

Technical Note

Thermal Ratings and Limitations

Gear reducers must withstand both mechanical and thermal influences in order to ensure sufficient life of the bearings, gears, oil and seals. Factors that limit the amount of torque that can be transmitted through the gear reducer include the required bearing life hours plus the strength of the gears, housing, keys, and output shaft. The mechanical torque rating must ensure that the gears and shafts can achieve an infinite fatigue life and that the bearings can achieve at least a finite number of hours. The lower the load torque is compared to the mechanical torque rating, the higher the service factor and the longer the bearing life.

While mechanical influences are usually the most prominent, thermal influences cannot be ignored. In fact, thermal influences become more predominate as the gear reducer size increases, especially in sizes 97 and larger. Oil temperature often becomes the critical limitation. Unacceptably high oil temperature changes the properties of the oil and can ultimately damage gears, bearings, and seals. The following parameters directly affect the oil temperature.

- Speed
- Mounting Position
- Gear Reducer Design
- Environment
- Output Torque
- Duty Cycle

1. Speed

Oil has a viscosity, an internal resistance to flow. Energy is required to overcome the resistance, allowing the oil to flow and the gears to rotate. As the oil churns, sheer force rips the oil molecules apart, creating friction and converting the energy into heat. The same concept occurs within a household high-speed blender. The longer the food spins in the blender, the hotter it becomes. Food can actually boil and cook within minutes, due solely to the friction within the water molecules.

Gear reducers with lower ratios have higher output speeds and are especially prone to heat. The lower the ratio, the faster the gears rotate in the oil, which induces more sheer stress and more friction. Furthermore, heat produced by the sheer is exponentially, not linearly, proportional to the speed! Therefore, any application with an inverter merits thermal consideration if the frequency extends above 60Hz. Above 60Hz, the speed increases and so does the heat.

High temperature is not limited to low ratios. Any ratio could be problematic, depending on the individual gear diameters. The first and last gears are generally the most critical, since they are partly immersed in oil. As a gear diameter increases, so does the circumferential speed and heat! Therefore, it is possible for a certain ratio with a large pinion gear to have a considerably higher oil temperature than an adjacent ratio with a smaller pinion gear.

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Gear reducers containing a worm gear set, such as SEW's S-series, have another parameter to consider - efficiency. As the speed decreases, the efficiency decreases. At low speeds, there is more sliding friction and more heat. Thus, it is common for a low speed worm reducer with more sliding friction to have a higher oil temperature than a higher speed worm reducer with more churning friction.

2. Mounting Position

Each mounting position requires a different amount of oil to ensure that all gears are properly splash-lubricated. M1 requires the least. M4 requires the most since the gear reducer is filled almost entirely with oil. More oil requires more energy to move it, producing more heat. Imagine running along the beach in three inches of water compared to two feet of water. Obviously, two feet of water requires much more energy.

3. Gear Reducer Design

Larger reducers have larger gears that naturally have more surface area. Therefore, they move more oil, producing more churning and heat. Imagine rowing a boat with a stick instead of an oar. An oar has more surface area to move water.

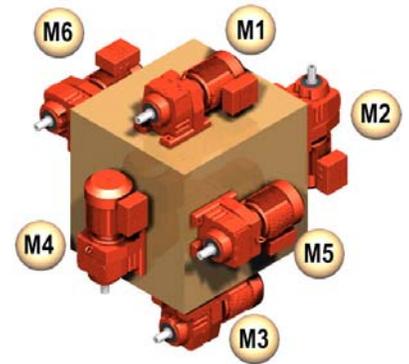
The shaft type and flange design contribute to the rate at which the heat dissipates within the gear reducer via conduction. The faster the heat conducts, the cooler the oil remains. A B5 reducer flange acts as an additional heat sink to dissipate more heat than a reducer without a flange. Therefore, an FAF107 with a hollow shaft and B5 flange has a different thermal rating than a F107 with a solid shaft and no flange.

An integral motor whose pinion shaft extends inside the reducer also acts as an additional heat sink. Thus, an FAF97DRE132MC4 integral gearmotor dissipates more heat than a FAF97AM215 C-face reducer and C-face motor.

4. Environment

The area (ambient) temperature obviously impacts the oil temperature. So does area convection. An indoor gear reducer that is covered or at close quarters dissipates heat much less than an uncovered reducer located outdoors in the wind. Similarly, C-Face gear reducers with a TENV motor are hotter than the same reducer with a TEFC motor. The forced convection from the fan provides additional cooling for the gear reducer.

Surface conduction contributes to oil temperature since it determines how quickly heat dissipates away from the reducer. Metal surfaces are good conductors whereas concrete surfaces are poor conductors. A gear reducer on a metal surface will have a lower oil temperature than the same reducer on a concrete surface.



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5. Output Torque

As a general rule, gear reducers with helical gears lose 1.5% efficiency per gear stage. Thus, a 3-stage reducer is 95.5% efficient. Friction from the meshing gears and from the balls rolling within the raceway of the bearings converts the remaining 4.5% of the torque to heat.

In many cases involving large reducers with low ratios, the heat created from torque is generally small in comparison to the heat generated from oil churning. In fact, a reducer with no load may produce enough heat just from the oil churning to require high temperature synthetic oil, without considering any additional heat from the torque transfer.

6. Duty Cycle

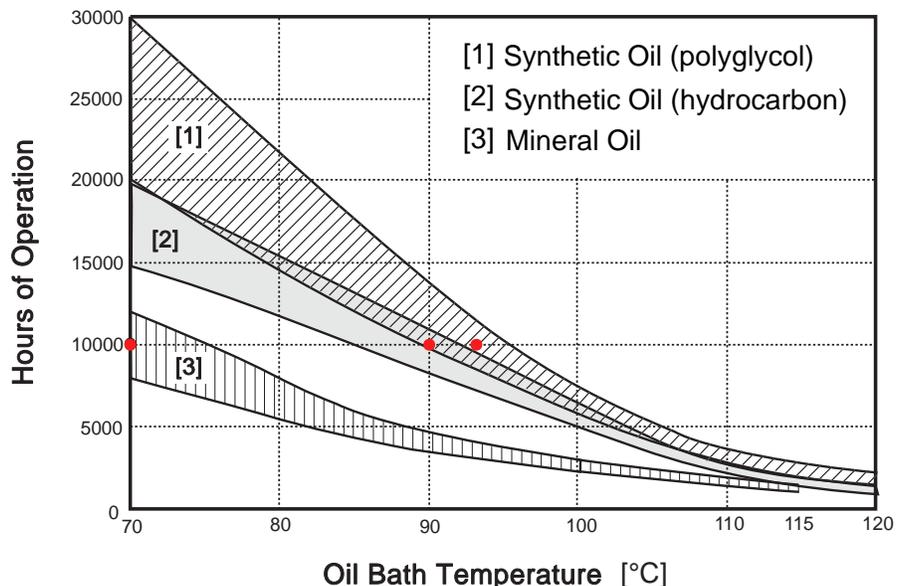
Any motor that operates continuously for ten minutes or more has a duty cycle = 100%. After ten minutes the motor reaches a stable operating temperature. For a reducer, the time varies based upon size. Larger reducers require longer times. If the reducer operates less than 100%, the oil has periods of cooling that contribute to a lower average (i.e. root mean square) temperature. Therefore, it is able to handle additional heat from torque transfer, resulting in a higher thermal HP capacity.

Effects of High Oil Temperature

Heat reduces seal life and increases oxidation, which requires more frequent oil changes. The graph below shows how oil life decreases exponentially with temperature. Notice how synthetic oil provides the maximum hours between oil changes and allows a considerably higher sustained oil bath temperature than mineral oil for the same amount of hours.

Example:

As indicated by the red dots on the graph, a reducer may operate 10,000 hours with synthetic polyglycol oil @ 93°C, synthetic hydrocarbon @ 90°C or mineral oil @ 70°C before the oil breaks down from heat and requires changing.



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Understanding the sources of heat aids the user in eliminating excess heat as much as possible. However, a high oil temperature is often unavoidable. Therefore, it is important to properly protect the gear reducer against its damaging effects for maximum longevity.

Using high temperature synthetic oil along with FKM seals permits a higher oil bath temperature without damaging the gears and bearings. Synthetic oil does not break down as quickly as mineral oil. In addition, FKM seals can endure much higher heat than standard nitrile seals. Both the gear reducer output shaft and the motor pinion shaft should contain FKM seals since the seals directly contact the oil. Another advisory is to add SEW's inner FKM seal that interlocks with the outer seal on the output shaft, providing a total of two FKM seals and 3 lips.

If the output speed is high and the reducer is nearly filled with oil, such as an M4 mounting, overflow and/or foaming may occur from high speed churning, regardless of temperature.

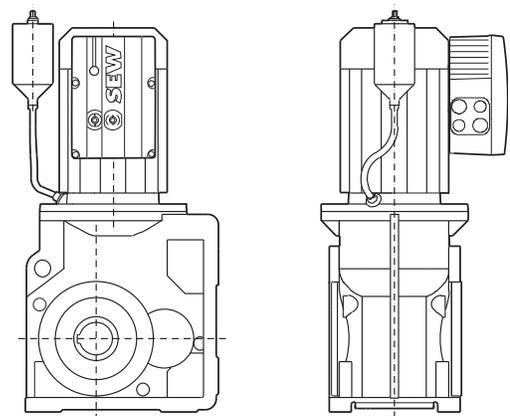
Overflow may also occur with a high oil temperature since hot oil can create high pressure and force oil out of the breather.

Should oil spillage at the breather become problematic, or if the oil temperature merits synthetic oil with FKM seals, an oil compensator is recommended in an M4 mounting, as shown at right. The reservoir and tube attach to the motor fan guard and thread into the breather hole. As the oil rises, it collects in the reservoir.

To easily select a gearmotor with all recommended features for your specific application, visit SEW's online quotation program: www.ptpilot.com.

PT Pilot uses your mounting position and area temperature to calculate the thermal capacity of all selections. It returns only valid selections and automatically adds FKM seals and synthetic oil where necessary.

In general, reducers smaller than size 97 with helical or bevel gears operating at 25°C are not normally subject to thermal limitations.



Oil Compensator



www.ptpilot.com

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Frequently Asked Questions

1. Is the use of FKM seals and high temperature synthetic oil unique to SEW?

No. Factors that influence oil temperature are physical properties that are not unique to SEW. However, SEW is able to make appropriate recommendations based upon a proprietary calculation program that accurately determines the oil sump temperature.

2. Do I need to use an oil compensator every time I have an M4 mounting?

It is highly recommended if PT Pilot determines that the oil temperature requires FKM seals and synthetic oil. Hot oil can cause high pressure which may merit the use of an oil compensator to prevent the oil from being forced out of the breather. In general, it is not necessary for a reducer smaller than size 97 operating in 25°C ambient with a 4-pole motor.

3. If I am using a gearmotor on a conveyor that operates for a few minutes and then stops for a few minutes, what do I need to do?

The application is not 100% duty. Therefore, there are rest periods to allow the oil to cool. If the reducer is not an S-series, is smaller than size 97, and has an ambient temperature less than 40°C, nothing more is usually needed. However, consider entering the parameters into the Calculator section of PT Pilot. PT Pilot computes the duty cycle, compares it to the thermal ratings of all selections, and returns all valid selections.

4. When do I need to add synthetic oil to my gear reducer?

- Use high, medium, or low temperature synthetic oil anytime to extend the hours between oil changes (often more than double), as shown on the previous graph.
- Use high, medium, or low temperature synthetic oil anytime to reduce friction, yielding a lower oil temperature and extending the life of bearings and seals.
- High temperature synthetic oil is always required whenever the ambient temperature is close to 60°C (140°F) or higher.
- Visit www.ptpilot.com and enter your model number or your parameters. PT Pilot automatically adds high temperature synthetic oil if your oil temperature requires it.
- If the gear reducer is already working in the field, measure the oil temperature after it reaches a steady state value. If it is close to 80°C (176°F), use high temperature synthetic oil.