INTRODUCTION

STP 512A replaces STP 512 (published in 1972). STP 512 was a compilation of the automotive gear lubricant tests used to define API services GL-4, GL-5, and GL-6. The GL-4 and GL-6 services are presently considered obsolete by API because: the test equipment originally used to define these services is no longer available; and alternate equipment/procedures have not been developed. At present, only the Gear Lubricant Service Designation API GL-5 can be completely defined. STP 512A contains 1987 versions of the original GL-5 performance tests updated under the guidance of ASTM.

Gear lubricants have changed significantly over the past four decades in response to performance demands imposed by changes in operating conditions, design and metallurgy of automotive axles and transmissions. The API Lubricant Service Designations for Automotive Manual Transmissions and Axles[1] allows matching performance requirements and lubricant quality. Each of these six Lubricant Service Designations, (API GL-1 through GL-6) states in qualitative terms the kind of service in which a gear lubricant is expected to perform satisfactorily. Both the type of gears and the operating conditions for the lubricant are included in each Service Designation.

Supplementing of the qualitative API Designations with performance definitions is needed particularly for Designations GL-4, GL-5, and GL-6 (Appendix 1). These definitions include a series of tests and associated minimum performance requirements.

Under the API, ASTM, SAE Tripartite System, a Lubricant Performance and Service Classification Maintenance Procedure - SAE J1146 November 1980 (1986 SAE Handbook 3:23.47) - is designed to keep abreast of changing requirements by redefining existing categories, adding new or declaring as obsolete lubricant categories for automotive applications. Under this system, ASTM is responsible for defining the technical language (test techniques and performance criteria), while API defines the user language and assigns the category designation. The API designations as well as other items of information are published in the SAE Handbook under "Axle and Manual Transmission Lubricants" - SAE J308 Nov. 82 (1986 SAE Handbook 3:23.20).

SCOPE

The purpose of this publication is to provide detailed procedures for the API GL-5 gear tests. A total of six independent test procedures are required to define API GL-5 Service (Table 1).

The API GL-5 Service Designation is important because it

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[1] *API Publication No. 1560 available from the American Petroleum Institute, 2101 L Street, Northwest, Washington, DC 20037.*

represents the most commonly specified and commercially available type of automotive gear lubricant. It is estimated that 80 percent of gear lubricants produced are formulated to satisfy the API GL-5 Service Designation.

API GL-5 performance tests originated with the U.S. Army Gear Lubricant Specification MIL-L-2105B. The latter was updated to encompass multigrade oils, SAE 80W-90 and 85W-140 in 1976 (MIL-L-2105C), but performance requirements were unchanged.

TABLE 1
API GL-5
Required Laboratory Tests

Test Designation	Type	Characteristics Measured
L-33	Gear test using axle components	Resistance to corrosion in the presence of moisture
L-37	Gear test using complete axle assembly	Resistance to gear distress under the conditions of low speed high torque
L-42	Gear test using complete axle assembly	Resistance to gear distress (scoring) under conditions of high speed and shock loads
L-60	Bench test using spur gears	Thermal oxidation stability
ASTM D 892*	Bench test	Foaming tendencies
ASTM D 130*	Bench test	Stability in the presence of copper and copper alloys

**These test methods are available in ASTM's Annual Book of Standards, Vol. 05.01.*

In 1987 MIL-L-2105C was replaced by MIL-L-2105D (allowing the use of re-refined base oils) without a change in performance tests. These remain as summarized in Table 1.

It should be noted that several differences exist between API GL-5 and the Military Specification MIL-L-2105D. In addition to the six API GL-5 performance tests, MIL-L-2105D also requires:

(1) Evidence of compatibility with previously approved oils (FTM 3455.1).

(2) Field testing of new additive systems and/or unique base stocks, e.g., synthetic components.

(3) Third party performance review system (SAE Lubricants Review Institute).

(4) Approval by the U.S. Army Belvoir Research, Development and Engineering Center.

API GL-4 and GL-6 Service Designations are considered to be obsolete since the equipment used in performing one or more of the required tests is no longer available. While the original type of testing cannot be performed on new oils, lubricants of these types (API GL-4 and GL-6) may be available via previously approved lubricant formulations. ASTM is currently considering new tests to describe lubricant applications requiring other than API GL-5 service oils.

MILITARY APPROVAL

Gear lubricants purchased by the U.S. Military, NATO affiliates and some federal, state and local government agencies must be approved under MIL-L-2105C. The mechanism by which lubricants are reviewed is outlined in the LRI Gear Lubricant Review Committee procedures available from SAE at the address below:

Society of Automotive Engineers
400 Commonwealth Drive
Warrendale, PA 15096
Attention: Mr. G. Pollak

API GL-5 GEAR TESTS

The following sections detail the four test procedures for API GL-5 gear tests: Section 1 (L-33 Test Method); Section 2 (L-37 Test Method); Section 3 (L-42 Test Method); and Section 4 (L-60 Test Method).

API GL-5 BENCH TESTS

Copper Corrosion (ASTM D 130)

Copper containing mechanical components such as thrustwashers and synchronizer elements, may be found in axles and transmissions where gear lubricant use is specified. Consequently, it is important that these lubricants are equally compatible with both copper alloys and ferrous metals. ASTM D 130 - Method for Detection of Copper Corrosion from Petroleum Products by the Copper Strip Tarnish Test (Vol. 05.01) - is used in combination with appropriate limits to define the degree of copper corrosion protection provided by gear lubricants.

Foaming Tendency (ASTM D 892)

Churning and agitation of the lubricant in the axle can result in air entrainment and foaming. The consequence of excessive foaming may be leakage and depletion of lubricant supply. ASTM D 892 - Test Method for Foaming Characteristics of Lubricating Oils (Vol. 05.01) - is the procedure used to determine the lubricants ability to resist foaming in service.

REFERENCE OILS

Reference oils for each of the API GL-5 gear tests are available from the ASTM Test Monitoring Center, 4400 Fifth Avenue, Pittsburgh, PA 15213, Attn: Mr. Paul Eisaman.

The correct reference oils required for each of the API GL-5 tests are listed in Table 2.

TABLE 2-- Reference Oils and Tests

Performance Test	Reference Oil*	
	High Level	Low Level
L-33	RGO 124	RGL 122
L-37	RGO 105	RGO 103
L-42	RGO 110	RGO 108
L-60	RGO 4668	RGO 4669

**Alternate reference oils are under consideration by ASTM. For current information on API GL-5 reference oils contact ASTM Test Monitoring Center.*

PRECISION

The precision of the API GL-5 gear tests has not been established with the exception of ASTM D 892 and ASTM D 130. As additional data is generated, it is anticipated that a statistical evaluation can be determined.

PROCEDURES

MIL-L-2105C Chemical and Physical Requirements

TABLE 3 - CHEMICAL AND PHYSICAL PROPERTIES REQUIREMENTS OF MIL-L-2105C

	Values		
	Grade 75W	Grade 80W-90	Grade 85W-140
Viscosity at 100°C (212°F)			
Kinematic, cSt, min	4.1	13.5	24.0
max	-	24.0	41.0
Temperature for apparent viscosity of 150,000 cP, °C, max	-40	-26	-12
Channel point °C, max	-45	-35	-20
Flash point °C, min	150	165	180
Gravity, °API	x	x	x
Viscosity index	x	x	x
Pour point	x	x	x
Pentane insolubles	x	x	x
Sulfated ash	x	x	x
Sulfur (total)	x	x	x
Sulfur contributed by additive	x	x	x
Phosphorus	x	x	x
Nitrogen	x	x	x
Boron	x	x	x
Zinc	x	x	x
Potassium	x	x	x
Chlorine	x	x	x
Organo-metallic components	x	x	x

X=Report (determination or measurement required)

MIL-L-2105D Storage Stability and Compatibility

Lubricants must not exhibit any separation upon storage or when mixed with other lubricants, particularly those of the same performance categories. If separation occurs, the result is additive depletion with accompanying loss of performance. A modified CRC L-22 (Federal Test Method 3440) is used for evaluation of solubility.

To assess a lubricant's compatibility characteristics, the candidate oil is mixed with six reference oils representing previously approved gear lubricants. Evaluation is by a modified FTM 791b method 3430. The reference oils are supplied under code by:

Society of Automotive Engineers
400 Commonwealth Drive
Warrendale, PA 15096
Attention: Mr. G. Pollak

MIL-L-2105D Field Test Requirements

The following are excerpts from the LRI "Procedures of the Gear Lubricants Review Committee for Review at Gear Lubricants Under Military Specification MIL-L-2105C" (October 1985).

Field test information (to demonstrate satisfactory field service performance) is required when the following are used:

(1) Unknown or new additive packages including viscosity index improvers and combinations thereof.

(2) New processes for recovery, reconstitution and/or treatment of base stocks, or new types of base stocks or combinations thereof.

(3) More than a combined total of 2 mass % of low temperature flow improvers ("pour point depressants").

No changes in field test requirements are anticipated to accompany MIL-L-2105C to MIL-L-2105D change.

Additional information may be obtained by contacting the Gear Lubricant Review Committee Secretary at SAE World Headquarters (address below).

Related Documents

Document	Source
MIL-L-2105C or MIL-L-2105D	Department of the Army U.S. Army Belvoir R. & D. Center Attention: STRBE-VF Ft. Belvoir, VA 22060-5606
API 1560	American Petroleum Institute 2101 L Street, Northwest Washington, DC 20037
SAE J308 and LRI Procedures	Society of Automotive Engineers 400 Commonwealth Drive Warrendale, PA 15096

APPENDIX 1

API GL-4, GL-5, GL-6 Performance Criteria

GEAR PERFORMANCE	GL-4 MIL-L-2105	GL-5 MIL-L-2105C	GL-6
1. Gear Scoring Resistance Under Conditions of High Speed Shock Load	A) CRC L-19* or FTM 6504T B) Equal or Better than RGO-105	L-42 Gear/Pinion Coastside Scoring Equal or Better than RGO-110	Vehicle Rear Axle Score Test (Ford Drag Start Procedure 001) No Scoring After 500 Drag Starts
2. Resistance to Gear Distress Under Conditions of High Torque, Low Speed	CRC L-20 No tooth disturbance such as rippling, ridging, pitting or severe wear.	L-37 No tooth disturbance such as rippling, ridging, pitting or severe wear.	No Requirement
3. Corrosion Resistance in the Presence of Water	A) CRC L-13 or FTM 5313.1 B) CRC L-21 No evidence of rusting	L-33 No evidence of rusting after 7 days exposure on any working surface. Maximum of 0.5 $in.^2$ (3.2 cm^2) rust on cover plate (1% of surface area)	Ford BJ 10-3 Water Tolerance Merit rating of 8 or greater 0 (poor) 10 (clean)
4. Thermal and Oxidation Stability	No Requirement	L-60 Vis Increase 100% max Pentane Insol. 3% max Toluene Insol. 2% max	L-60 Vis Increase 100% max Pentane Insol. 3% max Toluene Insol. 2% max
5. Lubricant Stability in Motored Axle Test	No Requirement	No Requirement	Ford BJ 15-1 Stability - No Abrasive deposits Seal Life - No Cracking or leakage Viscosity Change - ±5% max

* Equipment no longer available. Impossible to conduct test per original procedure.

APPENDIX 1 (continued)

API GL-4, GL-5, GL-6 Performance Criteria

	GEAR PERFORMANMCE	GL-4	GL-5	GL-6
6.	Antifoaming Characteristics	CRC L-12 Readings taken immediately after 5 min aeration Sequence 1, 75°F (23.9°C)-21.97 fl oz (650 ml) Sequence 2, 200°F (93.3°C) 21.97 fl oz (650 ml)	ASTM D 892 Reading taken immediately after 5 min aeration Sequence 1 - 0.67 fl oz (20 ml) max Sequence 2 - 1.7 fl oz (50 ml) max Sequence 3 - 0.67 fl oz (20 ml) max	ASTM D 892 0.8 fl oz (25 ml) max immediately after aeration and 0 ml after standing in Sequence 1, 2 and 3
7.	Copper Corrosion	ASTM D-130 3b max after 1 h @ 250°F (121.1°C)	ASTM D 130 3 max after 3 h @ 250°F (121.1°C)	ASTM D 130 3a max after 3 h @ 250°F (121.1°C)
8.	Channeling Characteristics	No Requirement	FTM 3456.1 Modified SAE 75 - -49°F (-45°C) max SAE 80W90 95°F -31°F (-35°C) max SAE 85W140 68°F -40°F (-20°C) max	-25°F (-31.7°C)
9.	Separation Characteristics	FTM 3440, modified		
	Solubility measure separated material after centrifuging of oil stored for 30 days at room temperature - 84.9°F ± 49°F (29.4°C ± 9.5°C)	0.25% wt max of original non-petroleum material in sample	0.25 wt max of original non-petroleum material in sample	No Requirement
	Compatibility Same as solubility except mixed 50/50 with each of six ref. oils (available from SAE)	0.50% wt max of original non-petroleum material in sample	0.50% wt max of original non-petroleum material in sample	No Requirement