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SURFACE VEHICLE INFORMATION REPORT

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(R) AXLE AND MANUAL TRANSMISSION LUBRICANTS

Foreword—This Document has not changed other than to put it into the new SAE Technical Standards Board Format.

In 1943, the U.S. Army Ordnance Department (currently U.S. Army Belvoir Research, Development and Engineering Center) began qualifying gear lubricants against U.S. Army Specification 2–105. This specification has gone through several revisions and is now identified as MIL-L-2105D. The American Petroleum Institute recognizes gear lubricants meeting this latter specification as API Service GL-5 (API GL-5).

In 1977, the U.S. Army terminated direct sponsorship of the qualification process and contracted with SAE to: (a) perform the reviewing activity, and (b) make recommendations relative to the acceptance of candidate products under the military gear lubricant specification. In accordance with its contract with SAE, the U.S. Army retains sole responsibility for approving and qualifying products to its specification.

Following termination of the U.S. Army sponsorship, the SAE Board of Directors established a Lubricants Review Institute (LRI), which in turn has established an LRI Gear Lubricant Review Committee. This committee developed procedures for submitting candidate lubricants for review as well as procedures for reviewing such lubricants. The LRI activities are reviewed by SAE Legal Counsel to ensure compliance with applicable federal and state laws. The LRI Gear Lubricant Review Procedures can be obtained from SAE headquarters in Warrendale, PA.

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

2. References

2.1 Applicable Publications—The following publications form a part of the specification to the extent specified herein. Unless otherwise indicated the lastest revision of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J306—Axle and Manual Transmission Lubricant Viscosity Classification
LRI Gear Lubricant Review Procedures

1. Axle in this document is defined as a drive axle incorporating reduction gearing and/or differential gears.

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2.1.2 ASTM PUBLICATIONS—Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM D 130—Method for Detection of Copper Corrosion from Petroleum Products by the Copper Strip Tarnish Test
ASTM D 445—Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and the Calculation of Dynamic Viscosity)
ASTM D 471—Test Method for Rubber Property—Effect of Liquids
ASTM D 892—Test Method for Foaming Characteristics of Lubricating Oils
ASTM D 2983—Test Method for Oxidation Characteristics of Extreme Pressure Lubricating Oils
ASTM D 5182—Test Method for Evaluating the Scuffing (Scoring) Load Capacity of Oils
ASTM D 5579—Test Method for Evaluating the Thermal Stability of Manual Transmission Lubricants in a Cyclic Durability Test
ASTM D 5662—Test Method for Determining Automotive Gear Oil Compatibility with Typical Oil Seal Elastomers
ASTM D 5704—Test Method for Evaluation of the Thermal and Oxidative Stability of Lubricating Oils Used for Manual Transmissions and Final Drive Axles
ASTM STP 512—Laboratory Test Performance for Automotive Gear Lubricants Intended for API GL-5 Service (March, 1987)

2.1.3 API PUBLICATION—Available from American Petroleum Institute, 1220 L Street, Northwest, Washington, DC 20005.

API 1560 (July, 1995)—Lubricant Service Designation for Automotive Manual Transmissions and Axles

2.1.4 CRC PUBLICATIONS—Available from Coordinating Research Council Incorporated, 219 Perimeter Center Parkway, Suite 400, Atlanta, GA 30346-1301.

CRC L-12—Performance Test
CRC L-13—Performance Test
CRC L-19—Performance Test
CRC L-20—Performance Test
CRC L-21—Performance Test
CRC L-33—Performance Test
CRC L-37—Performance Test
CRC L-42—Performance Test
CRC L-60—Performance Test
Coordinating Research Council Manual 17

2.1.5 MILITARY PUBLICATION—Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-L-2105D

3. Performance Characteristics—In axles and manual 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. The following sections describe performance characteristics of axle and manual transmission lubricants which are important in field service. A lubricant is a blend of base stocks and additives optimized for a particular service. Additive packages are available to enhance base stock performance for each performance characteristic.

3.1 Load-Carrying Capacity—One of the most important performance characteristics is load-carrying capacity. The load on gear teeth is a function of the contact area of, and the force applied to the surfaces in contact. Contact area is controlled by gear design; applied force is determined by the power needed to drive the equipment. The load-carrying capacity of a gear lubricant is defined by the maximum load which can be sustained by the lubricant without failure of gear teeth surfaces. If the load-carrying capacity is exceeded, the lubricant fails to protect the gears and the gear teeth become damaged. The most common forms of damage are adhesive wear (scuffing) and scoring.

Load-carrying capacity is determined by a fluid's viscosity at the operating temperature, and by additives. Gear lubricants compounded to achieve increased load-carrying capacity may be referred to as "extreme pressure" (EP) lubricants. However, when this term is applied to a gear lubricant, it means only that the load-carrying capacity of the lubricant is greater than that of untreated oil,[2] with no distinction as to how much greater it may be. The American Petroleum Institute (API) has developed a classification system which addresses this concern (See section 5).

3.2 Viscosity—Viscosity specifications are generally determined by equipment manufacturers. Refer to SAE J306 for axle and manual transmission lubricant viscosity classification information.

3.2.1 VISCOSITY LOSS—MULTIGRADE LUBRICANTS—Viscosity and film thickness are critical in both axle and transmission applications. Some multigrade gear lubricants are formulated with viscosity modifiers. Caution should be exercised when multigrade gear lubricants are used, since these may experience significant viscosity loss due to shear in field service. The shear stresses and shear rates encountered in gear applications can be significantly greater than those in most other lubricant applications.

3.3 Thermal Stability and Oxidation Resistance—Factors affecting thermal stability (cleanliness) and oxidation (thickening) characteristics while the lubricant is in service include ambient temperature, duty cycle, length of service, and the effects of contamination. Poor lubricant performance can result in oil thickening and/or the formation of deposits on parts. Even when lubricants are stored (prior to use), care should be exercised to ensure that they are not exposed to extreme temperatures and are kept free of contaminants. These precautions are intended to ensure optimum lubricant life.

Modern vehicle designs have resulted in significantly higher operating temperatures in axles and transmissions. Oils which do not have a high degree of thermal stability and oxidation resistance can form significant carbon and varnish deposits, which can cause premature seal failure.

For automotive axles and transmissions in mild service, the temperature of the lubricant may not be sufficiently high to cause significant oxidation. For vehicles operating in moderate to severe conditions of service such as passenger cars pulling trailers, or for trucks or buses in service where higher temperatures occur, thermal stability and oxidation resistance are important factors. Accordingly, only oils with a high degree of thermal stability and oxidation resistance should be used in these applications. The vehicle operator should consult the manufacturer's service guide for drain and refill recommendations.

3.4 Foaming—Excessive foaming may interfere with proper lubrication of gear and bearing surfaces and, consequently, should be avoided. Further, foaming can cause leakage via normal venting passages, thereby reducing lubricant sump volume.

3.5 Corrosion—Corrosion is a chemical reaction of a metal surface with an oil contaminant or a by-product of used oil degradation which produces a surface film and/or soluble metal salts. Corrosion of ferrous or copper-containing metals can result in a build-up of iron and copper in the oil, leading to decreased oxidation resistance (see 3.3). As defined by the Coordinating Research Council, corrosion is "a general alteration of the finished surfaces accompanied by roughing **not** attributable to mechanical action."

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2. Untreated oil is defined as either refined petroluem or synthetic lubricant base oil containing no supplemental performance additives.

Excessive corrosion of heavy-duty components can lead to: (a) the reduction of designed contact areas, (b) an increase in insoluble debris, and (c) excessive movement ("play") of corroded components.

3.5.1 RUSTING—Rusting is a special case of corrosion of ferrous metals in the presence of water. Rust deteriorates or alters the original metal surface. It is evidenced by at least two of the following characteristics:

a. Color (usually red, yellow, brown, or black)
b. Depth (build-up or depression relative to adjacent areas)
c. Texture (such as etching or scale)

(See Coordinating Research Council Manual 17, Section 9—Miscellaneous)

3.6 Seal Compatibility—While the primary function of a gear lubricant is to protect gears and bearings, consideration must be given to the effect of a lubricant on seal elastomers used in the design of the component. Factors that can lead to early seal failure are loss of elongation or the ability to follow the shaft; change in hardness, which can lead to cracking; and volume change or swell, causing increased seal wear. Immersion testing, at conditions specific for axles and transmissions, may be used to establish the relative compatibility of the lubricant and the seal material.

4. Use and Handling of Gear Lubricants

4.1 Mixing Gear Lubricants—As a general practice, the mixing of lubricant types should be avoided. Specifically, mixing gear lubricants with engine oils can result in incompatibility due to reactions between the additive chemicals. Such reactions may result in a significant loss of performance or gear protection.

The mixing of MIL-L-2105 approved lubricants as in a top-up situation should not impair lubricant performance. MIL-L-2105 lubricants are required to demonstrate satisfactory storage stability when mixed with previously qualified gear lubricants.

5. API Gear Lubricant Classification—The following designations have been amended with the objective of improving user understanding of intended lubricant application. Refer to API Publication 1560, July 1995, for further information.

5.1 Inactive Categories—The following categories were declared inactive by SAE Technical Committee 3 on March 1, 1995. Oils may be marketed with these designations. However, ASTM does not plan to maintain the performance tests associated with these categories. In some cases these tests can no longer be run because parts or test installations are not available.

5.1.1 API GL-1 designates the type of service characteristic of manual transmissions operating under such mild conditions of low unit pressures and minimum sliding velocities, that untreated oil may be used satisfactorily. Oxidation and rust inhibitors, defoamers, and pour depressants may be used to improve the characteristics of lubricants intended for this service. Friction modifiers and extreme pressure additives shall not be used.

Due to the speeds and loads involved, untreated oil is generally not a satisfactory lubricant for many passenger car manual transmissions.[3] For some truck and tractor manual transmissions, untreated oils may be used successfully. In all cases, the transmission manufacturers' specific lubricant recommendations should be followed.

3. Automatic or semiautomatic transmissions, fluid couplings, torque converters, and tractor hydraulic systems usually require special lubricants. For the proper lubricant to be used, consult the equipment manufacturer or lubricant supplier.

5.1.2 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.

5.1.3 API GL-3 designates the type of service characteristic of manual transmissions and spiral-bevel axles operating under mild to moderate to severe conditions of speed and load. These service conditions require a lubricant having load-carrying capacities greater than those that will satisfy API GL-1 service, but below the requirements of lubricants satisfying the API GL-4 service.

Gear lubricants designated for API GL-3 service are not intended for hypoid gear applications.

5.1.4 API GL-6 designates the type of service characteristic of gears designed with a very high pinion offset. Such designs typically require (gear) score protection in excess of that provided by API GL-5 gear oils. The original API GL-6 test equipment is obsolete.

5.2 Active Categories

5.2.1 API GL-4 designates the type of service characteristic of spiral-bevel and hypoid[4] gears in automotive axles operated under moderate-speeds and loads. These oils may be used in selected manual transmission and transaxle applications. (Users should consult axle/transmission manufacturers' specific lubricant recommendations.)

While this service designation is still used commercially to describe lubricants, some test equipment used for performance verification is no longer available. SAE is reviewing the performance requirements of this category.

5.2.2 API GL-5 designates the type of service characteristic of gears, particularly hypoids in automotive axles operated under high-speed and/or low-speed, high-torque conditions. Lubricants qualified under U.S. Military specification MIL-L-2105D (formerly MIL-L-2105C) satisfy the requirements of the API GL-5 service designation. Details of the API GL-5 performance tests are contained in ASTM Publication STP-512A.

5.2.3 API MT-1 designates lubricants intended for non-synchronized manual transmissions used in buses and heavy-duty trucks. Lubricants meeting API MT-1 provide protection against the combination of thermal degradation, component wear, and oil seal deterioration which is not provided by lubricants meeting only the requirements of API GL-4 and GL-5.

API MT-1 does not address the performance requirements of synchronized transmissions and transaxles in passenger cars and heavy-duty applications.

API MT-1 lubricants should not be mixed with engine oils in the same transmission unit.

Transmission manufacturers' specific lubricant quality recommendations should be followed.

5.3 Performance Tests—Table 1 lists lubricant tests which are used to evaluate the performance characteristics discussed in Section 3. Tests which are used to define the performance levels of active API Categories are noted.

Successful performance on such tests does not automatically ensure satisfactory performance under field service conditions.

4. Friction requirements for axles equipped with limited slip differentials are normally defined by the axle manufacturer.

TABLE 1—LUBRICANT TESTS FOR EVALUATING PERFORMANCE CHARACTERISTICS

Performance Characteristic	Test Method	Method Reference	Required for API Category	Note
Load Carrying Capacity	• Gear Distress - Low Speed, High Load	L-37	GL-5	4
		CRC L-20	GL-4	
	• Gear Scoring - High-Speed Shock Load	L-42	GL-5	4
		CRC L-19	GL-4	1
	• Spur Gear Scuffing Load	ASTM D 5182	MT-1	
Viscosity	• Kinematic Viscosity	ASTM D 445		2
	• Low Temperature (Brookfield) Viscosity	ASTM D 2983		2
Thermal Stability and Oxidation Resistance	• Thermal and Oxidative Stability Test	L-60	GL-5	4
	• Thermal and Oxidative Stability/Component Cleanliness	ASTM D 5704	MT-1	
	• High-Temperature Cyclic Durability	ASTM D 5579	MT-1	
Foaming	• Foaming Characteristics	CRC L-12	GL-4	1
		ASTM D 892	GL-5, MT-1	
Corrosion Resistance	• Copper Strip Tarnish Test	ASTM D 130	GL-4, GL-5, MT-1	
	• Corrosion Resistance in the Presence of Water	CRC L-13	GL-4	1
		CRC L-21	GL-4	1
		L-33	GL-5	4
Seal Compatibility	• Compatibility with Automotive Seal Materials	ASTM D 5662	MT-1	3
Lubricant Stability and Compatibility	• Storage Solubility Characteristics	FTM 3440.1	MT-1	
	• Compatibility Characteristics	FTM 3430.2	MT-1	

NOTE 1—Equipment no longer available. Impossible to conduct original test procedure. ASTM is considering replacement tests.
NOTE 2—Viscosity requirement varies by equipment manufacturer.
NOTE 3—ASTM D 5662 is a specific application of ASTM D 471.
NOTE 4—Test Method described in ASTM STP-512.

5.3.1 REFERENCE OILS—Most tests used to define performance for the API gear oil categories are calibrated using selected reference oils. These oils are maintained by the ASTM Surveillance Panels which are responsible for the tests. The testing and inventory of these oils is carried out by the ASTM Test Monitoring Center. The oils are normally available only to laboratories which maintain or are qualifying test stands which are certified for LRI approval testing of oils. Information about reference oils can be obtained by contacting the Test Monitoring Center, 4400 Fifth Avenue, Pittsburgh, PA 15213 (Phone: 412-268-3315).

6. Notes

6.1 Marginal Indicia—The change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. An (R) symbol to the left of the document title indicates a complete revision of the report.

PREPARED BY THE SAE FUELS AND LUBRICANTS
TECHNICAL COMMITTEE 3—GEAR LUBRICANTS