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Automotive Lubricating Greases

SAE Recommended Practice
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Submitted for Recognition as
an American National Standard

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FUELS AND LUBRICANTS PRACTICE

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AUTOMOTIVE LUBRICATING GREASES

This SAE Recommended Practice was prepared by Technical Committee 4, Lubricating Greases, of the SAE Fuels and Lubricants Division to assist those concerned with the design of automotive components, and with the selection and marketing of greases for the lubrication of certain of those components on passenger cars, trucks, and buses. It is expected that the information contained will be helpful in the standardization of terms related to the types of greases and the means of designation.

1. DEFINITIONS OF LUBRICATING GREASE: A lubricating grease is a solid to semifluid mixture of a fluid lubricant and a thickening agent. Additives to impart special properties or performance characteristics may be incorporated. The fluid component may be a mineral (petroleum) oil or a synthetic fluid; the thickener may be a metallic soap or soaps or a nonsoap substance such as an organophilic modified clay, a urea compound, carbon black, or other material. The soaps commonly used are lithium, calcium (lime), sodium, aluminum, and barium, or certain combinations of these with other materials, such as calcium-lead. The viscosity of the fluid, the ratio of fluid to thickener, and the chemical nature of the thickener may vary widely. The properties of the finished grease are influenced by the processes of its manufacture as well as by the materials used.

2. BASIC PERFORMANCE REQUIREMENTS: Greases are most often used instead of fluids where a lubricant is required to maintain its original position in a mechanism, especially where opportunities for frequent relubrication may be limited or economically unjustifiable. This requirement may be due to the physical configuration of the mechanism, the type of motion, the type of sealing, or to the need for the lubricant to perform all or part of any sealing function in the prevention of lubricant loss or the entrance of contaminants. Because of their essentially solid nature, greases do not perform the cooling and cleaning functions associated with the use of a fluid lubricant. With these exceptions, greases are expected to accomplish all other functions of fluid lubricants.

2. (Continued):

A satisfactory grease for a given application is expected to:

1. Provide adequate lubrication to reduce friction and to prevent harmful wear of bearing components.

2. Protect against corrosion.

3. Act as a seal to prevent entry of dirt and water.

4. Resist leakage, dripping, or undesirable throw-off from the lubricated surfaces.

5. Resist objectionable change in structure or consistency with mechanical working (in the bearing) during prolonged service.

6. Not stiffen excessively to cause undue resistance to motion in cold weather.

7. Have suitable physical characteristics for the method of application.

8. Be compatible with elastomer seals and other materials of construction in the lubricated portion of the mechanism.

9. Tolerate some degree of contamination, such as moisture, without loss of significant characteristics.

10. Have suitable oxidation and thermal stability for the intended application.

3. PROPERTIES OF GREASES:

3.1 Consistency: A measure of relative hardness. This property is commonly expressed in terms of the ASTM penetration or NLGI consistency number. The ASTM penetration is a numerical statement of the actual penetration of the grease sample, in tenths of a millimeter, by a standard test cone under stated conditions. The higher the penetration value, the softer the grease. The National Lubricating Grease Institute classifies greases according to their ASTM penetration as shown in Table 1.

The consistency of a grease is an important factor in its ability to lubricate, seal, and remain in place, and to the methods and ease by which it can be dispensed and applied. Most automotive greases are in the NLGI No. 1, 2, or 3 range, that is, ranging from soft to medium consistency.

3.2 Texture and Structure: The appearance and feel of greases. A grease may be described as smooth, buttery, fibrous, long- or short-fibered, stringy, tacky, etc. These characteristics are influenced by the viscosity of the fluid, type of thickener, proportion of each of these components, presence of certain additives, and process of manufacture. There are no standard test methods for quantitative definitions of these properties. Texture and structure are factors in the adhesiveness and ease of handling of a grease.

3.3 Structural Stability: The ability of a grease to retain its as-manufactured consistency and texture despite age, temperature, mechanical working, and other influences, or its ability to return to its original state when a transient influence is removed.

3.4 Mechanical Stability: The resistance of a grease to permanent changes in consistency due to the continuous application of shearing forces.

The stability of a grease is important to its ability to provide adequate lubrication and sealing and to remain properly in place during use.

3.5 Apparent Viscosity: The ratio of shear stress to rate of shear at a stated temperature and shear rate. Grease is by nature a plastic material. Therefore, the usual concept of viscosity valid for simple fluids (that is, internal resistance to flow) is not entirely applicable. The ratio of shear stress to shear rate varies as the shear rate changes. The apparent viscosity of most greases decreases with increase of either temperature or shear rate. Apparent viscosity greatly influences the ease of handling and dispensing a grease.

3.6 Dropping Point: The temperature at which the grease generally passes from a plastic solid to a liquid state, and flows throught an orifice under standard test conditions. The dropping point is incorrectly regarded by some as establishing the maximum temperature for acceptable use. Performance at high temperature also depends on other factors such as duration of exposure, evaporation resistance, and design of the lubricated mechanism.

TABLE 1--NLGI[a] CONSISTENCY NUMBERS

NLGI Consistency No.	ASTM Worked (60 Strokes) Penetration at 25°C (77°F) tenths of a millimeter	NLGI Consistency No.	ASTM Worked (60 Strokes) Penetration at 25°C (77°F) tenths of a millimeter
000	445 to 475	3	220 to 250
00	400 to 430	4	175 to 205
0	355 to 385	5	130 to 160
1	310 to 340	6	85 to 115
2	265 to 295		

[a]National Lubricating Grease Institute, 4635 Wyandotte St., Kansas City, Missouri 64112.

3.7 Oxidation Resistance: The resistance to chemical deterioration in storage and in service caused by exposure to air. It depends basically on the stability of the individual grease components, and can be improved by use of antioxidants. High oxidation resistance is important wherever long storage or service life is required or where high temperatures prevail even for short periods.

3.8 Protection Against Friction and Wear: A protection greatly influenced by the viscosity and type of the fluid component and by grease structural and consistency characteristics. This performance characteristic can be altered by the use of additives.

3.9 Protection Against Corrosion: A protection depending on grease composition, the ability to form and maintain a seal against the entrance of corrosive (and other undesirable) materials, and the reaction to water. Some greases are water resistant or waterproof, meaning that they resist the washing effect of water and do not absorb it to any extent. Others can absorb varying amounts of water without appreciable damage to their structure or consistency, and may in service provide better protection against corrosion than waterproof greases, since the latter may permit the accumulation of free water in bearings. Rust protection may be improved by the use of suitable additives.

3.10 Bleeding or Oil Separation: The separation of liquid lubricant from a grease. Slight bleeding is regarded as desirable by some as indicative of good lubricating ability in rolling element bearings.

3.11 Color: A superficial grease property without performance significance.

Of the above properties, oxidation resistance, protection against friction and wear, protection against corrosion, and structural stability are probably of most importance in automotive service as far as actual performance in bearings is concerned.

There is, of course, the problem of getting grease to the bearings to be lubricated. Certain terms, by no means of strict, rigid interpretation, are used to describe the factors involved: feedability, pumpability, and dispensability.

3.12 Feedability, or Slumpability: The ability to flow to the suction of the grease-dispensing equipment or mechanism to be lubricated.

3.13 Pumpability: The ability to flow through the grease-dispensing lines at a satisfactory rate, without the necessity of using excessively high pressures.

3.14 Dispensability: The ease with which a grease may be transferred from its container to the point of application. For practical purposes, it is a combination of feedability and pumpability.

4. GREASE TESTING: Many of the above grease properties are determined by tests which have been standardized or otherwise accorded industry recognition. These, in conjunction with simulated performance tests, permit some approximate judgment for the proper selection of greases for a given application. They are, however, not considered to be replacements for, or equivalent to, long-time service tests.

Table 2 shows some of the more important tests, both standard and otherwise, identified as to sponsor, title, and purpose.

5. DESIGNATION OF GREASES BY FIELDS OF USE: Greases are commonly classified and designated according to chemical composition, such as calcium-soap grease; by broad type of usage, such as antifriction bearing grease or multipurpose grease; by specific properties, such as high temperature grease; by special additives, such as extreme-pressure grease or graphite grease; and by specific applications, such as automotive-wheel-bearing grease. SAE recognizes the following designations for greases used in servicing passenger cars, trucks, and buses according to their specific applications.

5.1 Wheel-Bearing Grease: This term designates lubricating greases of such composition, structure, and consistency as to be suitable for longtime use in antifriction wheel bearings.

NOTE: Generally, these greases have high resistance to the deteriorating effects of temperature and the separating effects of centrifugal action. They should have good antirust properties. They should not exhibit oil-soap separation or excessive softening which could result in leakage that could lead to braking failure.

5.2 Universal Joint Grease: This term designates lubricating greases of such composition, structure, and consistency as to be suitable for the lubrication of those types of automotive universal joints requiring grease lubrication.

NOTE: Some designs of universal joints require lubricants other than the usual universal joint type. Manufacturers' recommendations or lubrication charts should be consulted.

Ø TABLE 2--GREASE TESTS

Test Designation	Test Purpose
ASTM D 128, Analysis of Lubricating Grease	Determination of nominal chemical composition, such as soap, unsaponifiable matter (mineral oil), water, free alkalinity, free fatty acid, glycerine, and insolubles. NOTE: This procedure has a supplementary method useful for greases containing nonsoap thickeners or synthetic fluids.
ASTM D 217, Cone Penetration of Lubricating Grease	Measurement of relative hardness by unworked and worked penetration; test satisfactory up to penetrations of 400 (tenths of millimeter) at 25°C (77°F), or to 475 with alternate cone.

Test Designation	Test Purpose
ASTM D 566, Dropping Point of Lubricating Grease	Establishment of temperature at which grease generally passes from plastic to liquid state; not regarded as indicative of service suitability; limited to dropping points up to 260°C (500°F). (In this test, some nonsoap-thickened greases may release oil before the grease flows which is defined as their dropping point.)
ASTM D 942, Oxidation Stability of Lubricating Greases by the Oxygen Bomb Method	Determination of resistance to oxidation under static conditions in a sealed system at elevated temperatures; not indicative of the stability of greases under dynamic service conditions, nor the stability of greases stored in containers for long periods, nor the stability of films of grease on machine parts.
ASTM D 972, Evaporation Loss of Lubricating Oils and Greases	Evaluation of weight loss by evaporation at temperatures up to 149°C (300°F).
ASTM D 1092, Apparent Viscosity of Lubricating Greases	Determination of apparent viscosity in temperature range of -54 to 38°C (-65 to 100°F); results relatable to ease of handling and dispensing.
ASTM D 1263, Leakage Tendencies of Automotive Wheel-Bearing Greases	Evaluation of leakage tendencies from an unsealed wheel bearing assembly, run for 6 h at 104°C (220°F); permits screening candidate greases; not a replacement for long-time service tests.
ASTM D 1264, Water Washout Characteristics of Lubricating Greases	Evaluation of resistance to water washout from rotating bearings at 38°C (100°F) and at 80°C (175°F) under prescribed conditions; not a replacement for actual service tests; not suitable for fibrous greases.
ASTM D 1403, Cone Penetration of Lubricating Grease Using One-Quarter and One-Half Scale Cone Equipment	Essentially same as ASTM D 217, using small grease samples, but reserved to greases of NLGI Nos. 0 to 4 consistency.

Test Designation	Test Purpose
ASTM D 1478, Low Temperature Torque of Ball Bearing Greases	Determination of the extent to which a grease retards the rotation of a slow-speed ball bearing when subjected to temperatures below 0°F (-18°C). This method was developed using a test temperature of -65°F and greases with extremely-low torque characteristics. Although higher test temperatures are commonly used, the precision statements may not apply to temperatures other than -65°F or to greases with torque characteristics different from those used to establish precision.
ASTM D 1741, Functional Life of Ball-Bearing Greases	Endurance life of grease lubricated 306 ball bearings at 3600 rpm; evaluation valid up to 125°C (257°F) operating temperature; is primarily a screening test and does not replace long-time service tests.
ASTM D 1742, Oil Separation from Lubricating Grease During Storage	Determination of tendency of oil constituent to separate from parent grease while in containers; suitable for NLGI No. 1 or harder greases; results are indicative of oil separation in containers, but not of oil separation under dynamic service conditions.
ASTM D 1743, Corrosion Preventive Properties of Lubricating Greases	Determination of surface damage due to corrosion, such as pitting, etching, rusting, or black stains on raceways and rollers of tapered roller bearings which have been run-in and stored for a prescribed period at a definite temperature and 100% relative humidity.
ASTM D 1831, Roll Stability of Lubricating Grease	Determination of changes in consistency after working in tester for 2 h at room temperature. Although test significance has not been determined, changes in worked penetration of a grease after rolling are believed to be an indication of its shear stability under conditions of this low shear test.
ASTM D 2265, Dropping Point of Lubricating Grease of Wide-Temperature Range	See remarks under ASTM D 566; test is also valid for high temperature greases (up to 330°C (635°F)).

Test Designation	Test Purpose
ASTM D 2266, Wear Preventive Characteristics of Lubricating Grease (Four-Ball Method)	Determination of wear preventive characteristics of grease when a rotating loaded steel ball slides against three similar stationary steel balls, measured by wear-scar diameters on stationary balls after completion of test; not indicative of results in actual service, and cannot distinguish between extreme-pressure (EP) and nonextreme-pressure (non-EP) greases.
ASTM D 2509, Measurement of Extreme-Pressure Properties of Lubricating Grease (Timken® Lubricant and Wear Tester)	Determination of load carrying ability of lubricating greases by Timken® Lubricant and Wear Tester. In this device, a rectangular steel test block is forced against a rotating steel ring. Scar width and surface conditions are noted. Method differentiates between lubricants of various extreme-pressure levels; not a replacement for actual service tests.
ASTM D 2595, Evaporation Loss of Lubricating Grease Over Wide-Temperature Range	Evaluation of weight loss by evaporation at temperatures between 93 and 316°C (200 and 600°F).
ASTM D 2596, Measurement of Extreme-Pressure Properties of Lubricating Grease (Four-Ball Method)	Load-carrying properties up to extremely high pressures: (a) loadwear index (formerly mean-Hertz load) and (b) weld point by Four-Ball EP Tester.
ASTM D 3232, Measurement of Flow Properties of Lubricating Greases at High Temperatures	Measurement of the flow properties of lubricating greases under high-temperature low-shear conditions.
ASTM D 3428, Torque Stability Wear and Brine Sensitivity Evaluation of Ball Joint Greases	Evaluation of grease performance by two procedures in tension-type automotive ball joints as determined by noise level, wear and torque stability; used as a screening test to aid in selection of greases for the lubrication of automotive chassis ball joints.
ASTM D 3527, Life Performance of Automotive Wheel Bearing Grease	Evaluation of the high-temperature life performance of wheel bearing grease.

Test Designation	Test Purpose
ASTM D 4170, Fretting Wear Protection by Lubricating Grease[a]	Evaluation of fretting wear protection characteristic by measuring mass loss of ball thrust bearings oscillated under load; correlates with fretting protection performance of greases in wheel bearings of passenger cars being shipped long distances.
ASTM D 4289, Compatibility of Lubricating Grease with Elastomers	Determination of hardness and volume changes in elastomers caused by contact with lubricating grease.
ASTM D 4290, Determining the Leakage Tendencies of Automotive Wheel Bearing Grease Under Accelerated Conditions	Evaluation of leakage tendency of a grease from unsealed wheel bearings run 20h at 1000 rpm and thrust loaded to 111 N (25 lb force). Unlike D 1263, this method which is conducted at a higher temperature, 160°C (320°F), differentiates among wheel bearing greases having distinctly different high temperature leakage characteristics.
ø ASTM D 4693, Low Temperature Torque of Grease-Lubricated Wheel Bearings	Determination of the viscous resistance of a grease in a wheel bearing assembly rotated at low speed in a low-temperature environment; used to evaluate both wheel bearing and chassis greases for performance in low-temperature service.
Ford Ball-Joint Grease Test	Evaluation of grease performance in tension and compression type automotive ball joints as determined by general surface condition, rust, joint and seal wear, and noise level under simulated service conditions.
NLGI Method, Matching Lubricating Grease Flow Properties with Lubricating Grease Dispensing Pump Delivery Behavior at Low Temperature[b]	Determination of ability of a pump to dispense a grease at a stated temperature, and therefore primarily a pump test; can supply comparative data on two or more greases using same pumping equipment and test temperatures.

[a]NLGI Spokesman, August 1983, page 156.
[b]NLGI Spokesman, May 1960, page 47.