Axle and Manual Transmission Lubricants—SAE J308c

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SAE Information Report

Report of Lubricants Division approved February 1924 and last revised by Fuels and Lubricants Technical Committee April 1976.

This SAE Information Report was prepared by the SAE Fuels and Lubricants Technical Committee for two purposes: (1) to assist the users of automotive equipment in the selection of differential and manual transmission lubricants for field use, and (2) to promote a uniform practice for use by marketers of lubricants and by equipment builders in identifying and recommending these lubricants by type.

In both differentials and transmissions, gears and bearings of different designs are employed under a variety of service conditions. Therefore, the selection of a lubricant involves careful consideration of the performance characteristics required.

1. Load-Carrying Capacity—One of the most important gear lubricant performance characteristics is load-carrying capacity. Some gears are operated under such loads and speeds that the very low capacity of straight mineral oil is adequate. However, most gears require lubricants of greater load-carrying capacity, which is provided through the use of additives.

Gear lubricants compounded to achieve increased load-carrying capacity are referred to as "extreme-pressure" (EP) lubricants. However, when this term is applied to gear lubricant it means only that the load-carrying capacity of the lubricant is greater than that of straight mineral oil, with no distinction as to how much greater it may be. Therefore, to differentiate among EP lubricants of various load-carrying capacities, it is necessary to classify them further. The Coordinating Research Council (CRC) and the American Petroleum Institute (API) have devised ways to aid in this classification.

CRC has available reference gear oils (RGO) that can be used to rate the load-carrying capacity of a gear lubricant. The rating, or comparison, can be done in either automotive equipment on the road or in full-scale laboratory equipment. The reference oils use a numerical rating scale that ranges from RGO-100, very low load-carrying capacity, to RGO-115, very high load-carrying capacity. RGO-100 is a solvent refined straight mineral oil and RGO-115 is the same mineral oil containing 15% (wt.) of a particular EP additive. The complete designation shows the percent additive followed by the SAE viscosity grade, such as RGO-110-90 or RGO-112-80.

The following designations are quoted from API Publication 1560, Lubricant Service Designations for Automotive Manual Transmissions[1] and Axles, February 1976.

"**API-GL-1** Designates the type of service characteristic of automotive spiral-bevel and worm-gear axles and some manually operated transmissions operating under such mild conditions of low unit pressures and sliding velocities, that straight mineral oil can be used satisfactorily. Oxidation and rust inhibitors, defoamers, and pour depressants may be utilized to improve the characteristics of lubricants for this service. Frictional modifiers and extreme pressure agents shall not be utilized."

Lubricants suitable for this type of service are, therefore, considered to be "straight mineral gear oils." In antiscoring protection, these lubricants are comparable to CRC RGO-100.

Due to speeds and loads involved, straight mineral oil is not a satisfactory lubricant for most 4-speed and some 3-speed passenger car manual transmissions.[1] For some truck and tractor manual transmissions, straight mineral oil is suitable.

"**API-GL-2** Designates the type of service characteristic of automotive type worm-gear axles operating under such conditions of load, temperature, and sliding velocities, that lubricants satisfactory for API-GL-1 service will not suffice."

Products suited for this type of service contain antiwear or very mild extreme-pressure agents which provide protection for worm gears.

There are relatively very few differentials in use that are equipped with worm gears. The GL-2 designation is included in this list for those worm gears used in a service that has been found to require a lubricant other than straight mineral oil.

"**API-GL-3** Designates the type of service characteristic of manual transmissions and spiral-bevel axles operating under moderately severe conditions of speed and load. These service conditions require a lubricant having load carrying capacities greater than those which will satisfy API-GL-1 service, but below the requirements of lubricants satisfying API-GL-4 service."

Lubricants designated for this service typically contain additives which react with tooth surfaces at the temperatures resulting from high speed or load. Due to the rate of reactivity or the relatively low concentration of the additives, products designated for GL-3 are not formulated to provide adequate protection for hypoid gears. The scoring resistance of such oils is comparable to that provided by CRC reference gear oils below RGO-104.

"**API-GL-4** This classification is still used commercially to describe lubricants, but the equipment required for the anti-scoring test procedures to verify lubricant performance is no longer available.

Designates the type of service characteristic of gears, particularly hypoid[2] in passenger cars and other automotive type equipment operated under high-speed, low-torque, and low-speed, high-torque conditions.

Lubricants suitable for this service are those which provide antiscore protection equal or better than defined by CRC Reference Gear Oil RGO-105 and have been subjected to the test procedures and provide the performance levels described in ASTM STP-512 dated April 1972.[3]"

"**API-GL-5** Designates the type of service characteristic of gears, particularly hypoid[2] in passenger cars and other automotive equipment operated under high-speed, shock-load; high-speed, low-torque; and low-speed, high-torque conditions.

Lubricants suitable for this service are those which provide anti-score protection equal to or better than defined by CRC Reference Gear Oil RGO-110 and have been subjected to the test procedures and provide the performance levels described in ASTM STP-512 dated April 1972.[3]"

"**API-GL-6** This is an obsolete classification. The equipment required for the test procedures to verify lubricant performance is no longer available.

The type of service designated by API-GL-6 is characteristic of gears, specifically high offset hypoid[2] gears (above 2 in offset and approaching 25% of ring gear diameter) in passenger cars and other automotive equipment operated under high-speed, high-performance conditions.

Lubricants suitable for this service are those which provide anti-score protection equal to or greater than Reference Gear Oil L-1000[4] and have been subjected to the test procedures and provide the performance levels described in ASTM STP-512 dated April 1972.[3]"

In addition to load-carrying capacity, the equipment manufacturer, lubricant supplier, and the vehicle operator should consider the following factors.

2. Viscosity and Viscosity Index—Viscosity determines ease of gear shifting and influences channeling at low temperatures. It has some relation to load-carrying capacity, leakage, and gear noise.

Viscosity, which is a measure of resistance to flow, increases with decreasing temperature. At a given temperature, Newtonian oils will not experience a viscosity change with a change in shear rate. A non-Newtonian oil may exhibit several different apparent viscosities in different parts of a differential due to variations in shear rate, and a "permanent" viscosity loss due to high shear rate conditions. The method of determining viscosity must give values which have been shown to correlate with performance.

Two viscosity methods are pertinent to gear oils. ASTM D 445 measures kinematic viscosity based on the time for oil to flow by gravity through the capillary tube. The common unit is centistokes (cSt) and the corresponding numerically equal Systems International (SI) unit is mm^2/s. The most common test temperatures are 100° and 210°F (38° and 99°C). ASTM D 2983 Brookfield method has significance for measuring apparent viscosity at low temperatures (for example at +10°F [−12°C] or lower) because most oils are non-Newtonian at these temperatures. The common unit is centipoise (cP); the Pascal second (Pa·s) is the SI unit.

The viscosity-temperature relationship of an oil depends primarily on the nature or composition of the oil. A minimum change in viscosity with temperature is desirable. ASTM D 341, Standard Viscosity-Temperature Charts, provides a series of six charts so constructed that for any given petroleum oil, the viscosity-temperature values can be approximated by a straight line over the applicable temperature range in which the oil is a Newtonian liquid. At low temperatures there are serious limitations with these charts. To be accurate, only interpolated values should be taken from these charts. Measurements of the viscosity of a gear lubricant should be made at or near the temperature at which it is expected to perform. This is especially true at low temperatures by ASTM D 2983 since viscosity-related problems may occur

NOTE: Lubricants suitable for more than one service classification may be so designated.

[1] Automatic or semi-automatic transmissions, fluid couplings, torque converters, and tractor hydraulic systems usually require special lubricants. For the proper lubricant to be used, consult the manufacturer or lubricant supplier.

[2] Limited slip differentials generally have special lubrication requirements. The lubricant supplier should be consulted regarding the suitability of his lubricant for such differentials. Information helpful in evaluating lubricants for this type of service may be found in ASTM STP-512 dated April 1972.

[3] The complete publication is titled "Laboratory Performance Tests for Automotive Gear Lubricants Intended for API-GL-4, GL-5, and GL-6 Services."

[4] Reference Gear Oil L-1000 is available for a fee from Southwest Research Institute, P. O. Drawer 28510, San Antonio, Texas 78284.