Designation: D4693 – 07 (Reapproved 2012)

Standard Test Method for Low-Temperature Torque of Grease-Lubricated Wheel Bearings[1]

This standard is issued under the fixed designation D4693; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the determination of the extent to which a test grease retards the rotation of a specially-manufactured, spring-loaded, automotive-type wheel bearing assembly when subjected to low temperatures. Torque values, calculated from restraining-force determinations, are a measure of the viscous resistance of the grease. This test method was developed with greases giving torques of less than 35 N·m at −40°C.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.3 **WARNING**—Mercury has been designated by many regulatory agencies as a hazardous material that can cause central nervous system, kidney and liver damage. Mercury, or its vapor, may be hazardous to health and corrosive to materials. Caution should be taken when handling mercury and mercury containing products. See the applicable product Material Safety Data Sheet (MSDS) for details and EPA's website—http://www.epa.gov/mercury/faq.htm—for additional information. Users should be aware that selling mercury and/or mercury containing products into your state or country may be prohibited by law.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D217 Test Methods for Cone Penetration of Lubricating Grease

D1403 Test Methods for Cone Penetration of Lubricating Grease Using One-Quarter and One-Half Scale Cone Equipment

D3527 Test Method for Life Performance of Automotive Wheel Bearing Grease

D4175 Terminology Relating to Petroleum, Petroleum Products, and Lubricants

E1 Specification for ASTM Liquid-in-Glass Thermometers

E77 Test Method for Inspection and Verification of Thermometers

E220 Test Method for Calibration of Thermocouples By Comparison Techniques

E230 Specification and Temperature-Electromotive Force (EMF) Tables for Standardized Thermocouples

E563 Practice for Preparation and Use of an Ice-Point Bath as a Reference Temperature

E585/E585M Specification for Compacted Mineral-Insulated, Metal-Sheathed, Base Metal Thermocouple Cable

E608/E608M Specification for Mineral-Insulated, Metal-Sheathed Base Metal Thermocouples

2.2 *Military Standard:*[3]

MIL-G-10924F Specification for Automotive and Artillery

2.3 *ABMA Standard:*[4]

Anti-Friction Bearing Manufacturer Assoc. (AFBMA) Standard 19, 1974 (ANSI B.3.19-1975)

3. Terminology

3.1 *Definitions:*

3.1.1 *automotive wheel bearing grease, n*—a lubricating grease specifically formulated to lubricate automotive wheel bearings at relatively high grease temperatures and bearing speeds. **D3527**

3.1.2 *lubricant, n*—any material interposed between two surfaces that reduces the friction or wear between them. **D4175**

[1] This test method is under the jurisdiction of Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.G0 on Lubricating Grease.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

[4] Available from American Bearing Manufacturers Association (ABMA), 2025 M St., NW, Suite 800, Washington, DC 20036. www.americanbearings.org

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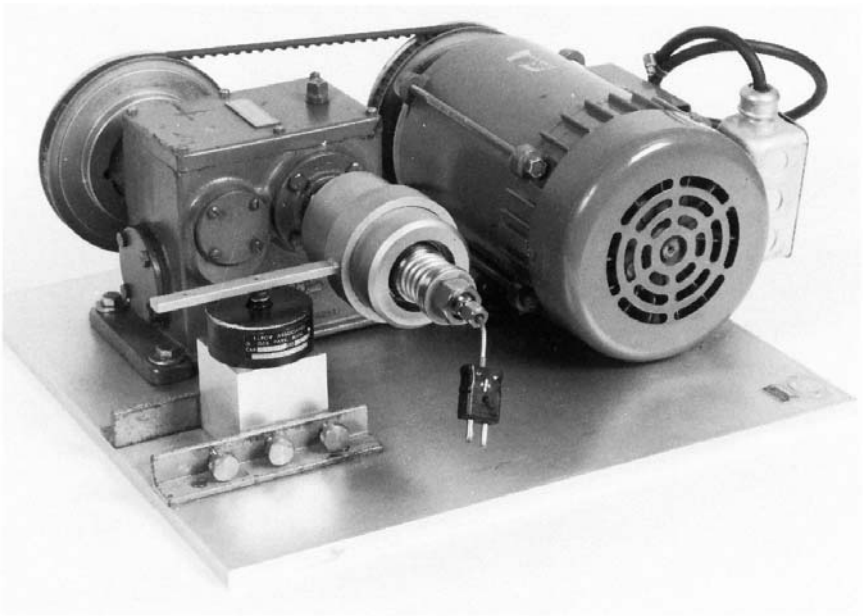

FIG. 1 Low-Temperature Torque Apparatus

3.1.3 *lubricating grease, n*—a semi-fluid to solid product of a dispersion of a thickener in a liquid lubricant.

3.1.3.1 *Discussion*—The dispersion of the thickener forms a two-phase system and immobilizes the liquid lubricant by surface tension and other physical forces. Other ingredients are commonly included to impact special properties. **D217**

3.1.4 *thickener, n—in lubricating grease*, a substance composed of finely-divided particles dispersed in a liquid lubricant to form the product's structure.

3.1.4.1 *Discussion*—The solid thickener can be fibers (such as various metallic soaps) or plates or spheres (such as certain non-soap thickeners) which are insoluble or, at the most, only very slightly soluble in the liquid lubricant. The general requirements are that the solid particles be extremely small, uniformly dispered, and capable of forming a relatively stable, gel-like structure with the liquid lubricant. **D217**

4. Summary of Test Method

4.1 A freshly stirred and worked sample of test grease is packed into the bearings of a specially-manufactured, automotive-type spindle-bearings-hub assembly. The assembly is heated and then cold soaked at −40°C, unless another test temperature is specified by the grease specification. The spindle is rotated at 1 rpm and the torque required to prevent rotation of the hub is measured at 60 s.

5. Significance and Use

5.1 This test method differentiates among greases having distinctly different low-temperature characteristics. This test is used for specification purposes and correlates with its precursor which has been used to predict the performance of greases in automotive wheel bearings in low-temperature service.[5] It is the responsibility of the user to determine the correlation with other types of service.

6. Apparatus

6.1 *Low-Temperature Wheel Bearing Torque Apparatus,*[6,7] illustrated in Fig. 1.

NOTE 1—Several apparatus configurations are available, differing mainly in the drive system. For example, with large cold chambers, a unitized apparatus (see Fig. 1) can be used totally within the cold chamber. With small cold chambers, the drive system can be mounted externally and only the test unit subjected to low temperature. Regardless of the exact configuration, the essential apparatus consists of a 1/3 hp electric motor connected to a gear reducer by means of a timing belt and pulleys, which drive a specially-manufactured spindle-bearings-hub assembly equipped with a spring-loading mechanism. For apparatus contained totally within the cold chamber, the drive system should be prepared by replacing the grease in the motor bearings with a suitable low-temperature grease (<1 N·m torque at −40°C), such as one meeting the requirements of Specification MIL-G-10924F or similar, and the lubricant in the gear reducer should be replaced with a suitable low-temperature (< −50°C pour point) worm-gear lubricant.[7,8] In addition, if not already so-equipped, large-diameter (152 mm), narrow-width (13 mm) timing pulleys and a suitable timing belt should be used.

6.2 *Torque Measuring System,* consisting of a strain-gage load cell with a matching bridge-balance unit,[7,9] a suitable

[5] Verdura, T. M., "Performance of Service Station Wheel Bearing Greases in a New Low-Temperature Test," *NLGI Spokesman 35* 10-21, 1971.

[6] The sole source of supply of the apparatus known to the committee at this time is available from Koehler Instrument Company, Inc., 1595 Sycamore Avenue, Bohemia, NY 11716.

[7] If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

[8] The sole source of supply of the apparatus known to the committee at this time is Mobil SHC 624 (or similar), available from Mobil Oil Corporation, 3225 Gallows Rd., Fairfax, VA 22037.

[9] The sole source of supply of the apparatus known to the committee at this time is a Model 3167-50 load cell and matching electronic circuitry, available from Lebow Associates, Inc., 1728 Maplelawn, Troy, MI 48084.

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TABLE 1 Torque Test Results at –40°C with NLGI Reference System A (Batch 3)

Mean value	3.7 N·m
Standard deviation	0.67 N·m
Confidence limits, 95 %:	
Lower	3.2
Upper	4.1

strip-chart recorder to record the load-cell output, and a series of weights (up to 20 kg, at least) suitable for load-cell calibration.

NOTE 2—In order to calculate torque from force measurements, the load cell should be located a known distance from the test-unit centerline; 100 mm is convenient. A convenient way to do this is to centrally drill a 1.78-mm diameter hole (No. 50 drill) in the torque arm, 100 mm from the spindle centerline; temporarily replace the load cell contact with a second contact having a 1.59-mm diameter pin (soldered in place) extending about 5 mm above the contact point; position the load cell to permit insertion of the pin in the torque-arm hole; secure the position of the load cell by tightening the clamping screws; replace pin contact with original contact before running test.

6.3 *Temperature Measuring System,* consisting of Type T (preferred) or Type J (acceptable), 3.18-mm diameter metal-sheathed, grounded thermocouples meeting Specifications E585/E585M and E608/E608M and conforming to the special limits of error defined in Table 1 of Specification E230; a suitable potentiometer, satisfying the requirements for Groups B or C as described in Test Method E220; an ASTM 73C precision thermometer meeting Specification E1, certified (traceable to National Institute of Standards and Technology certification) or verified and calibrated according to Test Method E77; a suitable comparator as described in Test Method E77; and an ice bath prepared according to Practice E563.

NOTE 3—Other temperature-measuring instrumentation, such as a precision platinum resistance thermometer, may be used instead of thermocouples, providing the limits of error are within those defined in Specification E230.

6.4 *Test Bearing*—Use LM67010-LM67048 and LM11910-LM11949 (AFBMA Standard 19) inboard and outboard tapered roller bearings, respectively.

6.5 *Low-Temperature Test Chamber,* equipped with internal fan, and capable of maintaining the spindle at –40 ± 0.5°C, and with sufficient capacity to cool the spindle at the rate shown in Fig. 2(A) and Fig. 2(B).

6.6 *Laboratory Oven,* forced air, capable of maintaining 70 ± 3°C.

6.7 *Grease Packer,* as described in Test Method D3527 or equivalent.

6.8 *Ultrasonic Cleaner.*[7,10]

7. Reagents and Materials

7.1 *Purity of Reagents*—Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society where such specifications are available.[11] Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

7.2 *Ethylene Glycol,* commercial automotive antifreeze. (**Warning—**Moderately toxic. Can be harmful if inhaled, swallowed or absorbed through skin. Contact can irritate eyes, or mucosa.)

7.3 *n-Heptane,* reagent grade. (**Warning—**Flammable. Harmful if inhaled.)

7.3.1 *n*-Heptane is recommended as the cleaning solvent for the test bearings, as a replacement for the more hazardous solvents used previously (chloroform and 1,1,1–tricholoroethane). However, the precision of the test has not been established with the use of n-heptane. In referee situations, contractual parties should agree on the acceptability of n-heptane for the test.

7.4 *Chloroform,* reagent grade. (**Warning—**Health hazard.)

7.4.1 This test method and the precision statement were originally developed using chloroform as the cleaning solvent for the test bearings. However, the use of chloroform is discouraged, because of its known health hazards. If it is deemed necessary to use chloroform in a referee situation, it is the responsibility of the contractual parties to ensure that proper precautions are taken.

7.5 *1,1,1-Trichloroethane,* reagent grade. (**Warning—**Health hazard.)

7.5.1 This test method was revised in the past to specify the use of 1,1,1–trichloroethane as a replacement for chloroform. However, 1,1,1–trichloroethane also has health and environmental risks associated with its use. Therefore, its use is discouraged for this test method, and it is recommended that n-heptane is used instead. If it is deemed necessary to use 1,1,1–trichloroethane in a referee situation, it is the responsibility of the contractual parties to ensure that the proper precautions are taken.

NOTE 4—This test method (and the precision values) was originally developed using chloroform. This was subsequently replaced by 1,1,1-trichloroethane which was declared an ozone depleting substance by the U.S. Environmental Protection Agency (EPA). Federal regulations ban the production of this material after December 31, 1995, but existing stocks may continue to be used. Currently there are no EPA restrictions on the use of chloroform, but the user should be aware of its health hazards, if it is used. No other solvent (including *n*-heptane) intended as a substitute for 1,1,1-trichloroethane in this test method has been cooperatively evaluated. (**Warning—**If the functionally equivalent solvent is flammable or a health hazard, proper precautions should be taken.)

8. Calibration

8.1 *Torque Calibration:*

[10] The sole source of supply of the apparatus known to the committee at this time is Bransonic 220, having a capacity of about 4 L operating at an output frequency of about 55 kHz, with a power input of about 125 W, available from Branson Ultrasonics Corporation, 41 Eagle Rd., Danbury, CT 06813-1961.

[11] *Reagent Chemicals, American Chemical Society Specifications* , American Chemical Society, Washington, DC. For suggestions on the testing of reagents not listed by the American Chemical Society, see *Analar Standards for Laboratory Chemicals*, BDH Ltd., Poole, Dorset, U.K., and the *United States Pharmacopeia and National Formulary*, U.S. Pharmacopeial Convention, Inc. (USPC), Rockville, MD.

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