



## Gear Oils

Many changes have taken place in gear oil requirements and gear oil specifications. With the multiviscosity gear oils becoming very popular in the cold temperature regions and the coast-to-coast operation of many vehicles, it was necessary to establish a low-temperature specification.

### Axle & Manual Transmissions

#### SAE J306

The Society of Automotive Engineers publishes the Axle and Manual Transmission Lubricant Viscosity Classification, SAE J306. This classification is based on the lubricant viscosity measurements and may encompass both high and low temperature variations. A multi-viscosity graded lubricant, such as an SAE 75W-90, meets the low- and high-

temperature requirements shown in the table below. That is, it conforms to the SAE 75W Brookfield and kinematic viscosity requirements at low temperatures and is in the kinematic viscosity range provided for SAE 90 at high temperatures.

The selection of an axle or transmission lubricant should be based on the lowest and highest service temperatures. The multi-viscosity-graded lubricants may be satisfactory at both temperature extremes. The SAE 70W, 75W, 80W and 85W are for low temperatures, and the SAE 80, 85, 90, 110, 140, 190 and 250 are for the high heat applications. This eliminates spring and fall oil changes. Below is a chart outlining the viscosity grades defined by SAE J306.

### Axle & Manual Transmission Lubricant Viscosity Classification

SAE Viscosity Grade	Maximum Temperature (°C) for Viscosity of 150,000 cP [ASTM D2983]	Viscosity at 100°C [ASTM D445]	
		Minimum (mm <sup>2</sup> /s)	Maximum (mm <sup>2</sup> /s)
70W	-55	3.72	—
75W	-40	4.4	—
80	—	8.02	<11.0
80W	-26	5.29	—
85	—	10.15	<13.5
85W	-12	6.46	—
90	—	13.13	<18.5
110	—	17.4	<24.0
140	—	23.74	<32.5
190	—	33.33	<41.0
250	—	48.49	—

The 150,000-cP viscosity value used for the definition of low-temperature properties was derived through a series of tests that show pinion bearing failures have occurred at viscosities higher than 150,000 cP. The Brookfield method was shown to give adequate precision at this viscosity level. Each low temperature gear lubricant must not exceed a maximum viscosity of 150,000 cP at the temperature indicated. A 150,000-cP fluid appears like a semifluid grease, which will barely pour.



## Automotive Gear Applications

### **API GL-5**

The American Petroleum Institute's (API) GL-5 designates the type of service characteristics of gears, particularly hypoid in passenger cars and other automotive equipment operated under high speed/shock load, high speed/low torque and low speed/high torque conditions. Many light- and medium-duty applications still require API GL-5 solely, but virtually all heavy-duty applications now require API MT-1, SAE J2360 or other OEM specification that requires higher performance, namely in the areas of sludge control and seal compatibility. Most often API GL-5 serves as a core specification to others that define enhanced performance. One can think of API GL-5 as the practical minimum to deliver acceptable performance and equipment reliability. Lubricants meeting API MT-1, SAE J2360 or other OEM specifications almost universally meet API GL-5. The latest specifications for API GL-5 can be found in ASTM D7450.

### **API MT-1**

API MT-1 designates the type of service characteristics of non-synchronized manual transmissions used in buses and heavy-duty trucks. Lubricants that meet the API MT-1 requirements provide protection against the combination of thermal degradation, component wear and oil seal deterioration not provided by lubricants of API GL-1 through GL-5 quality. This was achieved by developing a single lubricant that combined the cleanliness and oil seal life typical of engine oils with the load carry-capability of gear oils. The latest specifications for API MT-1 can be found in ASTM D5760.

### **MIL-PRF-2105E**

MIL-PRF-2105E has been re-written as SAE J2360. A fluid meeting SAE J2360 will provide equivalent and satisfactory performance in the same applications. A few OEMs still recommend MIL-PRF-2105E, but the majority have transitioned to recommending SAE J2360 or their own specifications, which are often derived from SAE J2360.

### **SAE J2360**

SAE J2360 represents a step up in performance over basic API GL-5 and MT-1 lubricants. SAE J2360 includes all tests required by API GL-5 as a core, but incorporates several additional tests – ASTM D5704, ASTM D5662, ASTM D7603 – that ensure better protection in modern applications. ASTM D5704 ensures that the oil keeps shafts, gears and oil seals free from sludge and deposits. ASTM D5662 ensures that the oil does not cause oil seals to harden, crack and deteriorate. ASTM D7603 ensures integrity during prolonged storage and compatibility with other SAE J2360-approved oils. SAE J2360 approval also requires acceptable performance in a controlled field trial. For a lubricant marketer to claim SAE J2360, the formulation along with all required data must be reviewed and approved by the Performance Review Institute (PRI).

### **Limited Slip Differentials**

Limited slip differentials were developed in the 1930s to counter the drive wheel slippage when different traction conditions exist on either side of an axle. These types of differentials are known to cause "chatter" or "squawk" when the lubricant either provides too much friction or not enough friction inside the differential; often referred to as noise, vibration and harshness (NVH). The goal of limited slip additive is to control the friction between the contacting parts inside the limited slip differential such that NVH is eliminated. In very severe applications, limited slip additive can promote increased friction between the gear teeth, leading to higher gear tooth temperature and an increased chance of scuffing. In addition, these additives are generally not very thermally stable; thus, if an application does not require limited slip additive, it is not desirable to have it in the oil.

### **LE Gear Oils for Automotive Applications**

- **Monolec® Gear Oil (703-704)** is a mineral-based, limited slip gear oil designed for use in light, medium and heavy-duty applications requiring API GL-5, API MT-1, and SAE J2360 performance.
- **Monolec® Syn Gear Oil (9919, 9923)** is a 100 percent synthetic, limited slip gear oil designed for use in light, medium and heavy-duty applications requiring API GL-5 and API MT-1 performance.

## Industrial Gearboxes

### **ISO 12925-1 and ISO 6743-6**

ISO 12925-1 and ISO 6743-6 are standards published by the International Standards Organization. ISO 12925-1 was first established in 1996 to cover lubricants for enclosed gear systems most commonly used by the industry. It does not cover extreme ranges of application in terms of gear design, operating temperatures and load conditions. Unlike AGMA 9005, ISO 12925-1 only covers lubricants for enclosed gear systems, and not lubricants for automotive or open gears. The intent is for this specification to be read in conjunction with ISO 6743-6 which deals with the classification of gear lubricants. Essentially, ISO 6743-6 serves as the classification system and ISO 12925-1 defines what those classifications are in terms of testing. ISO 3448 is used as the viscosity classification system.

The latest revision of ISO 6743-6 defines nine categories of enclosed gear lubricants - CKB, CKC, CKD, CKE, CKSMP, CKTG, CKES, CKPG, CKPR – six more than AGMA 9005-F16. Five of those categories are very similar to AGMA 9005-F16 in terms of testing requirements – CKB, CKC, CKD, CKE, CKSMP. Four of those categories define low environmental impact oils which are not covered in AGMA 9005-F16 – CKTG, CKES, CKPH and CKPR. Additionally, CKSMP is the first self-certifying gear oil standard to include FZG micropitting evaluations as a requirement. It also includes bearing wear evaluations, making ISO 12925-1:2018 CKSMP the current benchmark for performance when it comes to self-certifying industry standards.

### **DIN 51517-Part I/II/III**

DIN 51517 is a three-part industry standard published by the German Institute for Standardization. Part I defines oils of type “C,” which contain rust and oxidation inhibitors. Part II defines oils of type “CL,” which contain enhanced rust and oxidation inhibitors and are used where type “C” oils no longer deliver satisfactory performance. Typically, neither “C” nor “CL” contain any antiwear or antiscuff additives. Part III defines oils of type “CLP,” which contain rust, oxidation, antiwear and antiscuff additives and are used where “CL” oils no longer deliver satisfactory performance. Most often industrial gear oils will be of type “CLP,” as defined by DIN 51517-3. The latest revision was published in 2018 and is very similar to both AGMA 9005-F16 AS and ISO 12925-1 CKD in terms of testing requirements.

### **AGMA 9005-F16**

The first standard by AGMA was published in 1946 as AGMA 250.1. It was intended to offer guidelines on the gear-lubrication best practices of the time. Since that first publication, AGMA has continued to revise their specification to include both enclosed and open gearing as well as offer the end user and equipment builder more definitive guidelines for selecting lubricants based on current theory and practice.

The most current standard, AGMA 9005-F16, was adopted in 2016 and covers the following types of gearing: spur, helical (including double helical and herringbone), worm, non-offset bevel, and face. The standard provides lubricant classifications, guidelines for minimum performance characteristics, and generalized application and servicing guidelines for both open and enclosed metallic gearing that has been designed and rated in accordance with applicable AGMA standards. It classified industrial gear oils for enclosed gearboxes into three categories: rust and oxidation inhibited (R&O), antiscuff (AS), and compounded (CP).

One significant change that has occurred throughout the years that directly impacts end users is the adoption and then abandonment of the AGMA viscosity classification system. Prior to 2002, AGMA had developed and utilized their own viscosity classification system that encompassed both viscosity and type of gear oil. After the publication of AGMA 9005-E02 in 2002, AGMA decided to utilize the ISO 3448 viscosity classification system instead of the original AGMA viscosity classification system. The chart below shows how the two compare and where LE industrial gear oils fall in both of those systems.



## AGMA Standard 9005-F16 Viscosity Ranges for Enclosed Gear Drives

Inhibited LE Gear Oil (RO)	Antiscuff LE Gear Oil (c) (AS)	Compounded LE Gear Oil (d) (CP)	Viscosity Range (a) <i>mm<sup>2</sup>/s (cSt) at 40°C</i>	Equivalent ISO grade (b) <i>AGMA 9005-E02 and newer</i>	Historical AGMA Classifications <i>Older than AGMA 9005-E02</i>
6401 / 6801 / 9032	—	—	3.72	—	0 / OS
6402 / 6802 / 9046	1601	—	4.4	—	1 / 1S
6403 / 6803 / 9068	1602	—	8.02	<11.0	2 / 2EP / 2S
6404 / 6804 / 9100	1603 / 9919	—	5.29	—	3 / 3EP / 3S
6405 / 6805 / 9150	1604 / 9923 (e)	—	10.15	<13.5	4 / 4EP / 4S
6406 / 6806 / 9220	1605 / 9822 / 9705	9705	6.46	—	5 / 5EP / 5 S
6407 / 6807 / 9320	1606 / 9832 / 9706	9706	13.13	<18.5	6 / 6EP / 6 S
9460	1607 / 9846 / 9707	460 / 9707	17.4	<24.0	7 / 7CP / 7EP / 7 S
—	1608 / 9868	680	23.74	<32.5	8 / 8CP / 8EP / 8 S
—	1609	—	33.33	<41.0	8A / 8ACP / 8AEP / 8AS
—	1610	—	48.49	—	9 / 9EP / 9S

**Note:** Viscosity ranges for AGMA lubricant numbers will be identical to those of ASTM 2422.

(a) “Viscosity System for Industrial Lubricants” ASTM 2422. Also, British Standard SS 4231.

(b) “Industrial Liquid Lubricants-ISO Viscosity Classification” International Standard, ISO 3448.

(c) Antiscuff lubricants should be used only when recommended by gear drive manufacturer.

(d) Oils marked “CP” are compounded with 3-10% fatty or synthetic fatty oils.

(e) 9923 has a kinematic viscosity at 40C around 190 cSt, thus does not fall in either ISO VG.

### LE Gear Oils for Industrial Applications

- **Multilec® Industrial Oil (6801-6807)** is a mineral-based, general purpose lubricant designed for a variety of industrial applications, including: hydraulic, compressor, gear, bearing and R&O.

- **Monolec® Syn Industrial Oil (9032, 9046, 9068, 9100, 9150, 9220, 9320, 9460)** is a full synthetic, general purpose lubricant designed for a variety of industrial applications, including hydraulic, compressor, gear, bearing and R&O.

- **Almasol® Pure Mineral Gear Lubricant (401)** is a mineral-based lubricant designed for transmission and gearboxes specifying “pure” or “straight” mineral oil gear lubricant (API GL-1).

- **Duolec® Industrial Gear Oil (1601-1610)** is a mineral-based, industrial gear oil designed for use in heavy-duty industrial gearbox applications requiring extreme pressure (EP) additives.

- **Duolec® Syn Gear Lubricant (9815, 9822, 9832, 9846)** is a full synthetic, industrial gear oil designed for use in heavy-duty industrial gearbox applications requiring EP additives, enhanced thermal stability and wider operating temperatures.

- **Duolec® PAG Gear Lubricant (9705-9707)** is a full synthetic, PAG-based industrial gear oil designed for use in heavy-duty

industrial gearbox applications requiring EP additives, enhanced thermal stability, improved cleanliness, and wider operating temperatures. In addition, it provides exceptional performance in gearboxes containing worm gears due to its high film thickness under high loads with lots of sliding.

- **Monolec® Gear Oil (703-704)** is a mineral-based, limited slip gear oil designed for use in light, medium, and heavy-duty applications requiring API GL-5, API MT-1, and SAE J2360 performance. It can also be used in industrial gearbox applications requiring higher levels of EP performance.

- **Monolec® Syn Gear Oil (9919, 9923)** is a 100 percent synthetic, limited slip gear oil designed for use in light, medium and heavy-duty applications requiring API GL-5 and API MT-1 performance. It can also be used in industrial gearbox applications requiring higher levels of EP performance.

- **Almasol® Worm Gear Lubricant (460, 680)** is a mineral-based, compounded gear oil designed for use in gearboxes requiring high tolerance to high loads with lots of sliding, especially gearboxes containing worm gears.