm worm speed or 10 m/sec. (2000 ft./min) sliding velocity.”⁶

Pieces of equipment operating above these gear speeds are considered high-speed gears, and it is best to consult the OEM lubricant recommendations. Figure 2 shows a simple schematic that summarises how load, speed and viscosity come together during the lubricant selection process.

Step 9: ensure fluid durability for extended drains

Today, many realise that there are hidden costs to using inexpensive, lower performance lubricants. The less time a lubricant lasts during service, the more maintenance time is spent changing worn out lubricant. In addition, frequent lubricant changes produce more waste lubricant that has to be disposed of. While there are plenty of companies specialising in waste oil disposal, they usually charge for their services. To reduce the hidden costs, many users are looking to extend their drain intervals.

For extended drain service, the gear oil must have good durability. For this to occur, a proper synergy must exist between the base fluids and additives chosen for the gear oil formulation. For example, as mentioned in step 6, filtration tools might be employed to overcome operating environmental issues; however filters might also remove some of the additives, such as tackifiers and defoamants. Consult the manufacturer of the gear lubricant to verify their experience. If they have no experience with extended drain operation, request testing or continue searching for another supplier.

Step 10: evaluate price

Evaluating the price is the last step in this process for a reason. Unfortunately, many gear oil purchasers evaluate price first, and sometimes it is the only number they evaluate. This can be a costly mistake. According to Mike Johnson, lubrication consultant, trainer and author: “Lubricant purchases represent only 1 – 3% of maintenance expenses. Yet, the portion of the budget that can be directly impacted by lubricant expenditures can represent about 35% (20% from parts replacement, plus 15% from lube programme routine and overtime repair labour). The cost-to-cost leverage factor for lubricant savings opportunity vs. lubricant expense is an astounding 35:1. Investment in either process or product improvements can produce returns at several hundred percent investment with just a little effort.”⁷ Figure 3 provides an illustration of this breakdown.

While consideration of price is a valid part of the lubricant selection process, it should always be the last step. By the

time steps 1 – 9 have been completed, it is likely that the best lubricant for the gear application has become apparent. However, if several products appear to be equivalent, then price should finally become part of the selection process. The highest priced lubricant is not necessarily the best for a given application. For example, in a leaking gearbox it is probably not prudent to fill it with an expensive synthetic lubricant. On the flip side, this does not mean you should purchase the least expensive gear oil and ignore the leaking gearbox. In such a case, it is a maintenance issue and not a lubricant issue. As described by Mr. Johnson, leaving a problem like this unresolved can cost the company much more in the long run than initiating good maintenance practices and choosing high performance lubrication products.

Important numbers

Assuming that steps 1 – 10 have been considered and the final decision comes down to a comparison of data sheets, the question still remains: what numbers should one consider important? A review of various gear lubricant suppliers' data sheets will show that there can be dramatic differences between the claims made. Without knowledge, the tendency might be to go with the product with the most numbers and OEM claims on the data sheet. While this shows that the supplier was willing to put a sizeable investment into product development testing, it still does not necessarily prove that one product is better than the other for the application. Be wary of the lubricant

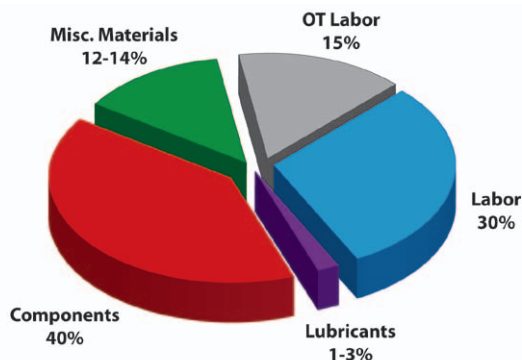


Figure 3. Typical maintenance budget divisions.

sales person who just points out one specific data point and emphasises this for the sale. Other factors affect the significance of those numbers, such as suitability for the application, test precision and units portrayed. Table 2 provides a list of common lubricant features, cross-referenced with application conditions and optimal test results, indicating lubricant suitability for that application.

Conclusion

Several resources are available to help the end user select the right gear lubricant. Some have focused only on speed, temperature and load, while others have added operating environment to the mix. Still others have added lubricant and equipment compatibility. All of these tend to confuse the end user. The result is that many end users look to their lubricant suppliers for assistance. This is a good plan, but can sometimes result in a mere comparison of price or data sheet numbers – in other words, a numbers game. Instead, try using this 10 step process for lubricant selection to make the process easier and more systematic, resulting in improved equipment reliability. Remember: be careful when playing the numbers game; most players end up losing. 🌐

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Table 2. Important information to look for on product data sheets			
Application	Lubricant feature	Common tests	Optimal results
All	OEM approvals		Check for any approval that is required
All	Viscosity	Viscosity, ASTM D445	Varies by grade
		Viscosity-Brookfield, ASTM D2983	Varies by grade
Extreme temperatures (extremely low startup: <-26 °C [-15 °F] or continued exposure to extremely high temperatures: >82 °C [180 °F])	Synthetic	N/A	N/A
Lightly loaded or high temperature operation	R&O	Oxidation at 121 °C, ASTM D2893B	≤6 max
		Oxidation rig test, viscosity increase, L60-1	≤100%
		Rust test, ASTM D665B	pass
Light to medium loading	Anti-wear (AW)	Four-ball wear, ASTM D4172	<0.50 mm



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