Dodge® gear reducers: lubrication basics

Proper lubrication is critical for achieving satisfactory performance of speed reducers. Mineral and synthetic are two basic types of lubricants used in these products. Synthetic lubricants fall into two categories: hydrocarbon (PAO) and polyglycol (PAG). Within these two categories lubricants can further be classified as biodegradable or as food grade. Each type of lubricant has its own specific characteristics and must be considered when choosing a lubricant. Several important characteristics of a lubricant include viscosity, viscosity index, pour point, and additives. One of the leading causes of speed reducer failure is due to improper lubrication. This includes choosing the incorrect viscosity, not maintaining the correct oil fill level, improper type of lubricant, and operating the gearbox with dirty or contaminated oil.

Lubricant Function

In all speed reducers or gear drives, friction is created between internal moving components. The primary function of a lubricant is the transmission of gear forces, prevention of wear and corrosion, and the removal or dissipation of heat from the meshing gears caused by the frictional sliding and rolling action of the gears and bearings. This is achieved by providing a thin layer of oil between moving components. This thin film of oil, called the elastohydrodynamic lubrication film or EHL film, separates the surfaces of mating components so that metal to metal contact is eliminated and wear is minimized.

In selecting the correct lubricant, important properties to consider are the lubricant's viscosity, the viscosity index, the pour point, and the corrosion resistance of the lubricant. In some cases, the flash point, or the point when the oil vapors ignite, should also be considered.

The viscosity of a lubricant, which is its ability to resist flowing when subjected to a force, helps determine the thickness of the oil film. The lubricant's resistance to flow occurs because of the properties of cohesion and adhesion within the lubricant. As the lubricant flows, adhesion causes the lubricant to stick to the surfaces of mating components. Adhesion combined with cohesion, the bonding or attracting forces between the molecules of the lubricant, causes shear layers within the thickness of the oil film. This determines the viscosity of a lubricant and is what creates the EHL film between moving components. The viscosity of a lubricant is determined by the International Standards Organizations (ISO) viscosity classification system. The ISO viscosity of a given lubricant is the midpoint of the viscosity as measured at 40°C and is expressed in centistokes (cSt).

The viscosity index is another important characteristic that must be considered when selecting a lubricant. The viscosity index indicates the ability of the lubricant to resist viscosity change as the temperature of the lubricant changes. The higher the viscosity index, the wider the operating temperature range of the oil while still maintaining its rated viscosity.

Another important property of a lubricant is its pour point. The pour point is the lowest temperature at which a lubricant will pour, temperatures lower than the pour point will cause the lubricant to solidify. For proper lubrication, the pour point of a lubricant should be at least 10°F to 15°F lower than the coldest expected ambient temperature.

Chemical additives are agents blended with the base oil stock to improve the performance of a lubricant. The additives can be single-purpose materials, or they can be multi-purpose materials. Rust and oxidation inhibitors are used to slow or stop oxidation and acid formation, and to enhance the oil's ability to reduce rusting. Anti-wear agents are used to minimize wear. Extreme pressure (EP) agents, which are more aggressive than anti-wear agents, bond to metal surfaces to provide protection from heavier loads. Demulsifiers are used to assist the oil in separating quickly from water and help to prevent rust. In addition to these, there are additional agents, such as detergents, friction modifiers, defoamants, and viscosity index improvers that can be used to enhance the overall performance of a lubricant.

The lubricant chosen for a specific application should have properties that will match the ambient conditions in which the speed reducer is expected to operate. The viscosity of lubricant must be able to maintain the EHL film when subjected to the forces created by the application. Insufficient viscosity will cause metal to metal contact and premature wear and even possible catastrophic failure. As the operating temperature of the speed reducer increases, the greater the viscosity requirement will be.

Speed Reducer Maintenance

The correct amount of oil must be maintained in a speed reducer to insure long and satisfactory performance. If the reducer operates with an insufficient amount of oil, premature gear or bearing failure can occur due to oil starvation. Overfilling the reducer will create excessive churning leading to excessive air entrapment. If this occurs, overheating will result due to the reduced ability of the air and oil mixture to dissipate heat. To get the most accurate oil level reading, the level should be checked with the reducer not operating and after the unit has had sufficient time to cool.

On new applications, the reducer should be operated under normal loads for approximately two weeks. During this break-in period, fine particles of metal will be removed from the mating surfaces of the internal components and gears. After the two week break in period, the oil should be drained, and the reducer flushed to remove all metal particles. The drain plug should also be cleaned prior to reinstallation. The drained oil can then be filtered and reused in the reducer. The oil level should be maintained to the proper level as indicated by the manufacturer. Below shows a typical failure due to oil starvation.


Damage Caused by Insufficient Lubrication.

Oil Life

As a speed reducer operates, the lubricant begins to breakdown and oxidize. This process continues throughout the life of the oil and begins to form sludge and varnish deposits along with increased acid levels. The sludge formation prevents effective lubrication and causes metal to metal contact between moving components.


Damage Caused by Contaminated Lubrication.

Speed reducers, like other types of equipment, should have a preventative maintenance schedule for changing the lubricant. This maintenance schedule is dependent on the local conditions in which the speed reducer operates and on the type of oil selected. Under normal operating conditions the lubricant should be changed every 2500 hours if using mineral oil or every 8000 hours if using synthetic oil. In extremely harsh environments the lubricant must be changed more frequently.

In most geared speed reducers, the operating hours between oil changes could be extended with the introduction of an oil analysis program. This includes performing an ICP spectroscopy test, particle quantification (PQ), viscosity at 40°C, and a water screen. Below are typical properties and contamination levels that an oil analysis program would be measuring.

Material	Limit PPM	Indication
Iron	200 ppm	Wear
Chromium	20 ppm	Wear
Nickel	20 ppm	Wear
Silicon	50 ppm	Contamination, Dirt
Calcium	900-3000 ppm	Additive
Phosphorus	900-2000 ppm	Anti-wear
Zinc	900-2000 ppm	Anti-wear
Water	500 ppm	Contamination
Viscosity	+/- 15% of starting value	Oil Breakdown
Oxidation	+2 over starting TAN	Oil Breakdown

To understand particle quantification, or PQ index, ISO has established cleanliness codes. This test measures the level of contamination per milliliter of lubricant at three different sizes of particulate and is expressed as a three number code. This test measures the quantity of particulate at 4µ, 6µ, and at 14µ. Each number represents a contaminate level code for the correlating particle size. As a starting point, for industrial speed reducers, the recommended ISO code is 17/16/13.

ISO 4406 Chart

Range Code	Particles per Milliliter	
24	>80,000	<160,000
23	>40,000	<80,000
22	>20,000	<40,000
21	>10,000	<20,000
20	>5,000	<10,000
19	>2,500	<5,000
18	>1,300	<2,500
17	>640	<1,300
16	>320	<640
15	>160	<320
14	>80	<160
13	>40	<80
12	>20	<40
11	>10	<20
10	>5	<10
9	>2.5	<5
8	>1.3	<2.5
7	>0.64	<1.3
6	>0.32	<0.64

From the chart above, The ISO code of 17/16/13 would indicate a 17 code for 4μ particles, 16 code of 6μ particles, and 13 code for 14μ particles. These codes includes all particles of the specific size and larger. In this example, the code would indicate 640 to 1300 particles that measure 4μ or larger.

Two additional tests to be performed during an oil analysis is to check the lubricants viscosity and water content. The measured viscosity should be compared to the base starting point of new oil. Once the viscosity varies by more than 15%, the oil should be changed. Also, water present in the analysis at 500 ppm or greater would indicate changing the oil.

Typically, when very cold or very hot ambient conditions exist, synthetic oil should be selected. An added benefit of synthetic oil is that it tends to reduce the overall operating temperature of the reducer. For worm type speed reducers, polyglycol synthetics are extremely effective in reducing sliding friction and extending the operating hours before a lubricant change is required.

Extreme pressure additives, such as graphite or sulfur-phosphorus, are highly effective in reducing friction. These types of lubricants, although very effective in reducing friction, generally should not be used with internal backstops or brakes which rely on friction to operate correctly. The manufacturer of the speed reducer should be contacted if there is any doubt about the suitability of EP lubricants.

In addition to decreased oil life, excessive operating temperatures can lead to increased lubricant contamination. The surface temperature of a heavily loaded speed reducer can reach over 200°F. Once the reducer is shut off, the reducer starts to cool down and condensation begins to form on the inside of the gear case. Over a period of time, depending on the ambient conditions, the amount of water forming on the inside of the housing can be substantial. This type of contamination can lead to bearing and gearing failure. The condensation displaces the lubricant and results in a thin oil film between mating components. Depending on the severity of the water contamination, the frequency of servicing the lubricant may need to be as short as 250 hours. Proper selection of desiccant filters and breathers will help minimize condensation damage.

Selecting the proper lubricant and maintaining and implementing a good oil sampling and analysis program will help to determine the proper intervals of servicing. Changing the oil more frequently than necessary will result in wasted resources and will drive maintenance cost up. Not changing the oil when needed will lead to premature reducer damage and possible catastrophic failure. The proper selection of a lubricant and establishment of a routine maintenance program will result in less downtime and higher productivity.

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