Designation: D7452 – 17

Standard Test Method for Evaluation of the Load Carrying Properties of Lubricants Used for Final Drive Axles, Under Conditions of High Speed and Shock Loading[1]

This standard is issued under the fixed designation D7452; 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.

INTRODUCTION

Portions of this test method are written for use by laboratories that make use of ASTM Test Monitoring Center (TMC)[2] services (see Annex A1 – Annex A4).

The TMC provides reference oils, and engineering and statistical services to laboratories that desire to produce test results that are statistically similar to those produced by laboratories previously calibrated by the TMC.

In general, the Test Purchaser decides if a calibrated test stand is to be used. Organizations such as the American Chemistry Council require that a laboratory use the TMC services as part of their test registration process. In addition, the American Petroleum Institute and the Gear Lubricant Review Committee of the Lubricant Review Institute (SAE International) require that a laboratory use the TMC services in seeking qualification of oils against their specifications.

The advantage of using the TMC services to calibrate test stands is that the test laboratory (and hence the Test Purchaser) has an assurance that the test stand was operating at the proper level of test severity. It should also be borne in mind that results obtained in a non-calibrated test stand may not be the same as those obtained in a test stand participating in the ASTM TMC services process.

Laboratories that choose not to use the TMC services may simply disregard these portions.

1. Scope*

1.1 This test method covers the determination of the anti-scoring properties of final drive axle lubricating oils when subjected to high-speed and shock conditions. This test method is commonly referred to as the L-42 test.[2]

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.2.1 *Exceptions*—SI units are provided for all parameters except where there is no direct equivalent such as the units for screw threads, National Pipe Threads/diameters, tubing size, and single source equipment suppliers.

1.3 *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.* Specific warning information is given in Sections 4 and 7.

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

D235 Specification for Mineral Spirits (Petroleum Spirits)

[1] This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.B0.03 on Automotive Gear Lubricants & Fluids.

Current edition approved May 1, 2017. Published May 2017. Originally approved in 2008. Last previous edition approved in 2016 as D7452 – 16. DOI: 10.1520/D7452-17.

[2] Until the next revision of this test method, the ASTM Test Monitoring Center (TMC) will update changes in this test method by means of information letters. Information letters may be obtained from the ASTM Test Monitoring Center, 6555 Penn Avenue, Pittsburgh, PA 15206, Attention: Administrator. This edition incorporates revisions in all information Letters through No. 16-1. The TMC is also a source of reference oils.

[3] 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.

***A Summary of Changes section appears at the end of this standard**

(Hydrocarbon Dry Cleaning Solvent)

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

2.2 *Society of Automotive Engineers Standards:*[4]

SAE J308 Information Report on Axle and Manual Transmission Lubricants

SAE J2360 Lubricating Oil, Gear Multipurpose (Metric) Military Use

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *coast side, n*—the convex side of the pinion and the concave side of the ring gear which are in contact during deceleration in a forward gear.

ASTM Distress Rating Manual 21[5]

3.1.2 *drive side, n*—the concave side of the pinion and the convex side of the ring gear which are in contact during acceleration in a forward gear.

ASTM Distress Rating Manual 21

3.1.3 *scoring, n—on the ring and the pinion gear teeth*, the displacement of metal by local momentary welding from the gear tooth, resulting in the development of a matt, or frosted dull surface.

ASTM Distress Rating Manual 21

4. Summary of Test Method

4.1 Charge a specially prepared light duty hypoid rear axle (Dana Model 44 ASTM Part No. 044AA100-1)[6] with the lubricant sample to be tested (see 10.1). Mount the axle between two load absorbing dynamometers which are driven with a V-8 gasoline engine through a manual transmission.

4.2 Condition the test axle with light loads at different speed, torque and temperature conditions on both the drive and coast sides of the gears. (**Warning—**High-speed rotating equipment, electrical shock, high-temperature surfaces.) After conditioning, subject the test axle to high speed and shock loadings at higher temperatures.

4.3 Rate the drive and coast side of the pinion and ring gears at the end of test (EOT) for scoring distress.

5. Significance and Use

5.1 Final drive axles are often subjected to severe service where they encounter high speed shock torque conditions, characterized by sudden accelerations and decelerations. This severe service can lead to scoring distress on the ring gear and pinion surface. This test method measures anti-scoring properties of final drive lubricants.

5.2 This test method is used or referred to in the following documents:

5.2.1 American Petroleum Institute (API) Publication 1560.[7]

5.2.2 SAE J308 and SAE J2360.

6. Apparatus

6.1 This test method provides a description of essential apparatus features, including mandatory equipment type and performance specifications where established.

6.2 *Test Axle*—The test unit consists of a Dana model 44 rear axle, 45 to 11 (4.09) ratio, and uncoated gears. (Dana ASTM part number 044AA100-1.[6] See 10.1.)

6.3 *Cover Plate*—Modify the rear cover plate of the test unit to provide an inspection port and thermocouple fitting. Locate the thermocouple fitting by using the locating fixture shown in Fig. A6.1. An optional ¼ in. NPT (National Pipe Thread) drain fitting may be added.

6.4 *Axle Shaft Assemble*—Use a Ford Axle shaft assembly, (Dana Part No. 26762-14X[6]) or equivalent with this test method.

6.5 *Hinge Plate Stand Assembly*—Mount and secure the test unit in place on the hinge plate assembly, see Figs. A6.6-A6.9.

6.6 *Temperature Control System*—The temperature control apparatus consists of a thermocouple, a temperature recording system, temperature controller and a cooling system that is able to maintain lubricant temperature at specified conditions.

6.6.1 *Thermocouple*—Install the thermocouple such that the thermocouple tip is flush with the cover plate lip by placing the cover plate face on a flat surface and inserting the thermocouple into the cover plate until the thermocouple tip is flush with the flat surface. For recording and control of the test lubricant temperature, use a ⅛ in. (3.2 mm) diameter J or K type closed tip style thermocouple.

6.6.2 *Temperature Recording System*—Throughout the test, ensure the temperature recording system records the temperature of the test oil at a minimum frequency of 1 Hz.

6.6.3 *Temperature Controller*—Proportional-Integral-Derivative (PID) type; percent output adjustable.

6.6.4 *Axle Cooling*—Use three spray nozzles to distribute water over the cover plate and axle housing as shown in Fig. A6.2. Actuate the water control valve by the temperature PID control system.

6.6.4.1 Depending on how the system is plumbed, use spray nozzles in any combination of the following part numbers: Straight Male NPT (Part No. 3/8GG-SS22), 90° Male NPT (Part No. 3/8GGA-SS22), Straight Female NPT (Part No. 3/8G-SS22), and 90° Female NPT (Part No. 3/8GA-SS22).[8,9]

6.6.4.2 Use a single control valve to control the cooling water supply. The control shall be a ½ in. (12.7 mm) two-way,

---

[4] Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001, http://www.sae.org.

[5] Formerly known as *CRC Rating Manual, No. 21*. Available from the ASTM website, www.astm.org, ASTM Stock No. TMCMNL21.

[6] Parts and *Model 44 Maintenance Manual* available from Dana Corporation, P.O. Box 2424, Fort Wayne, IN 46801.

[7] API Publication 1560, *Lubricant Service Designations for Automotive Manual Transmissions, Manual Transaxles, and Axles*, American Petroleum Institute, Washington, DC.

[8] The sole source supply of the apparatus known to the committee at this time is Spray Systems Company, and can be purchased through E. I. Pfaff Company, 3443 Edwards Road, Suite D, Cincinnati, OH 45208.

[9] 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.

C linear trim, air to close, Research Control valve. Use a single PID loop to maintain the axle lubricant temperature control for both the Standard and Canadian version test. A separate PID loop control for each version is not permitted. See Annex A5.

6.6.4.3 Use *only* ⅜ in. or ½ in. (9.5 mm or 12.7 mm) line material to the spray nozzles.

6.6.4.4 Use a minimum supply water pressure of 25 psig (172 kPa) to the control valve.

6.6.4.5 Use an axle containment box as shown in Fig. A6.10. The purpose is to contain water.

6.6.4.6 Use a locating pin or stop block as an indexing device to ensure that all subsequent axle installations are consistently installed perpendicular with the axle housing cover to engine and transmission drive-shaft centerline.

6.7 *Torque Meter*—Include in the test equipment a torque meter installed in the drive shaft (see Figs. A6.3-A6.5) to measure the torque applied to the pinion. Install a Himmelstein inline torque meter Model numbers MCRT28061T(1-4) or MCRT2661TN(1-4)[9,10] without a foot mount and a range of 10 000 lb-in. (1130 N·m) shall be installed to measure pinion torque. Additional suffix letters only indicate allowable options.

6.8 *Signal Conditioning*—Use a Himmelstein Models 701 or 711 strain gage conditioner for signal conditioning. Set the low pass cut-off frequency at 10 Hz.

6.9 *Digital Data Acquisition System*—System requires capability of measuring a minimum of five channels at sampling frequencies outlined in Section 10.

6.9.1 Do not use hardware or software filtering for the pinion torque channel during data acquisition periods of the test.

6.10 *Dynamometers*—Two axle dynamometers (Midwest Dynamatic, Model 3232)[9,11] with suitable control equipment capable of maintaining specified test conditions.

6.11 *Engine Speed Control*—System requires a device to maintain steady state conditions and also provide adjustable throttle acceleration and deceleration rates to attain specified shock loading torques.

6.11.1 *Throttle Controller System*—Use a Foxboro/Jordan Controller, Model AD7530.[9,12] Use a power transformer from Acme Electric Corp. PN T-1-81058 or equivalent, primary volts 120X240, secondary volts (120 V primary by 240 V secondary), 16/32 (13 mm) center tap, 0.500 kVA (0.5 kW) in conjunction with the Foxboro/Jordan Controller.

6.12 *Connecting Shafts*—Use connecting shafts of equal length ±1 in. (25.4 mm) and less than 30 in. (762 mm) long from flange face to flange face. Use a tubing diameter of 3.5 in. ± 0.2 in. (88.9 mm ± 5.1 mm) OD, with a wall thickness of 0.095 in. ± 0.005 in. (2.41 mm ± 0.13 mm) if tubing is required to fabricate the shafts. Ensure the shafts are dynamically (spin) balanced and strong enough to handle torques up to 2100 lbf-ft (2847 N·m). Use an operating angle of 0° ± 0.5°.

TABLE 1 Recommended Power Train Replacement Parts List

Parts	Part Number
Ramjet Engine Includes ECM	12495515
Five Speed Transmission	15747134 or 15747232
Bell Housing	15998496
Clutch Assembly	15002591
Throw Out Bearing	15705563
Dip Stick	10190942
Dip Stick Tube	12552920
Flywheel	10105832
Flywheel Bolt (6 req.)	12337973
Pilot Bearing	14061685
Master Cylinder	15727261
Actuating Cylinder	15046288
Pulley, Water Pump	14023155
Pulley, Crankshaft	14023147
Belt	9433720
Starter	10496873
Engine Control Unit	12489488
Throttle Body from 2000 Corvette.	17113669
Throttle Body TPS Connector	P/N 12116247
Throttle Body Actuator Motor Connector	P/N 12167121
K&N Inlet Air Filter	P/N RD6020

6.13 *Power Train*—The power train consists of a gasoline powered V-8 GM performance Ramjet 5.7 L marine engine coupled with a five speed manual transmission capable of supplying specified shock loading torques. The engine and transmission operating angle shall be 0° ± 0.5°.

6.13.1 All recommended replacement parts are available through local General Motors dealers. A list of these replacement parts are shown in Table 1. Do not make modifications to the engine that would affect the engines factory displacement or compression ratio.

6.14 *Drive Shaft*—Welded steel tubing, 3.5 in. ± 0.2 in. (90 mm ± 5.1 mm) outside diameter, 0.095 in. ± 0.005 in. (2.41 mm ± 0.13 mm) wall thickness, 34.5 in. ± 1 in. (880 mm ± 25 mm) long from center weld to center weld. (See Figs. A6.3-A6.5.) Dynamically (spin) balance the drive shaft and torque meter. The operating angle shall be 0° ± 0.5°.

6.14.1 *Transmission U-Joint*—(Spicer 5-178X)[13] or Neapco 2-1435[14]

6.14.2 *Pinion U-Joint*—(Spicer 5-153X).

6.14.3 *Flange Yoke*—Connects transmission yoke through u-joint to drive shaft.

6.14.4 *Pinion Drive Shaft Slip Yoke*—Connects the drive shaft through the u-joint to the axle yoke.

6.14.5 *Flange Adaptor*—Manufacture flange adapter to specifications in Figs. A6.4 and A6.5.

6.15 *Spring Plate*—Manufacture spring plates to specification as shown in Fig. A6.8.

6.16 *Spring Plate Rod Connection*—Mount a rod connecting the spring plate to the gear stand using ½ in. (13 mm) spherical rod ends. See Figs. A6.6 and A6.7.

[10] The sole source supply of the apparatus known to the committee at this time is S. Himmelstein and Company, 2490 Pembroke Avenue, Hoffman Estates, IL 60195.

[11] Available from Dyne Systems, P.O. Box 18 W209 N17391 Industrial Drive, Jackson, WI 53037.

[12] Available from Fox/Jordan, Inc., 5607 West Douglas Avenue, Milwaukee, WI 53218.

[13] Available from any local drive shaft supplier.

[14] Available from Neapco, LLC, 6735 Haggerty Rd., Belleville, MI 48111.

7. Reagents and Materials

7.1 *Sealing Compound*—Where necessary, use Permatex No. 2 or equivalent.

7.2 *Cleaning Solvent*—Use solvent meeting ASTM D235 Type II, Class C requirements for Aromatic Content (0 to 2) vol %, Flash Point (142 °F/61 °C, min) and Color (not darker than +25 on Saybolt Scale or 25 on Pt-Co Scale). (**Warning—** Health hazard, combustible.) Obtain a Certificate of Analysis for each batch of solvent from the supplier.

7.3 *Contact Pattern Marking Compound*—Wayne Metal Working Compound # M 99B 111A[15] or equivalent.

7.4 *Test Oil*—Use 3.5 pt (1655 mL) of test lubricant.

8. Preparation of Apparatus

8.1 *Cleaning of Reusable Hardware*—Clean as necessary with cleaning solvent (see 7.2) all reusable parts including: axle shafts, thermocouples, axle housing cover, and all associated drain pans and funnels used for the addition of and collection of test oil.

8.2 *Preparation of Axle:*

8.2.1 Pretest contact pattern procedure (see Annex A9).

8.2.2 Record break and turn.

8.2.3 Record the backlash reported from the manufacturer. The readings shall be between 0.004 in. and 0.012 in. (0.102 mm to 0.305 mm).

8.2.3.1 Measure and record backlash at four equally spaced locations. Report the average and the four readings.

8.2.4 Proceed to 8.2.9 if contact pattern and backlash are acceptable. Proceed to 8.2.5 if the contact pattern or backlash needs adjustment.

8.2.5 Follow Dana Model 44 Maintenance Manual[6] if contact pattern or backlash needs to be adjusted.

8.2.6 Assemble the gear unit using Dana Model 44 Maintenance Manual.[6] Apply gear contact pattern grease on the drive and coast side of the ring. Place a 30 lbf-ft ± 5 lbf-ft (40.7 N·m ± 6.8 N·m) turning torque on the ring and pinion. Rotate ring and pinion through the gear contact pattern grease on the drive and coast side.

8.2.7 Proceed to 8.2.8 if the contact pattern and backlash are acceptable. If the contact pattern requires further adjustment, repeat 8.2.5 and 8.2.6 until an acceptable pattern is obtained.

8.2.8 Measure and record backlash at four equally spaced locations. Report the average and the four readings.

8.2.9 Clean the gear with cleaning solvent (see 7.2) when gear contact pattern and backlash are at acceptable levels.

8.2.10 *Cleaning*—Wash the test unit in cleaning solvent (see 7.2), paying particular attention to the pinion bearing to remove all preservative oil. Blow dry with clean dry compressed air.

8.2.11 Install axle shafts in test unit.

8.2.12 Lubricate the carrier bearing, pinion bearings, differential gears, and the ring and pinion gears using 3.5 pt ± 0.1 pt (1655 mL ± 50 mL) of test lubricant.

8.2.13 Install the axle cover plate with gasket. It is not permissible to drain the oil and recharge the test axle once the test oil has been charged to the axle.

8.2.14 Install test unit on stand with pinion and axle shaft center lines horizontal. The operating angle shall be 0° ± 0.5°. After installing the axle, ensure that the hinge plate assembly is free.

8.2.15 Connect the dynamometers and drive shaft to the test unit.

9. Calibration and Standardization

9.1 Annex A2 describes general calibration procedures using TMC reference oils, including their storage and conditions of use, and the conduct and reporting of reference oil test results.

9.2 Annex A3 describes TMC maintenance activities including special reference oil tests, special use of the reference oil calibration system, donated reference oil test programs, introduction of new reference oils, and issuance of TMC information letters and memoranda.

9.3 Annex A4 provides information regarding how new laboratories can become part of the TMC Monitoring System, and the role of the TMC in determining precision of monitored test methods.

9.4 *Test Stand Calibration*—Calibration is established upon satisfactory completion of a reference oil test sequence that meets established reference oil targets.

9.4.1 Each calibration sequence consists of three operationally valid and statistically acceptable reference oil tests.

9.4.2 When a calibration is being performed after the twentieth non-reference oil test on a previously calibrated test stand, or after three months since the last satisfactory reference oil test, perform a single operationally valid and statistically acceptable reference oil test.

9.4.2.1 The calibration sequence consists of the new test and the last two calibration tests performed.

9.4.3 Each operationally valid test is considered statistically acceptable if the end of test pinion coast side scoring meets the Shewhart limits as published by the Test Monitoring Center. Specific Shewhart limits are defined for each gear batch and reference oil combination.

9.4.3.1 Repeat any operationally valid calibration test in the calibration sequence with an end-of-test pinion coast side scoring value exceeding the Shewhart limits until acceptable pinion scoring results are achieved.

9.5 *New Test Stand Calibration*—A new test stand is considered calibrated upon completion of satisfactory reference oil tests (assigned by the TMC) that meet established reference oil targets.

9.5.1 New test stand inspection by the TMC is also required to complete the calibration.

9.6 *In-Service Stand Calibration*—Calibrate previously referenced test stands according to instructions provided in 9.4; that is, after every twentieth non-reference oil test, or after three months since the last acceptable reference oil test sequence.

9.6.1 Also, if any of the special circumstances described below are involved, calibrate with a new three reference oil test calibration sequence:

9.6.1.1 After a test stand is moved, or

[15] The gear marking compound is made by Wayne Metal Working Company.

9.6.1.2 After changing axle batches, or

9.6.1.3 After changing throttle settings, or

9.6.1.4 After changing torque settings, or

9.6.1.5 After major computer changes, or

9.6.1.6 After a test not conforming to this test method was run in the stand since the last acceptable reference test, or

9.6.1.7 After 6 months since the last valid L42 calibration test, or

9.6.1.8 After two reference oil calibration attempts are made resulting in the end-of-test pinion coast side scoring not meeting the Shewhart limits as published by the Test Monitoring Center, or the tests are statistically unacceptable or operationally invalid.

9.6.2 If a new three reference oil test calibration sequence is being attempted, there shall not be more than five attempts between the first and last run numbers.

9.6.2.1 If the discrimination oil test (see 9.7) is also required, there shall not be more than eight attempts between the first and last run numbers.

9.7 *Discrimination Oil Testing*—Conduct a discrimination oil test on the test stand every six months from the completion of the last test in the calibration sequence or after four calibration sequences.

9.7.1 Discrimination Oils approved by the L-42 Surveillance Panel are oils that demonstrate lower-performance levels compared to that of regular TMC reference oils.

9.7.2 The end-of-test pinion coast side scoring value of the discrimination oil test shall be a minimum of twice the average value of the three acceptable reference oil tests for the discrimination test to be considered acceptable. The discrimination oil test may be conducted at any time during the calibration sequence. If the discrimination oil test isconducted at the end of the calibration sequence and a second discrimination oil test is needed, this second discrimination oil test, if acceptable, will count as 1 of the 20 non-reference oil tests. Repeat the complete calibration sequence (the three reference oil tests and the discrimination oil test) if both discrimination oil tests do not meet the above requirements.

9.8 *Correction Factor*—When using TMC Reference Oil 117 for stand calibration, add 6 % to the pinion scoring result and add 4 % to the ring scoring result. Report both the rated scoring and the corrected scoring in the space provided in the test report.

9.9 For all reference oil tests, the end-of-test coast side pinion scoring shall be equal to or greater than the end-of-test ring coast side scoring for the test to be acceptable.

9.10 *Reference Test Frequency*—The test stand calibration period is defined as three months or 20 tests, whichever occurs first. It begins on the completion date of an operationally and statistically acceptable reference oil test series as determined by the TMC. Any test started on or before the stand calibration expiration date is defined to have been run on a calibrated stand.

9.10.1 When a test stand is out of calibration for a period of six months or longer, renumber the stand, and follow LTMS guidelines for new stand introduction.

9.10.2 Report modification of test stand apparatus or completion of any nonstandard test on a calibrated test stand to the TMC immediately.

9.11 Assign a sequential test run number to every test start on any test stand before testing begins. All tests, including aborted starts and operationally invalid tests, shall retain their test number.

9.12 *Instrument Calibration*—Calibrate the wheel and pinion speed measuring systems and axle oil temperature control system at least every six months or 60 non-reference oil tests, whichever occurs first. Perform an instrument calibration against a known standard traceable to either the National Institute of Standards and Technology (NIST) or to a physical constant.

9.12.1 Prior to each reference oil test sequence, calibrate the pinion torque measuring device using a dead weight calibration. Perform the calibration on both the positive (drive) and negative (coast) side of zero.

9.12.2 *Engine Throttle Body Calibration*—Calibrate prior to every calibration sequence.

9.12.2.1 Warm the engine up until the coolant temperature is greater than 150 °F (65.6 °C).

9.12.2.2 Connect a voltmeter to the throttle position sensor (TPS) to measure the TPS voltage sent to the engine ECM.

9.12.2.3 Adjust the Foxboro/Jordon zero potentiometer to close the throttle until engine idle speed is at 675 r/min ± 75 r/min. Record the TPS voltage.

9.12.2.4 Set the throttle controller at 100 % output. Adjust the Foxboro/Jordon "span" potentiometer until the observed TPS voltage is 1.3 V ± 0.1 V higher than the voltage recorded in 9.12.2.3.

10. Procedure for Conducting the Test

10.1 The test axles are batch specific. See TMC Memo 94-200 for approved gear batches and test targets.

10.2 *Gear Conditioning*—All ramp targets should be reached in approximately five min. Minimize drive torque to prevent drive side scoring.

10.2.1 *Conditioning 1:*

10.2.1.1 Set the axle oil temperature control equipment at a set point of 225 °F (107.2 °C). When the axle oil temperature reaches set point, maintain the temperature within 225 °F ± 10 °F (107.2 °C ± 5.6 °C) until conditioning is complete.

10.2.1.2 *Shift Gears*—With the engine at operating temperature set the engine idle speed to 700 r/min ± 200 r/min (73 rad/s ± 21 rad/s). Prior to shifting gears set the engine speed manual output to achieve approximately 2000 r/min (209 rad/s). With no torque on the dynamometers smoothly shift the transmission through the gears (without bucking the axle) allowing the engine to recover to approximately 1500 r/min (157 rad/s) between shifts. Shift through the gears until 1:1 ratio (4th gear) is reached.

10.2.1.3 *Ramp & Condition*—Set data acquisition to record pinion torque, wheel speed and axle temperature at a minimum of 1 Hz. Accelerate both wheels to a speed of 575 r/min ± 5 r/min (60 rad/s ± 0.5 rad/s) (pinion speed 2352 r/min ±

20 r⁄min (246 rad⁄s ± 2 rad⁄s)). Apply a dynamometer excitation to achieve a pinion torque of 60 lbf-ft ± 20 lbf-ft (81 N·m ± 27 N·m). When both conditions are met, begin conditioning phase 1 and maintain for 10 min ± 0.5 min. At the end of this steady state operation lock dynamometer excitation at the output necessary to achieve 60 lbf-ft (81 N·m). Immediately proceed to 10.2.2.

10.2.2 *Conditioning 2*—Set data acquisition to record pinion torque and wheel speed at a minimum of 10 Hz and axle temperature at a minimum of 1 Hz. While maintaining the fixed dynamometer excitation, slowly cycle the wheel speed from 575 r⁄min ± 20 r⁄min (60 rad⁄s ± 0.5 rad⁄s) to 385 r⁄min ± 20 r⁄min (40 rad⁄s ± 0.5 rad/s). Maintain the fixed dynamometer excitation settings and control throttle movement slowly enough to maintain pinion torque values sufficient to properly condition the drive and coast side of the axle. Complete four cycles then immediately proceed to 10.2.3. The total time of the four cycles shall not exceed 5 min.

NOTE 1—It is believed that if the shape of both drive and coast segments of Conditioning 2 and Conditioning 4 are flat topped in nature (without any spikes in the acceleration or deceleration torque that would indicate a shock) the torque values found from this data stream will be a better representation of the gear conditioning.

10.2.3 *Conditioning 3:*

10.2.3.1 Maintain the axle oil temperature control at 225 °F ± 10 °F (107.2 °C ± 5.6 °C).

10.2.3.2 *Ramp & Condition*—Set data acquisition to record pinion torque, pinion speed and axle temperature at a minimum of 1 Hz. Accelerate both wheels to a wheel r/min speed of 815 r⁄min ± 5 r⁄min (85 rad⁄s ± 0.5 rad⁄s). Apply a dynamometer excitation to achieve a pinion torque of 70 lbf-ft ± 20 lbf-ft (95 N·m ± 27 N·m). When both conditions are met, maintain for 20 min ± 0.5 min. At the end of this steady state operation lock dynamometer excitation at the output necessary to achieve 70 lbf-ft (95 N·m). Immediately proceed to 10.2.4.

10.2.4 *Conditioning 4:*

10.2.4.1 Set data acquisition to record pinion torque and wheel speed at a minimum of 10 Hz and axle temperature at a minimum of 1 Hz. While maintaining the fixed dynamometer excitation, slowly cycle the wheel speed from 815 r⁄min ± 20 r⁄min (85 rad⁄s ± 2 rad⁄s) to 670 r⁄min ± 20 r⁄min (70 rad⁄s ± 2 rad⁄s). Maintain the fixed dynamometer excitation settings and control throttle movement slowly enough to maintain pinion torque values sufficient to properly condition the drive and coast side of the axle. Complete four cycles then immediately proceed to 10.2.4.2. The total time of the four cycles shall not exceed 5 min.

10.2.4.2 Shift transmission into neutral to avoid additional coast side conditioning. Bring engine r/min down to idle.

10.2.5 *Inspection 1*—(**Warning—**Differential is extremely hot. Hot oil can produce vapors.)

10.2.5.1 Inspect ring gear and report approximate drive and coast percent scoring. Inspection should take approximately 5 min. Make an effort to minimize the time spent during the inspection.

10.3 *Shock Series 1:*

10.3.1 *Shock Series 1 Preparation:*

10.3.1.1 Set the engine speed manual output to achieve approximately 2000 r⁄min (209 rad⁄s). prior to shifting gears. With no load on the dynamometers smoothly shift the transmission through the gears (without bucking the axle) allowing the engine to recover to approximately 1500 rpm (157 rad⁄s) between shifts. Shift through the gears until 1:1 ratio (4th gear) is reached. Set temperature control set point to 200 ºF (93.3 °C).

10.3.1.2 Set data acquisition to record pinion torque, wheel speed and axle temperature at a minimum of 1 Hz. Slowly accelerate the driveline until wheel speed is 530 r⁄min ± 5 r⁄min (55 rad⁄s ± 0.5 rad⁄s) (pinion speed 2168 r⁄min ± 20 r⁄min (227 rad⁄s ± 2 rad⁄s)). Apply dynamometers excitation to maintain 50 lbf-ft ± 10 lbf-ft (68 N·m ± 14 N·m) pinion torque.

10.3.1.3 Differential housing oil temperature shall be 200 °F ± 5 °F (93.3 °C ± 2.8 °C) at the start of Shock Series 1. See A5.2.2.2 for L-42 Canadian Version test.

10.3.1.4 Once pinion speed, pinion torque, and axle lubricant temperature reach steady state, lock dynamometer excitation at the output necessary to maintain 50 lbf-ft ± 10 lbf-ft (68 N·m ± 14 N·m), turn off axle oil temperature control, and proceed immediately to 10.3.2.

10.3.2 *Shock Series 1 Procedure:*

10.3.2.1 Turn the axle cooling water off after the ramp-up of Shock Series 1. Ensure that the axle cooling water is off during the shocks. See A5.2.2.3 for L-42 Canadian Version test.

10.3.2.2 Record axle oil temperature at the start of Shock Series 1 on the appropriate form. Maintain the fixed dynamometer excitation until the transmission is shifted into neutral at end of Shock Series 1 in 10.3.2.3.

10.3.2.3 Set data acquisition to acquire pinion torque data at a minimum of 100 Hz, wheel speed at a minimum of 10 Hz and axle temperature at a minimum of 1 Hz While maintaining the fixed dynamometer excitation begin cycling the wheel speed from 530 r⁄min ± 20 r⁄min (55 rad⁄s ± 2 rad⁄s) to 1050 r⁄min ± 20 r⁄min (110 rad⁄s ± 2 rad⁄s). Complete five cycles, ending by accelerating the engine to bring the pinion torque back to near 0, then proceed to 10.3.2.4.

10.3.2.4 Shift transmission into neutral to avoid additional coast side conditioning. Bring engine speed down to idle.

10.4 *Inspection 2*—(**Warning—**Differential is extremely hot. Hot oil can produce vapors.)

10.4.1 Inspect ring gear and report approximate drive and coast percent scoring. Inspection should take approximately 5 min. Make every effort to minimize the time spent during the inspection to maintain the axle temperature. Do not cool the axle at the end of Shock Series 1. Ensure the cooling water remains turned off for the remainder of the test. Table A5.1 shows alternative test versions.

10.5 *Shock Series 2:*

10.5.1 *Shock Series 2 Preparation:*

10.5.1.1 If the axle oil temperature is greater than 280 ºF (137.8 ºC) after Inspection 2, allow the axle oil temperature to cool (*without cooling water*) until axle oil temperature is less than or equal to 280 ºF (137.8 ºC) before shifting transmission through the gears. If the axle oil temperature is less than or equal to 280 °F (137.8 °C) after Inspection 2, proceed immediately to 10.5.1.2.

10.5.1.2 Set the engine speed manual output to achieve approximately 2000 r/min (209 rad/s). prior to shifting gears. With no torque on the dynamometers smoothly shift the transmission through the gears (without bucking the axle) allowing the engine to recover to approximately 1500 rpm (157 rad/s) between shifts. Shift through the gears until 1:1.67 ratio (3rd gear) is reached.

10.5.1.3 Set data acquisition to record pinion torque, wheel speed and axle temperature at a minimum of 1 Hz. Slowly accelerate the driveline until wheel speed is 530 r/min ± 5 r/min (55 rad/s ± 0.5 rad/s) (pinion speed 2168 r/min ± 20 r/min (227 rad/s ± 2 rad/s)). Apply dynamometers excitation to achieve 70 lbf-ft ± 10 lbf-ft (95 N·m ± 14 N·m) pinion torque. When steady state operation is achieved lock dynamometer excitation at the output necessary to maintain 70 lbf-ft ± 10 lbf-ft (95 N·m ± 14 N·m).

10.5.1.4 Record axle oil temperature at the start of Shock Series 2 on the appropriate form. Axle oil temperature shall be less than or equal to 280 °F (137.8 °C) at the start of Shock Series 2. See A5.2.2.4 for L-42 Canadian Version test.

10.5.1.5 Set data acquisition to acquire pinion torque data at a minimum of 100 Hz, wheel speed at a minimum of 10 Hz and axle temperature at a minimum of 1 Hz While maintaining the fixed dynamometer excitation begin cycling the wheel speed from 530 r/min ± 20 r/min (55 rad/s ± 2 rad/s) to 630 r/min ± 20 r/min (66 rad/s ± 2 rad/s). Complete ten cycles, ending by accelerating the engine to bring the pinion torque back to near 0, then proceed to 10.5.1.6.

10.5.1.6 Shift transmission into neutral to avoid additional coast side conditioning. Bring engine speed down to idle.

10.5.1.7 Record end of test time and test minutes in the appropriate test fields.

10.6 *Tear Down Procedure*—(**Warning—** The axle is very hot. Use caution.)

10.6.1 Disconnect dynamometers and drive shafts. Perform end of test procedures.

10.6.2 Check backlash in four equally spaced locations and record measurements on the appropriate form.

10.6.3 Disassemble axle for rating of ring and pinion.

10.6.4 Clean ring and pinion with cleaning solvent (see 7.2) and dry.

11. Determination of Test Results

11.1 *Part Rating:*

11.1.1 Rate and report both drive and coast side of pinion and ring gear for percent of total tooth area that exhibits scoring, see ASTM Distress Rating Manual 21 (formerly CRC Manual 21). Compare the percent scoring for the non-reference oil tests to the percent scoring for the three most recent acceptable reference oil tests.

11.1.2 For a valid rating ensure that the individual rating the test has participated in an ASTM gear rater calibration workshop within the previous twelve months.

11.2 A non-reference oil test that has not been run in a calibrated test stand or not conducted on approved hardware or both is considered non-interpretable. Note on the cover page of the test report that the test is non-interpretable and that it has not been conducted in a valid manner in accordance with the test method.

11.3 Reference oil tests, other than a discrimination oil test, and non-reference oil tests that exhibit end of test ring coast side scoring greater than end of test pinion coast side scoring are non-interpretable.

11.4 Consider reference oil tests, other than the discrimination oil tests, and non-reference oil tests that exhibit drive side scoring non-interpretable.

11.5 *Test Validity*—The test is determined to be operationally valid if the percent deviation of the critical operating parameters and number of shutdowns are within the limits specified and defined in Annex A8.

11.6 Round test results according to Practice E29.

12. Interpretation of Operational Data

12.1 *Data Stream Interpretation*—Figs. A6.11-A6.21 are required in the final test report. Examples shown are meant to display all data collected and optimize the resolution of the data. The *X* and *Y* axis may be rescaled to achieve this.

12.1.1 *Lubricant Temperature:*

12.1.1.1 The initial oil temperature for each test sequence shall consist of the average of the first 5 s of data during the sequence.

12.1.1.2 The maximum oil temperature for each test sequence is the single maximum value experienced during the sequence.

12.1.1.3 Referring to Fig. A6.21, plot all data collected from the start of Conditioning 1 to the end of Shock Series 2. Use the *X* axis as the elapse time data.

12.1.2 *Wheel Speeds:*

12.1.2.1 During Conditioning 1, see Fig. A6.11 location (A) and Conditioning 3, see Fig. A6.12 location (D), the reported wheel speeds shall be the average over the steady-state sequence.

12.1.2.2 Referring to Figs. A6.11 and A6.12, during Conditioning 2 or 4, the value of the maximum and minimum single scan conditioning 2 and 4 wheel speeds are located at (B_1-B_3 and C_1-C_4) and (E_1-E_3 and F_1-F_4) respectively. For both conditioning 2 and 4, independently report the maximum, minimum, and average of the single scan maximum speeds and the maximum, minimum, and average of the single scan minimum speeds by including all peaks and valleys not connected to a steady state operating condition phase.

12.1.2.3 Referring to Fig. A6.13, during Shock Series 1, the value of the maximum and minimum single scan Shock Series 1 wheel speeds are to be found at locations (G_1-G_5) and (H_1-H_4) respectively. Report the maximum, minimum, and average of the single scan maximum speeds and the maximum, minimum, and average of the single scan minimum speeds by including all peaks and valleys not connected to a steady state operating condition phase.

12.1.2.4 Referring to Fig. A6.14, during Shock Series 2, the value of the maximum and minimum single scan Shock Series 2 wheel speeds are to be found at locations (I_1-I_{10}) and (J_1-J_9)

respectively. Report the maximum, minimum, and average of the single scan maximum speeds and the maximum, minimum, and average of the single scan minimum speeds by including all peaks and valleys not connected to a steady state operating condition phase.

12.1.3 *Pinion Torque Conditioning 1–4:*

12.1.3.1 During Conditioning 1, see Fig. A6.15 location (K) and Conditioning 3, see Fig. A6.16 location (N), the reported pinion torque is the average torque over the steady state sequence.

12.1.3.2 Refer to Fig. A6.17, Conditioning 2 pinion torque, and Fig. A6.18, Conditioning 4 pinion torque. Locations (L_0-L_7) and locations (M_0-M_7) represent the zero line crossings for the pinion torque. The drive side gear contact segments are between points 1 and 2, 3 and 4, and 5 and 6, and 7 and beyond. The coast side gear contact segments are between points 0 and 1, 2 and 3, 4 and 5 and 6 and 7.

12.1.3.3 Referring to Figs. A6.17 and A6.18, Conditioning 2 pinion torque and conditioning 4 pinion torque, the maximum and minimum single scan conditioning 2 and 4 pinion torque values are located at (B_1-B_3 and C_1-C_4) and (E_1-E_3 and F_1-F_4) respectively. For both conditioning 2 and 4, independently report the maximum, minimum, and average of the single scan maximum pinion torques and the maximum, minimum, and average of the single scan minimum pinion torques by including all peaks and valleys not connected to a steady state operating condition phase. Ignore the drive side gear contact segments beyond zero crossings 7 since their stop times are not well defined.

12.1.4 *Pinion Torque—Shock Series 1:*

12.1.4.1 Referring to Fig. A6.19, the zero pinion torque crossings (O_0-O_9) are located where the pinion torque value crosses zero. The coast side gear contact segments are between points 0 and 1, 2 and 3, 4 and 5, 6 and 7, and 8 and 9. The drive side gear contact segments are between points 0 and prior, 1 and 2, 3 and 4, 5 and 6, and 7 and 8.

12.1.4.2 Referring to Fig. A6.19, during Shock Series 1, the value of the maximum and minimum single scan Shock Series 1 pinion torques is to be found at locations (P_1-P_5) and (Q_1-Q_5) respectively. Report the maximum, minimum, and average of the single scan maximum pinion torques and the maximum, minimum, and average of the single scan minimum pinion torques.

12.1.4.3 Calculate and report the maximum, minimum, and average drive side gear contact segment time. Calculate and report the maximum, minimum, and average coast side gear contact segment time. For these time calculations, ignore the first drive side segment and the last coast side segment since zero crossings are not well defined.

12.1.5 *Pinion Torque—Shock Series 2:*

12.1.5.1 Referring to Fig. A6.20, the zero pinion torque crossings (R_0-R_{19}) are located where the pinion torque value crosses zero. The coast side gear contact segments are between points 0 and 1, 2 and 3, 4 and 5, 6 and 7, 8 and 9, 10 and 11, 12 and 13, 14 and 15, 16 and 17, and 18 and 19. The drive side gear contact segments are between points 0 and prior, 1 and 2, 3 and 4, 5 and 6, 7 and 8, 9 and 10, 11 and 12, 13 and 14, 15 and 16, and 17 and 18.

12.1.5.2 Referring to Fig. A6.20, during Shock Series 2, the value of the maximum and minimum single scan Shock Series 2 pinion torques is to be found at locations (S_1-S_{10}) and (T_1-T_{10}) respectively. Report the maximum, minimum, and average of the single scan maximum pinion torques and the maximum, minimum, and average of the single scan minimum pinion torques.

12.1.5.3 Calculate and report the maximum, minimum, and average drive side gear contact segment time. Calculate and report the maximum, minimum, and average coast side gear contact segment time. For these time calculations, ignore the first drive side segment and the last coast side segment since zero crossings are not well defined.

12.1.6 *Total Test Time:*

12.1.6.1 Calculate and report total test time starting from the beginning of Conditioning 1 to the end of Shock 2.

13. Report

13.1 For reference oil results, use the standardized report form set available from the ASTM TMC.

NOTE 2—Report the non-reference oil test results on these same forms if the results are intended to be submitted as candidate oil results against a specification.

13.1.1 Fill out the report forms according to the formats shown in the data dictionary.

13.1.2 Transmit results to the TMC within 5 working days of test completion.

13.1.3 Transmit the results electronically as described in the ASTM Data Communications Committee Test Report Transmission Model (Section 2 — Flat File Transmission Format) available from the ASTM TMC. Upload files via the TMC's website.

13.2 Report all reference oil test results, whether aborted, invalidated, or successfully completed, to the TMC.

13.3 *Deviations from Test Operational Limits*—Report all deviations from specified test operational limits.

13.4 *Precision of Reported Units*—Use the Practice E29 rounding off method for critical pass/fail test result data. Report the data to the same precision as indicated in data dictionary.

13.5 In the space provided, note the time, date, test hour, and duration of any shutdown or off-test condition. Document the outcome of all prior reference oil tests from the current calibration sequence that were operationally or statistically invalid.

13.6 If a calibration period is extended beyond the normal calibration period length, make a note in the comment section

TABLE 2 Reference Oil Statistics[A]

Variable, Merits	Intermediate Precision		Reproducibility	
	$s_{i.p.}$[B]	i.p.[C]	s_R[B]	R[C]
Scoring	5.523	15.464	5.732	16.050

[A] These statistics are based on results from tests obtained on TMC Reference Oils 116, 116-1, and 117 from Sept. 28, 2005 to Aug. 19, 2015.
[B] s = standard deviations.
[C] This value is obtained by multiplying the standard deviation by 2.8.

and attach a written confirmation of the granted extension from the TMC to the test report. List the outcomes of previous runs that may need to be considered as part of the extension in the comment section.

13.7 When reporting the stand set-up version, use the L-42 data dictionary format of yyyymmdd-x; where: (*1*) yyyymmdd is the date the calibration sequence is started, and (*2*) x is a number that starts with one and is incremented each time a change is made that requires that calibration sequence to be started over.

13.7.1 Changing the torque settings is an example of a change that would require the calibration sequence to start over.

14. Precision and Bias

14.1 *Precision:*

14.1.1 Test precision is established on the basis of operationally valid reference oil test results monitored by the TMC.

14.1.2 *Intermediate Precision Conditions*—Conditions where test results are obtained with the same test method using the same oil, with changing conditions such as operators, measuring equipment, test stands, test engines and time.

NOTE 3—Intermediate precision is the appropriate term for this test method rather than repeatability, which defines more rigorous within-laboratory conditions.

14.1.2.1 *Intermediate Precision Limit (i.p.)*—The difference between two results obtained under intermediate precision conditions that would, in the long run, in the normal and correct conduct of the test method, exceed the values shown in Table 2 in only one case in twenty. When only a single test result is available, the Intermediate Precision Limit can be used to calculate a range (test result ± Intermediate Precision Limit) outside of which a second test result would be expected to fall about one time in twenty.

14.1.3 *Reproducibility Conditions*—Conditions where test results are obtained with the same test method using the same test oil in different laboratories with different operators using different equipment.

14.1.3.1 *Reproducibility Limit (R)*—The difference between two results obtained under reproducibility conditions that would, in the long run, in the normal and correct conduct of the test method, exceed the values shown in Table 2 in only one case in twenty. When only a single test result is available, the Reproducibility Limit can be used to calculate a range (test result ± Reproducibility Limit) outside of which a second test result would be expected to fall about one time in twenty.

14.2 *Bias*—No estimate of bias is possible, as the behavior of a lubricant is determined only under the specific conditions of the test and no absolute standards exist.

15. Keywords

15.1 automotive gear oils; extreme pressure lubricants; final drive axle; hypoid gear lubricants; L-42

ANNEXES

(Mandatory Information)

A1. ASTM TEST MONITORING CENTER ORGANIZATION

A1.1 *Nature and Functions of the ASTM Test Monitoring Center (TMC)*—The TMC is a non-profit organization located in Pittsburgh, Pennsylvania and is staffed to: administer engineering studies; conduct laboratory inspections; perform statistical analyses of reference oil test data; blend, store, and ship reference oils; and provide the associated administrative functions to maintain the referencing calibration program for various lubricant tests as directed by ASTM Subcommittee D02.B0 and the TMC Executive Committee. The TMC coordinates its activities with the test sponsors, the test developers, the surveillance panels, and the testing laboratories. Contact TMC through the TMC Director at:

ASTM Test Monitoring Center
555 Penn Avenue
Pittsburgh, PA 15206-4489
www.astmtmc.cmu.edu

A1.2 *Rules of Operation of the ASTM TMC*—The TMC operates in accordance with the ASTM Charter, the ASTM Bylaws, the Regulations Governing ASTM Technical Committees, the Bylaws Governing ASTM Committee D02, and the Rules and Regulations Governing the ASTM Test Monitoring System.

A1.3 *Management of the ASTM TMC*—The management of the Test Monitoring System is vested in the Executive Committee elected by Subcommittee D02.B0. The Executive Committee selects the TMC Director who is responsible for directing the activities of the TMC.

A1.4 *Operating Income of the ASTM TMC*—The TMC operating income is obtained from fees levied on the reference oils supplied and on the calibration tests conducted. Fee schedules are established by the Executive Committee and reviewed by Subcommittee D02.B0.

A2. ASTM TEST MONITORING CENTER: CALIBRATION PROCEDURES

A2.1 *Reference Oils*—These oils are formulated or selected to represent specific chemical, or performance levels, or both. They are usually supplied directly to a testing laboratory under code numbers to ensure that the laboratory is not influenced by prior knowledge of acceptable results in assessing test results. The TMC determines the specific reference oil the laboratory shall test.

A2.1.1 *Reference Oil Data Reporting*—Test laboratories that receive reference oils for stand calibration shall submit data to the TMC on every sample of reference oil they receive. If a shipment contains any missing or damaged samples, the laboratory shall notify the TMC immediately.

A2.2 *Calibration Testing*:

A2.2.1 Full-scale calibration testing shall be conducted at regular intervals. These full-scale tests are conducted using coded reference oils supplied by the TMC. It is a laboratory's responsibility to keep the on-site reference oil inventory at or above the minimum level specified by the TMC test engineers.

A2.2.2 *Test Stands Used for Non-Standard Tests*—If a non-standard test is conducted on a previously calibrated test stand, the laboratory shall conduct a reference oil test on that stand to demonstrate that it continues to be calibrated, prior to running standard tests.

A2.3 *Reference Oil Storage*—Store reference oils under cover in locations where the ambient temperature is between –10 °C and +50 °C.

A2.4 *Analysis of Reference Oil*—Unless specifically authorized by the TMC, do not analyze TMCreference oils, either physically or chemically. Do not resell ASTM reference oils or supply them to other laboratories without the approval of the TMC. The reference oils are supplied only for the intended purpose of obtaining calibration under the ASTM Test Monitoring System. Any unauthorized use is strictly forbidden. The testing laboratory tacitly agrees to use the TMC reference oils exclusively in accordance with the TMC's published Policies for Use and Analysis of ASTM Reference Oils, and to run and report the reference oil test results according to TMC guidelines. Additional policies for the use and analysis of ASTM Reference Oils are available from the TMC.

A2.5 *Conducting a Reference Oil Test*—When laboratory personnel are ready to run a reference calibration test, they shall request an oil code via the TMC website.

A2.6 *Reporting Reference Oil Test Results*—Upon completion of the reference oil test, the test laboratory transmits the data electronically to the TMC, as described in Section 13. The TMC reviews the data and contacts the laboratory engineer to report the laboratory's calibration status. All reference oil test results, whether aborted, invalidated, or successfully completed, shall be reported to the TMC.

A2.6.1 All deviations from the specified test method shall be reported.

A3. ASTM TEST MONITORING CENTER: MAINTENANCE ACTIVITIES

A3.1 *Special Reference Oil Tests*—To ensure continuous severity and precision monitoring, calibration tests are conducted periodically throughout the year. Occasionally, the majority or even all of the industry's test stands will conduct calibration tests at roughly the same time. This could result in an unacceptably large time frame when very few calibration tests are conducted. The TMC can shorten or extend calibration periods as needed to provide a consistent flow of reference oil test data. Adjustments to calibration periods are made such that laboratories incur no net loss or gain in calibration status.

A3.2 *Special Use of the Reference Oil Calibration System*—The surveillance panel has the option to use the reference oil system to evaluate changes that have potential impact on test severity and precision. This option is only taken when a program of donated tests is not feasible. The surveillance panel and the TMC shall develop a detailed plan for the test program. This plan requires all reference oil tests in the program to be completed as close to the same time as possible, so that no laboratory/stand calibration status is left pending for an excessive length of time. In order to maintain the integrity of the reference oil monitoring system, each reference oil test is conducted so as to be interpretable for stand calibration. To facilitate the required test scheduling, the surveillance panel may direct the TMC to lengthen and shorten reference oil calibration periods within laboratories such that the laboratories incur no net loss or gain in calibration status. To ensure accurate stand, or laboratory, or both severity assessments, conduct non-reference oil tests the same as reference oil tests.

A3.3 *Donated Reference Oil Test Programs*—The surveillance panel is charged with maintaining effective reference oil test severity and precision monitoring. During times of new parts introductions, new or re-blended reference oil additions, and procedural revisions, it may be necessary to evaluate the possible effects on severity and precision levels. The surveillance panel may choose to conduct a program of donated reference oil tests in those laboratories participating in the monitoring system, in order to quantify the effect of a particular change on severity and precision. Typically, the surveillance panel requests its panel members to volunteer enough reference oil test results to create a robust data set. Broad laboratory participation is needed to provide a representative sampling of the industry. To ensure the quality of the data obtained, donated tests are conducted on calibrated test stands. The surveillance panel shall arrange an appropriate number of donated tests and ensure completion of the test program in a timely manner.

A3.4 *Intervals Between Reference Oil Tests*—Under special circumstances, such as extended downtime caused by industry-wide parts or fuel shortages, the TMC may extend the intervals between reference oil tests.

A3.5 *Introducing New Reference Oils*—Reference oils produce various results. When new reference oils are selected, participating laboratories will be requested to conduct their share of tests to enable the TMC to recommend industry test targets. ASTM surveillance panels require a minimum number of tests to establish the industry test targets for new reference oils.

A3.6 *TMC Information Letters*—Occasionally it is necessary to revise the test method, and notify the test laboratories of the change, prior to consideration of the revision by Subcommittee D02.B0. In such a case, the TMC issues an Information Letter. Information Letters are balloted semi-annually by Subcommittee D02.B0, and subsequently by D02. By this means, the Society due process procedures are applied to these Information Letters.

A3.6.1 *Issuing Authority*—The authority to issue an Information Letter differs according to its nature. In the case of an Information Letter concerning a part number change which does not affect test results, the TMC is authorized to issue such a letter. Long-term studies by the surveillance panel to improve the test procedure through improved operation and hardware control may result in the issuance of an Information Letter. If obvious procedural items affecting test results need immediate attention, the test sponsor and the TMC issue an Information Letter and present the background and data supporting that action to the surveillance panel for approval prior to the semiannual Subcommittee D02.B0 meeting.

A3.7 *TMC Memoranda*—In addition to the Information Letters, supplementary memoranda are issued. These are developed by the TMC and distributed to the appropriate surveillance panel and participating laboratories. They convey such information as batch approvals for test parts or materials, clarification of the test procedure, notes and suggestions of the collection and analysis of special data that the TMC may request, or for any other pertinent matters having no direct effect on the test performance, results, or precision and bias.

A4. ASTM TEST MONITORING CENTER: RELATED INFORMATION

A4.1 *New Laboratories*—Laboratories wishing to become part of the ASTM Test Monitoring System will be requested to conduct reference oil tests to ensure that the laboratory is using the proper testing techniques. Information concerning fees, laboratory inspection, reagents, testing practices, appropriate committee membership, and rater training can be obtained by contacting the TMC Director.

A4.2 *Information Letters: COTCO Approval*—Authority for the issuance of Information Letters was given by the committee on Technical Committee Operations in 1984, as follows: "COTCO recognizes that D02 has a unique and complex situation. The use of Information Letters is approved providing each letter contains a disclaimer to the affect that such has not obtained ASTM consensus. These Information Letters should be moved to such consensus as rapidly as possible."

A4.3 *Precision Data*—The TMC determines the precision of test methods by analyzing results of calibration tests conducted on reference oils. Precision data are updated regularly. Current precision data can be obtained from the TMC.

A5. L-42 TEST VERSIONS

A5.1 *Test Versions*—This test method has two commonly used versions. The test procedures and conditions described previously in this test method will be referred to as the standard version. All versions maintain the same test procedures, pinion loads, and wheel speed conditions. The differences occur in the axle oil temperature only. Table A5.1 describes each version.

NOTE A5.1—In shock series 2 for the Canadian test method, the cooling water control set point is set to 200 °F (93.3 °C). The maximum rise above the starting temperature during the shock sequence is to be 15 °F (8.3 °C), or the test is considered non-interpretable.

TABLE A5.1 Test Versions[A,B]

Test Version	Shock Series 1 Starting Temperature	Shock Series 2 Starting Temperature
Standard	200 °F ± 5 °F (93.3 °C ± 2.8 °C)	See 10.5.1.1
Canadian	175 °F ± 5 °F (79.4 °C ± 2.8 °C)	200 °F ± 5 °F (93.3 °C ± 2.8 °C)

[A] Both versions use the same wheel speed, load conditions, and test procedures (except Note A5.1) as described in Section 10.
[B] The Canadian test version is typically used for evaluation of 70W, 70W-XX, 75W, and 75W-xx lubricants.

A5.2 L-42 Canadian Version Test Requirements

A5.2.1 *Calibration Test Acceptance* (see Section 9):

A5.2.1.1 Calibration status of the L-42 Canadian Version test is determined by successfully calibrating a test stand according to the L-42 Standard Version test requirements detailed in Section 9. In other words, a stand that is calibrated for the L-42 Standard Version test is automatically calibrated for the L-42 Canadian Version test.

A5.2.2 *Test Procedure:*

A5.2.2.1 Operate the test as outlined in 10.1 through 10.5 of the L-42 Standard Version test with the exceptions of the following sections. The procedure modifications listed in this annex refer to the corresponding section of the L-42 Standard Version test.

A5.2.2.2 Differential housing oil temperature is 175 °F ± 5 °F (79.4 °C ± 2.8 °C) at the start of Shock Series 1, see 10.3.1.3.

A5.2.2.3 Ensure that the axle cooling water remains turned on through out the remainder of the test, see 10.3.2.1.

A5.2.2.4 Set and maintain the differential housing oil temperature at 200 °F ± 5 °F (93.3 °C ± 2.8 °C), see 10.5.1.1.

A6. SYSTEM DRAWINGS

A6.1 The following drawings are shown to assist the users of this test method.

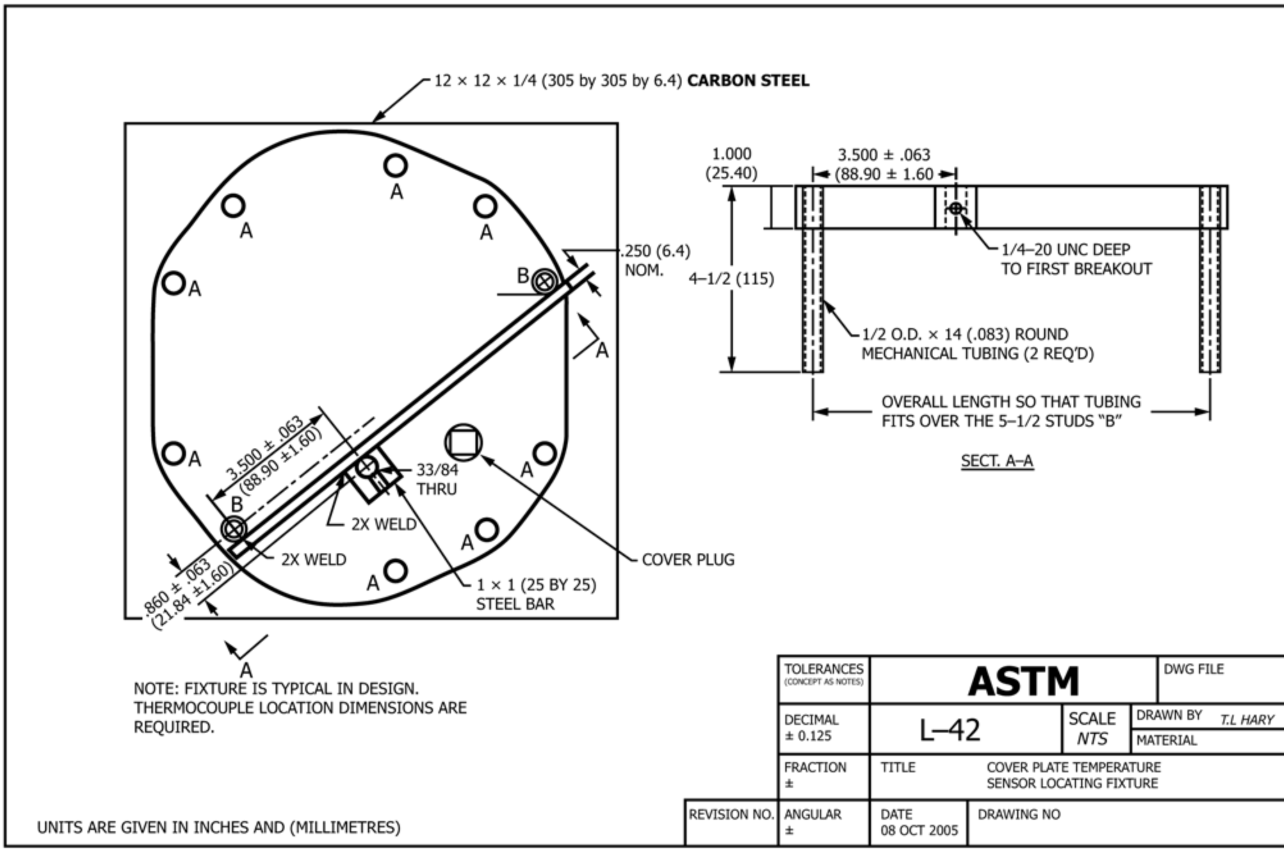

FIG. A6.1 Cover Plate Temperature Sensor Locating Device

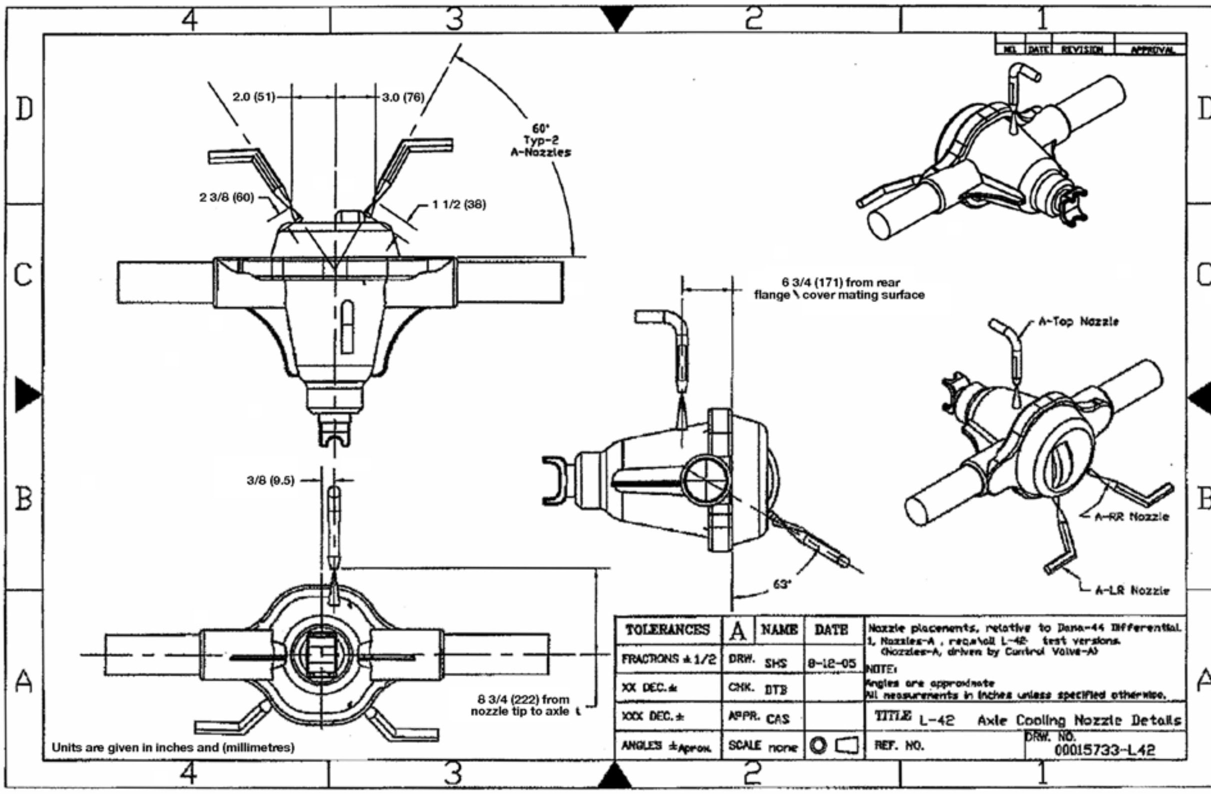

FIG. A6.2 Location of Spray Nozzles on Axle

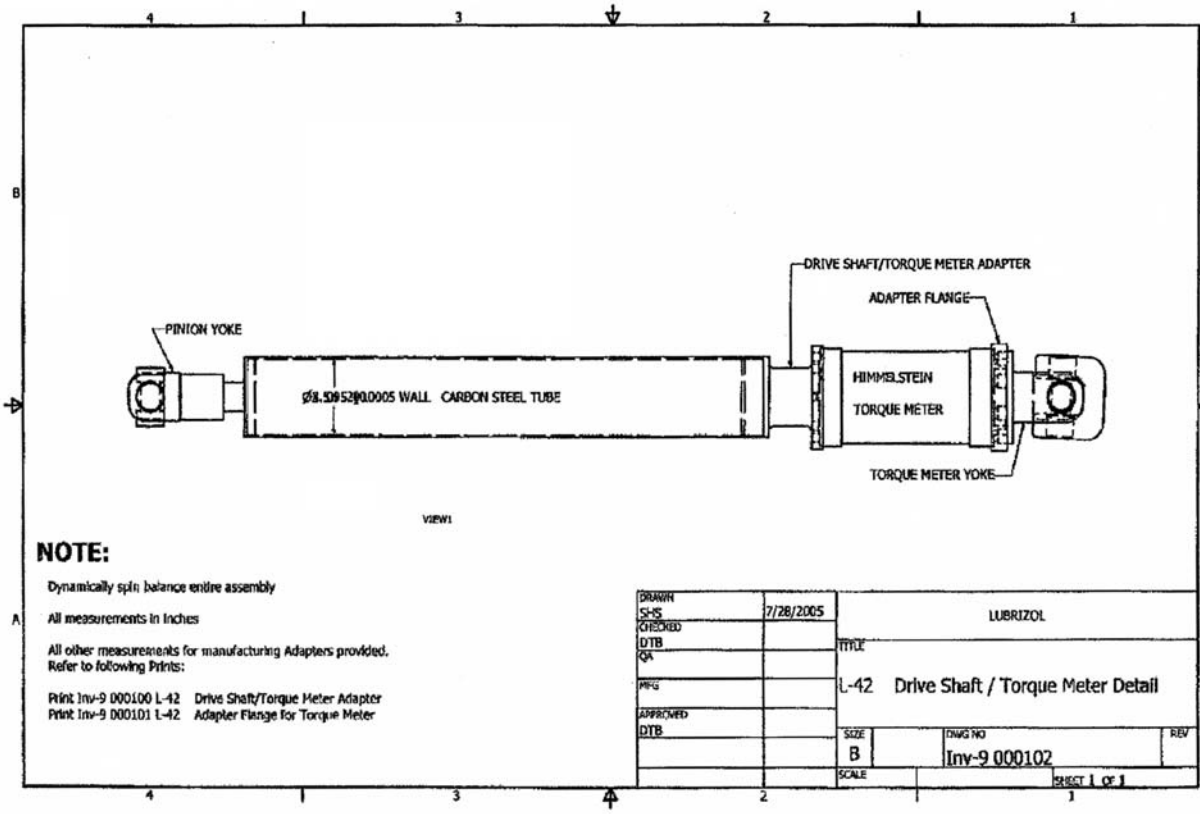

FIG. A6.3 Drive Shaft Torque Meter Assembly

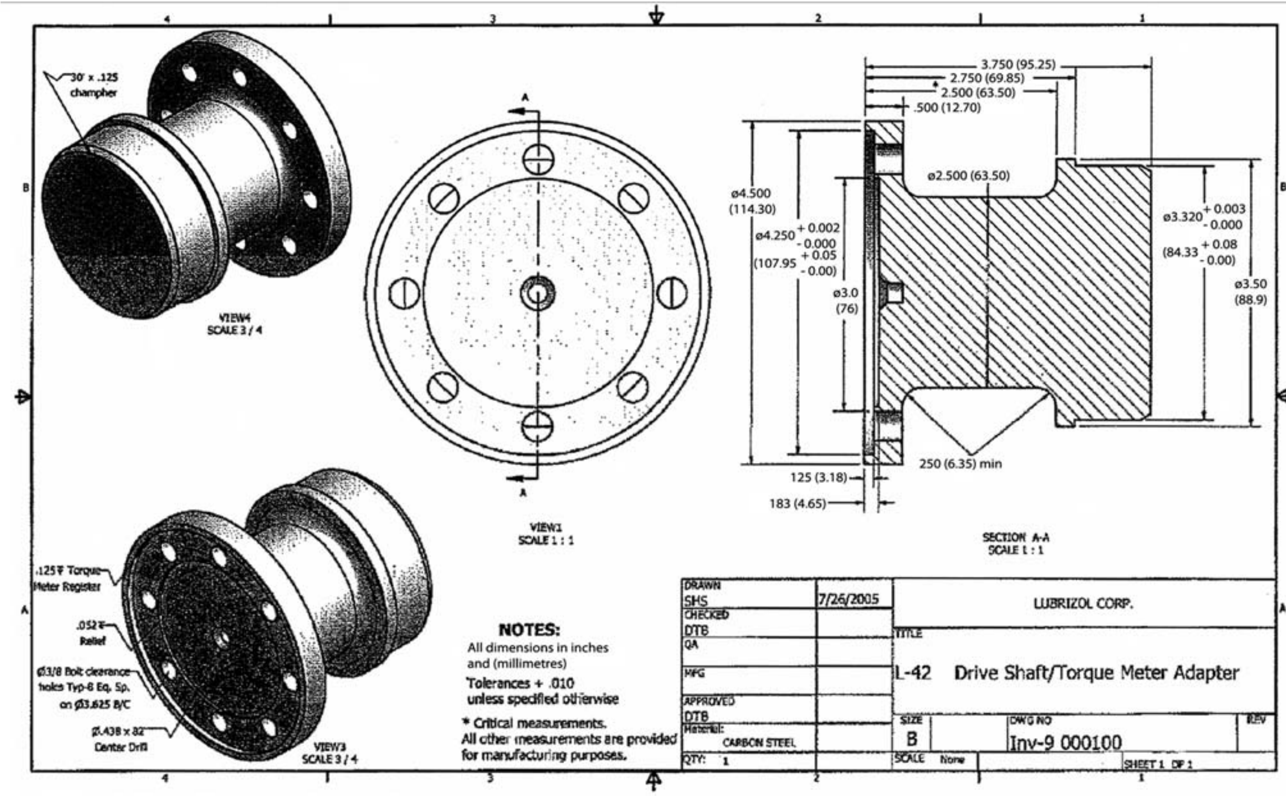

FIG. A6.4 Torque Meter Adapter

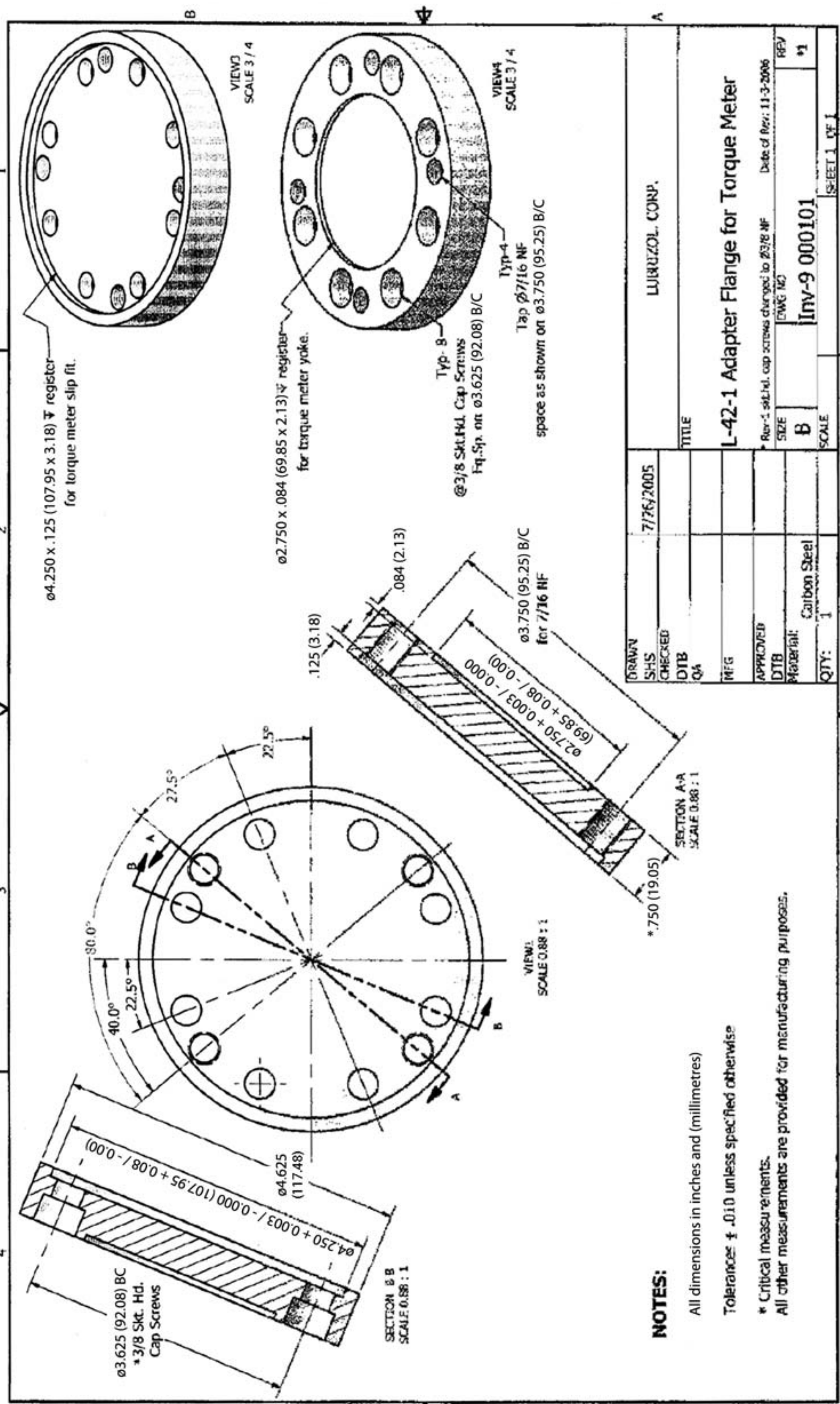

FIG. A6.5 Torque Meter Adapter Flange

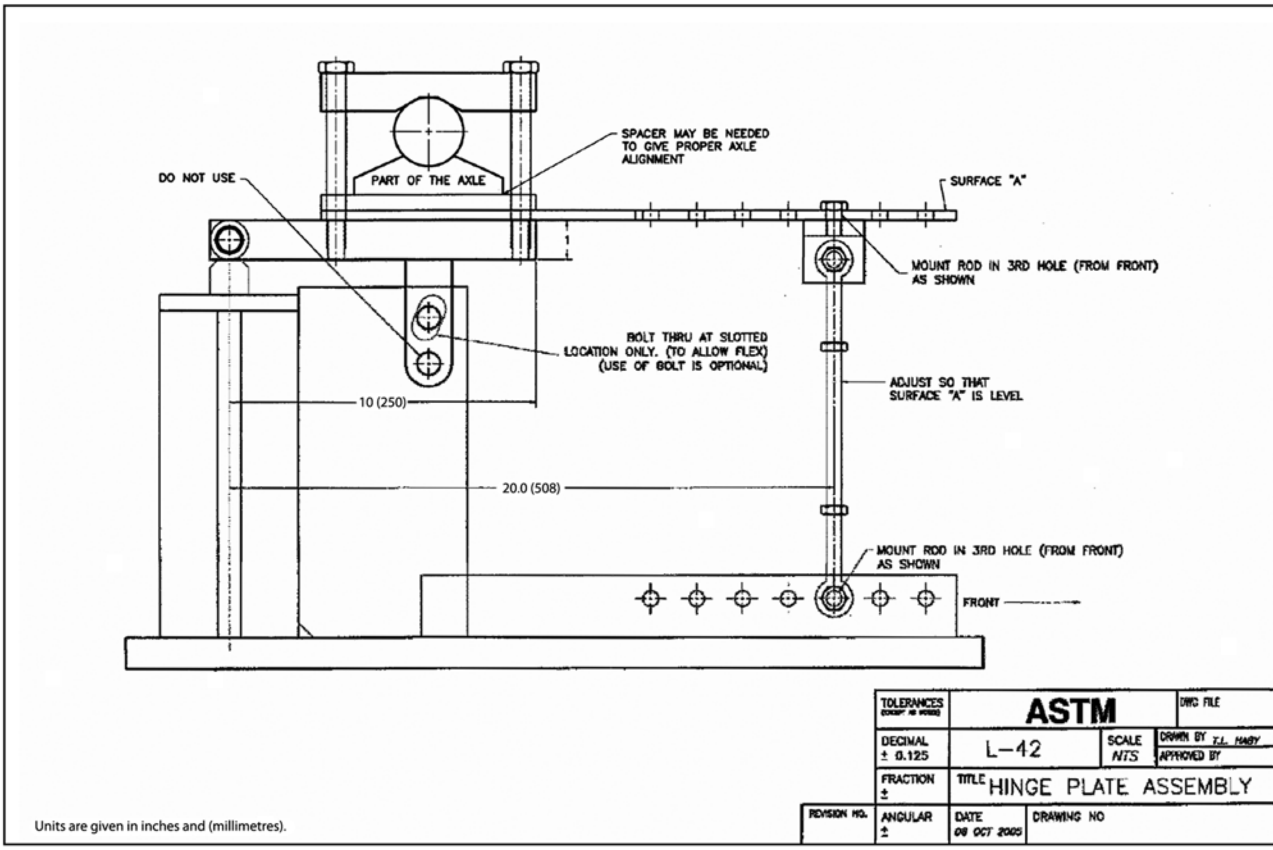

FIG. A6.6 Hinge Plate Stand Assembly

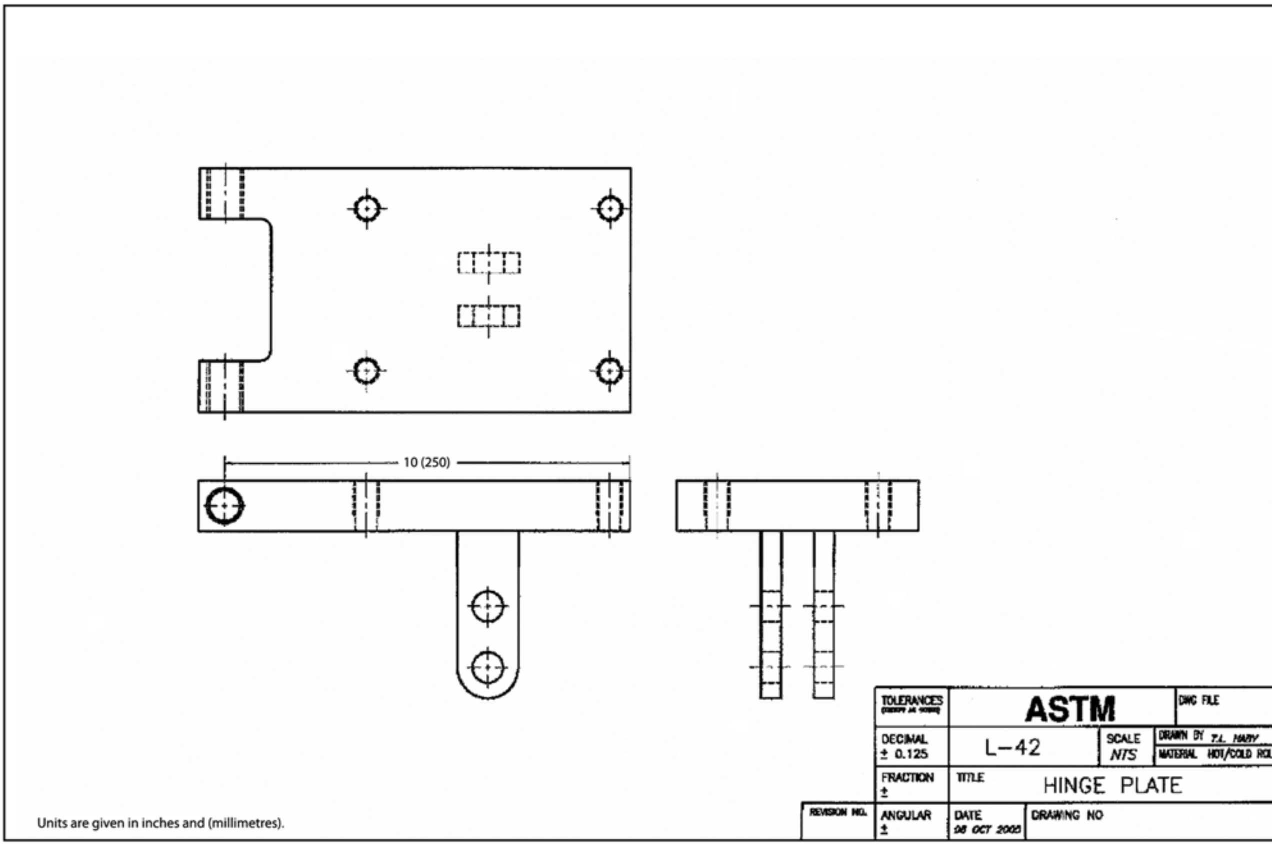

FIG. A6.7 Hinge Plate

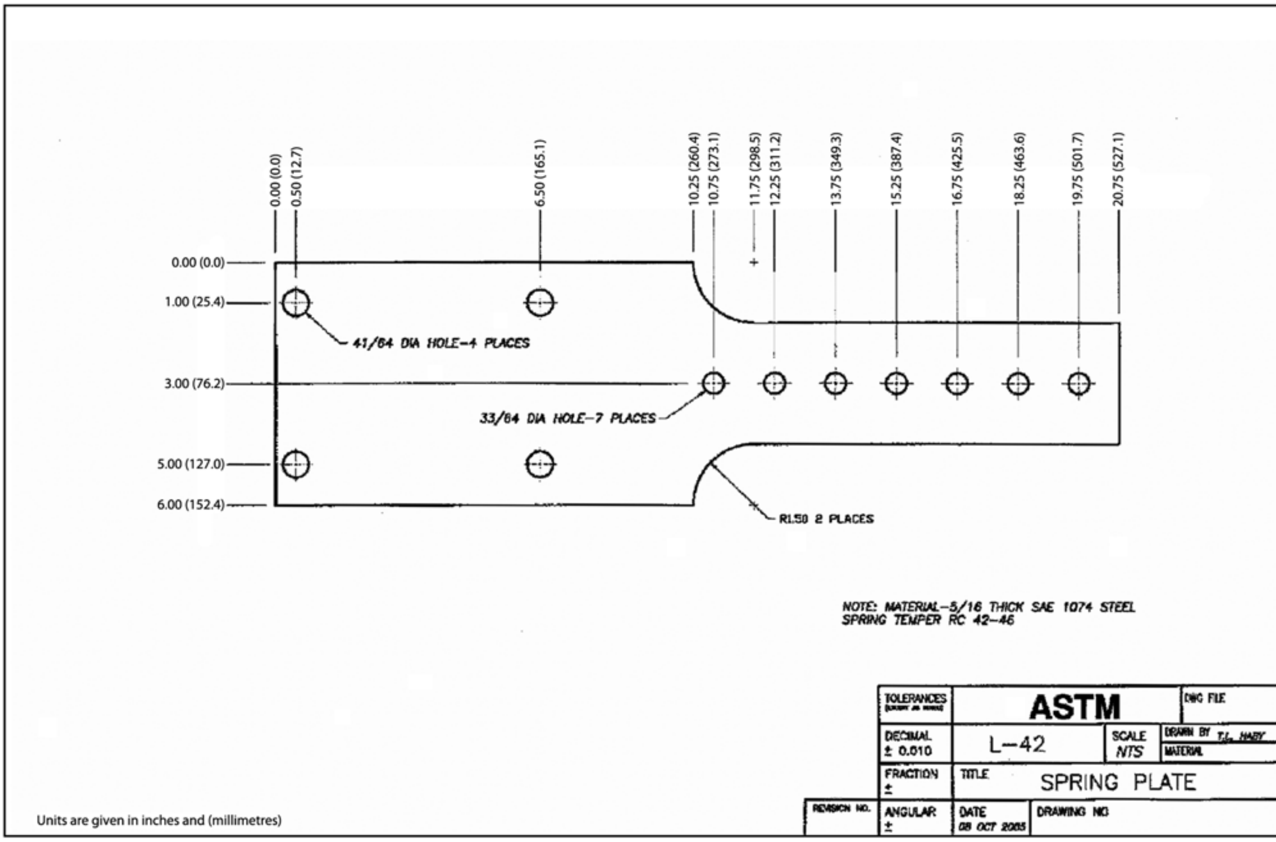

FIG. A6.8 Spring Plate

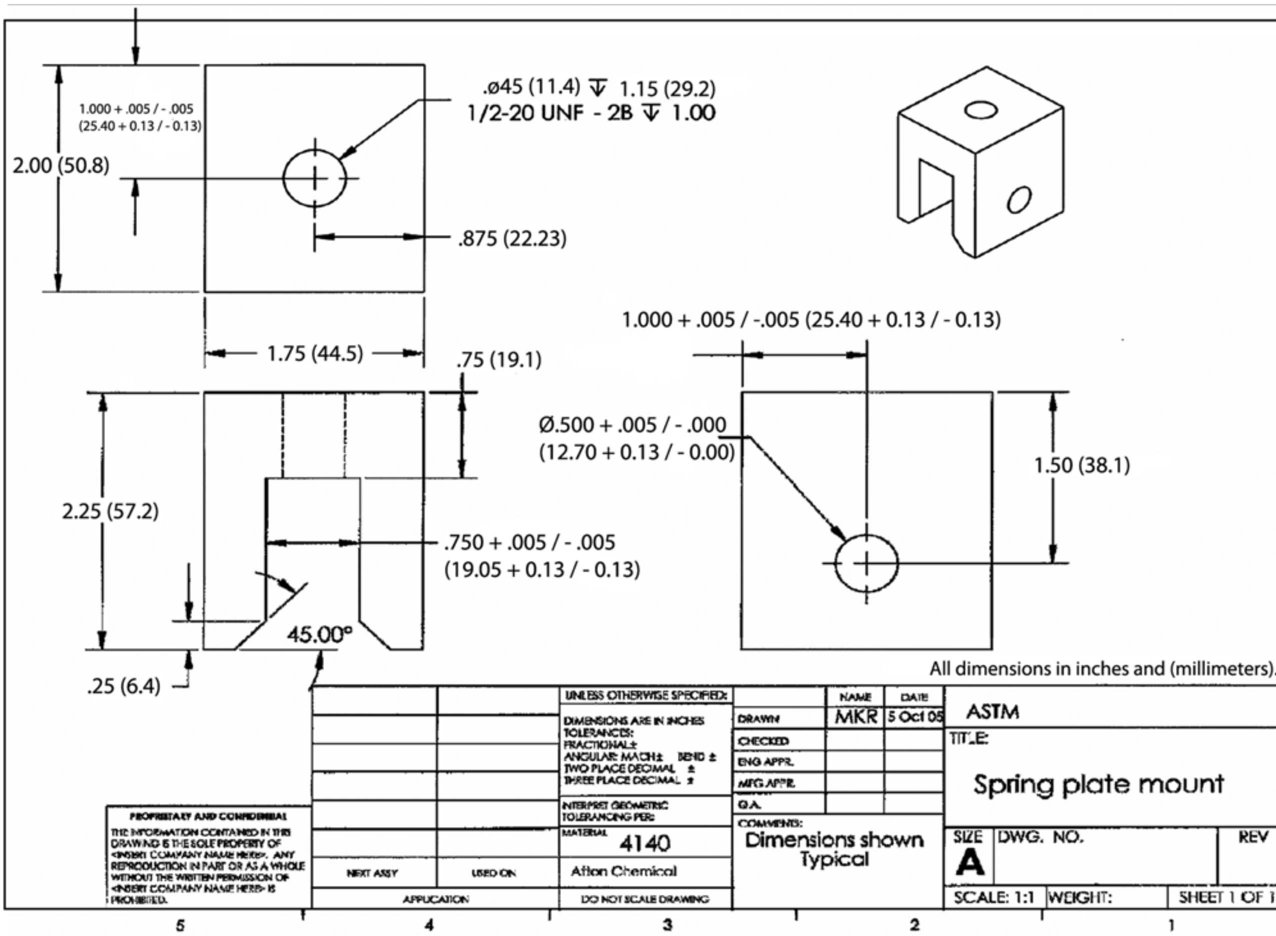

FIG. A6.9 Spring Plate Mount

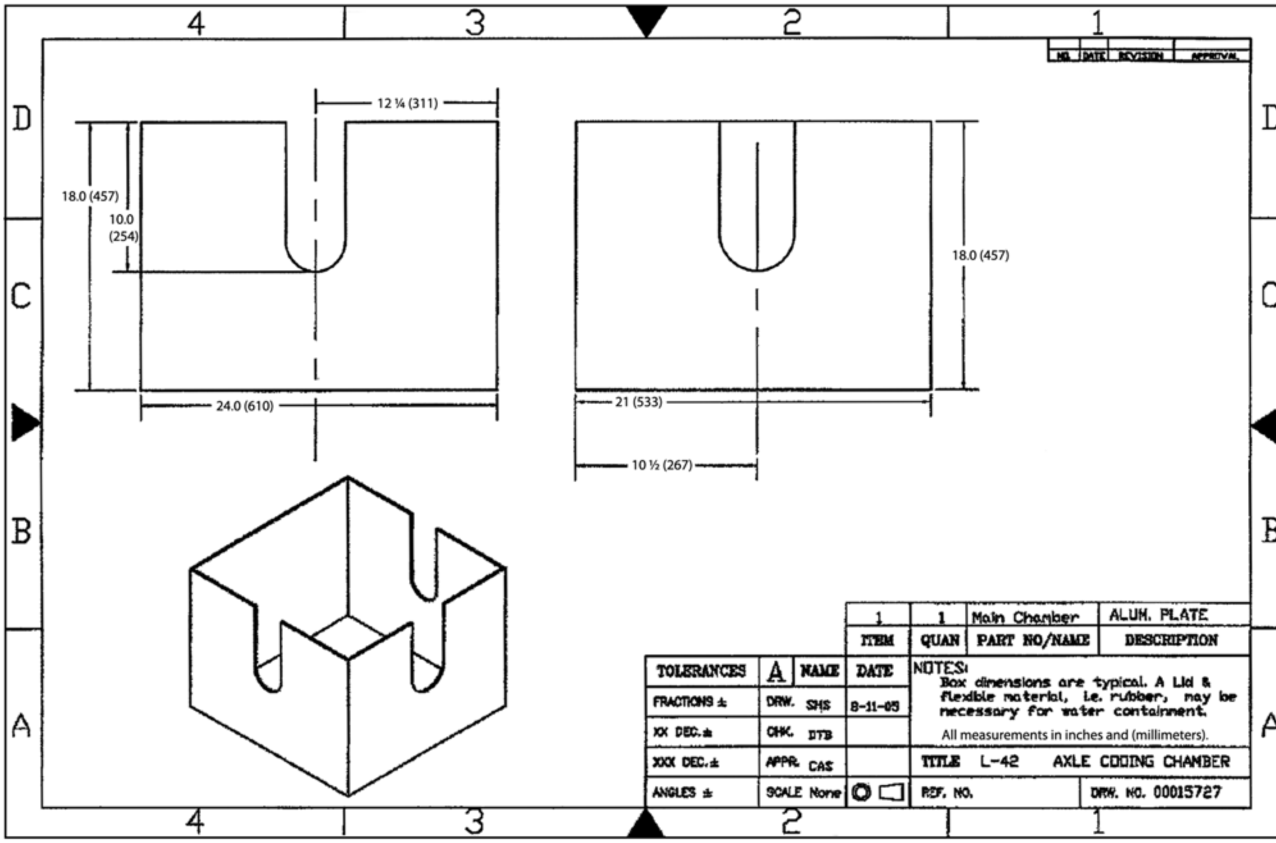

FIG. A6.10 Axle Containment Box

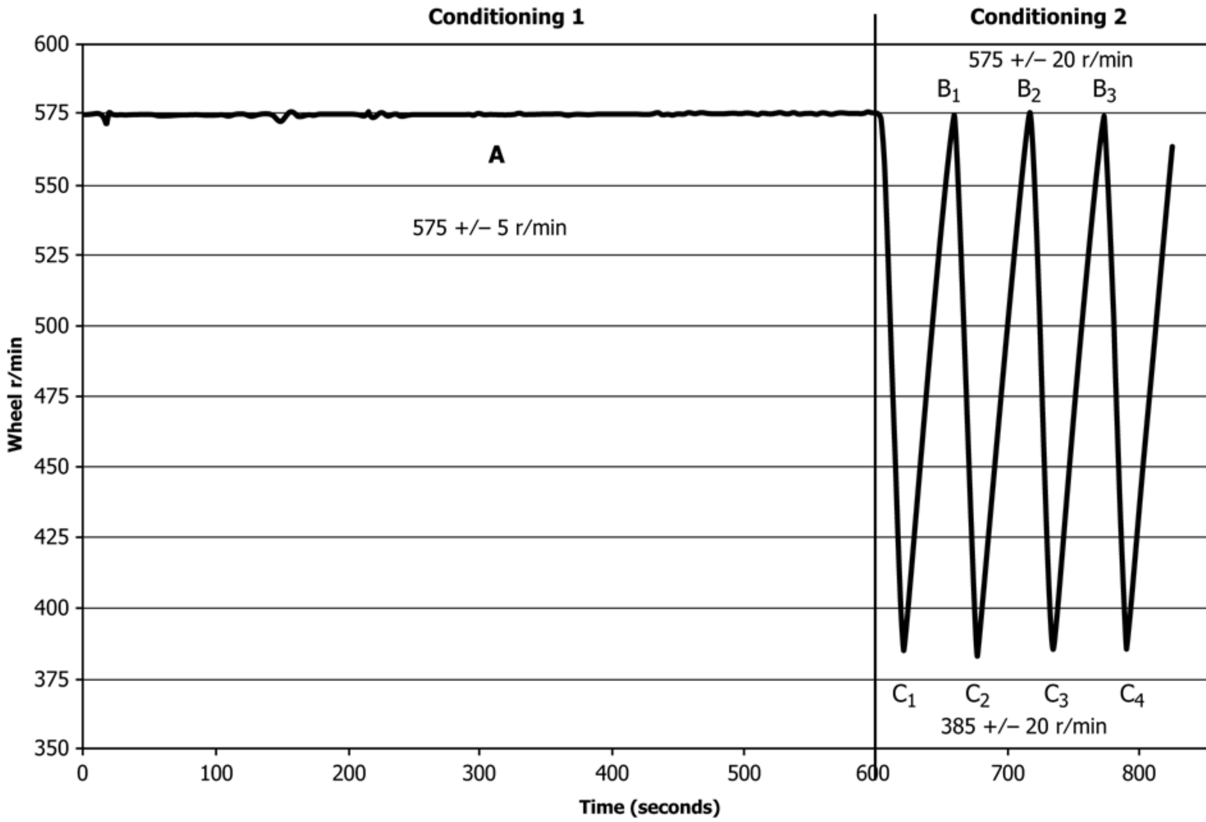

FIG. A6.11 Conditioning 1 & 2—Wheel Speed

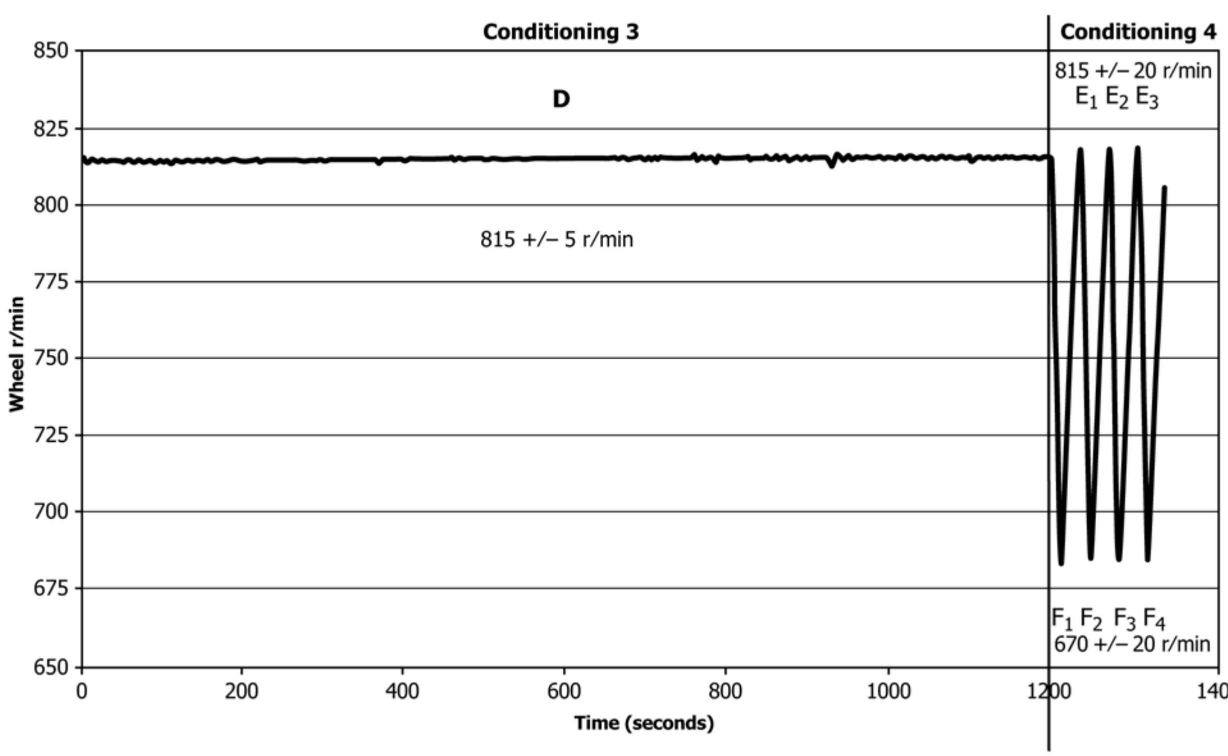

FIG. A6.12 Conditioning 3 & 4—Wheel Speed

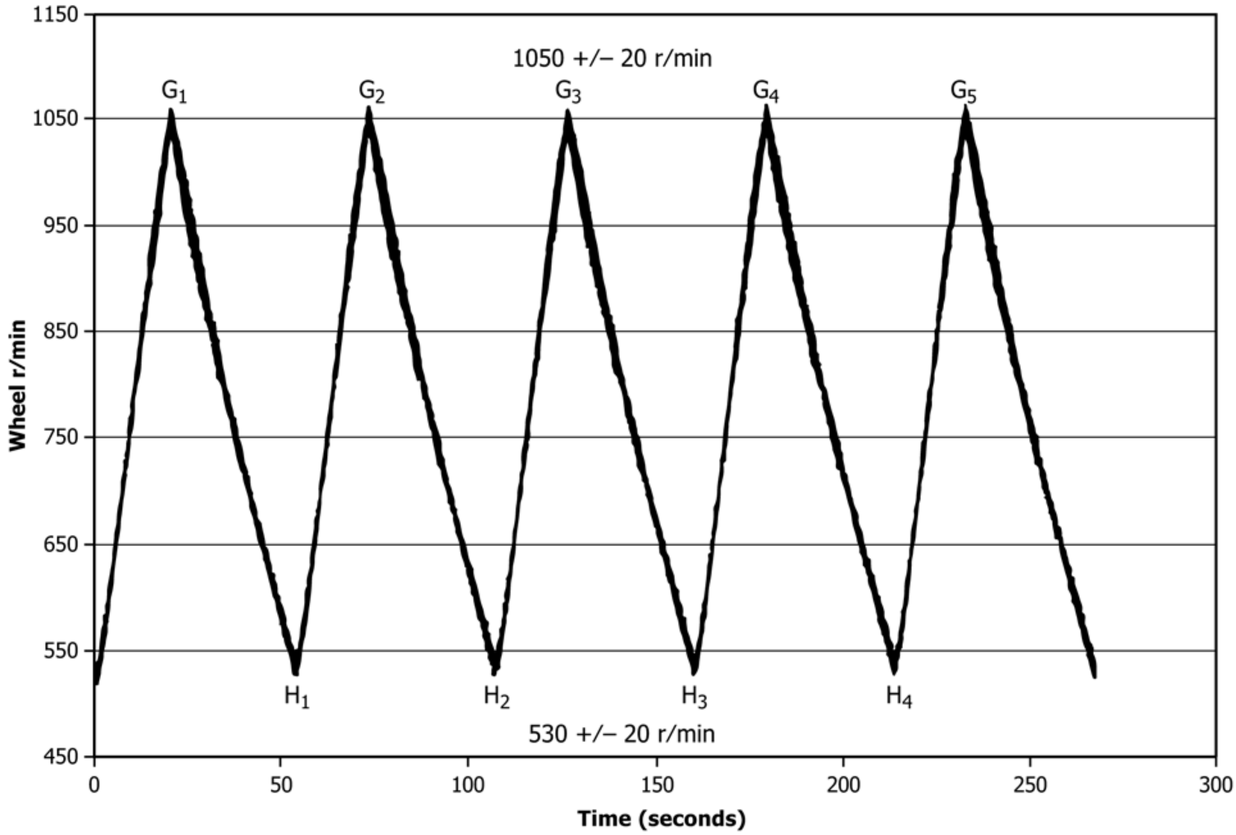

FIG. A6.13 Shock Series One—Wheel Speed (5 Shocks)

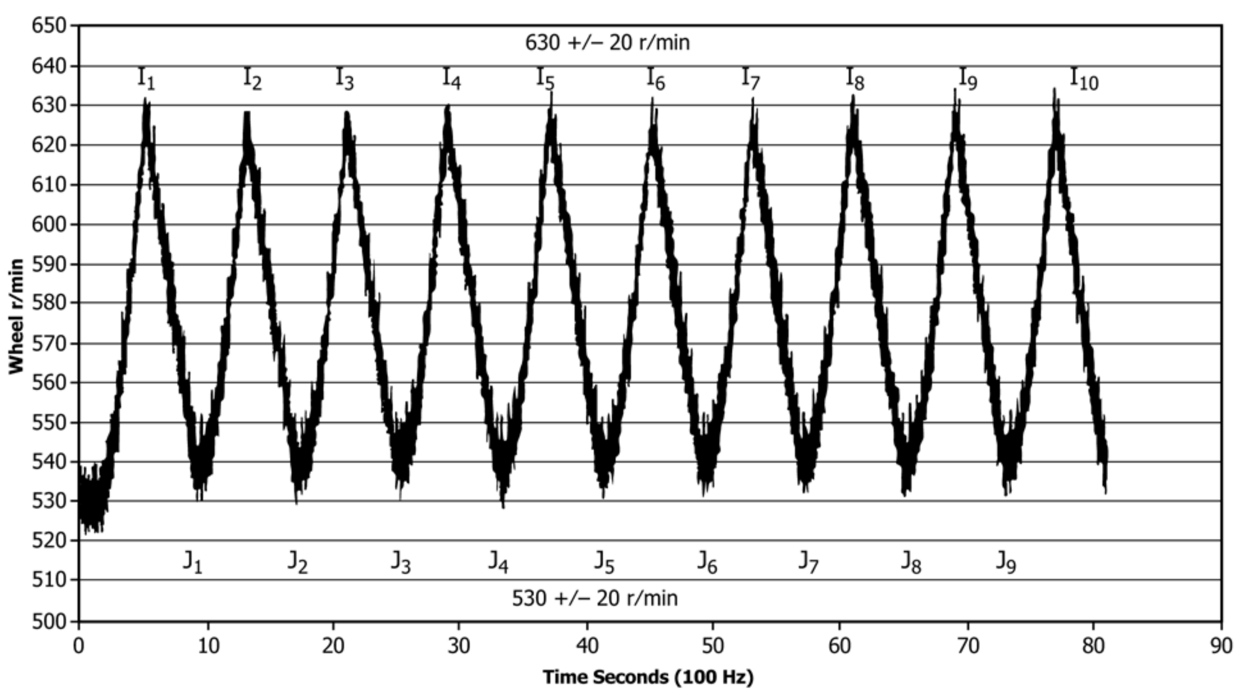

FIG. A6.14 Shock Series Two—Wheel Speed (10 Shocks)

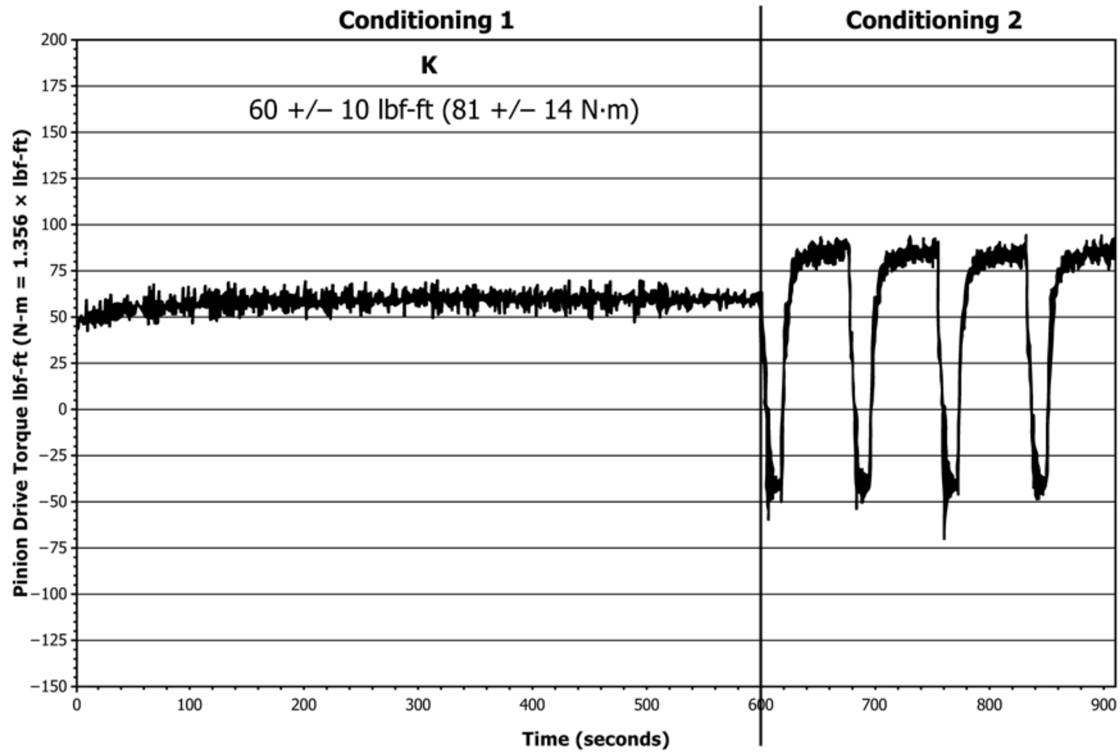

FIG. A6.15 Conditioning 1 & 2—Pinion Torque

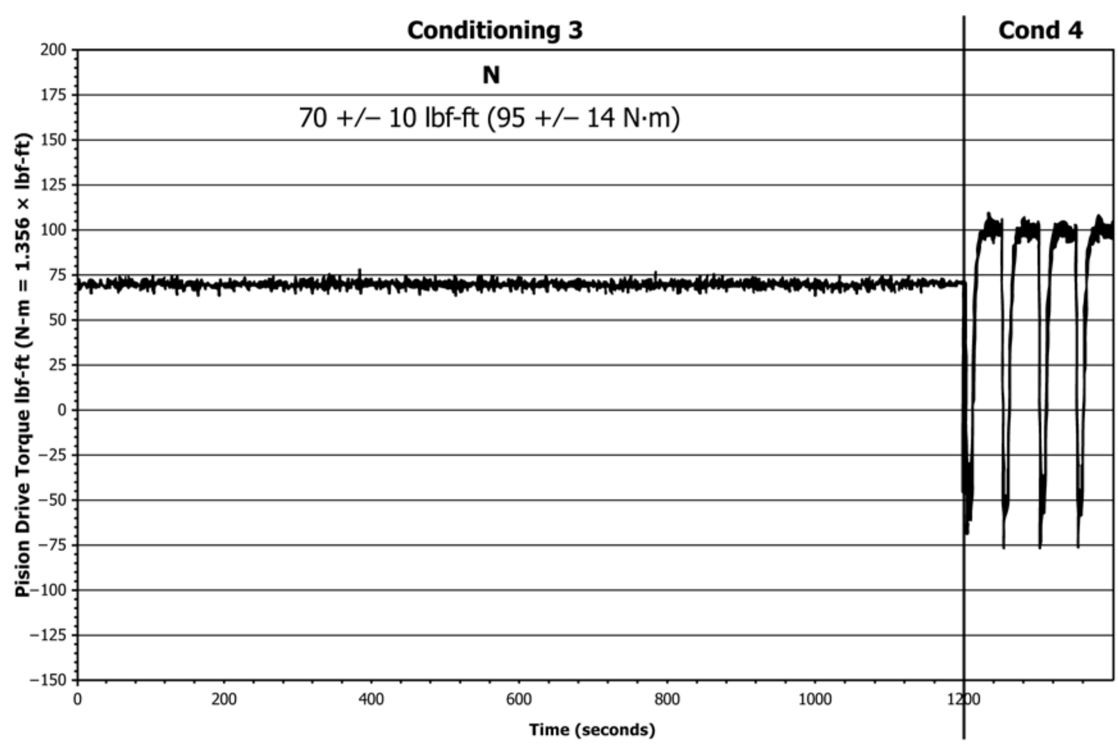

FIG. A6.16 Conditioning 3 & 4—Pinion Torque

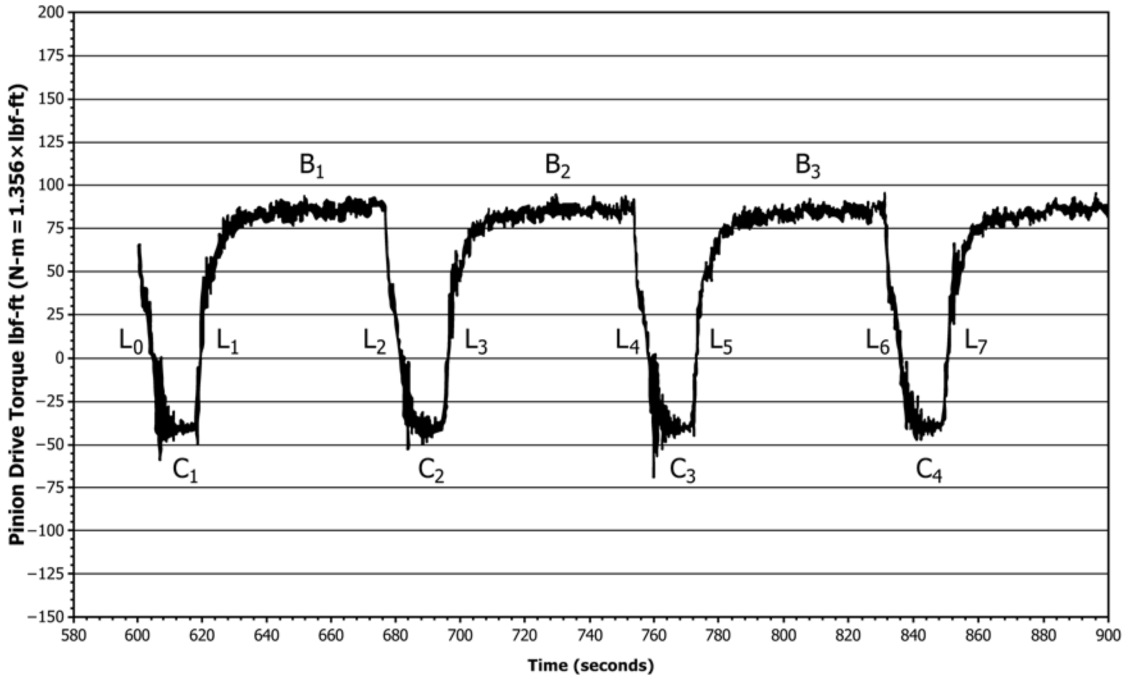

FIG. A6.17 Conditioning 2—Pinion Torque (Exploded View)

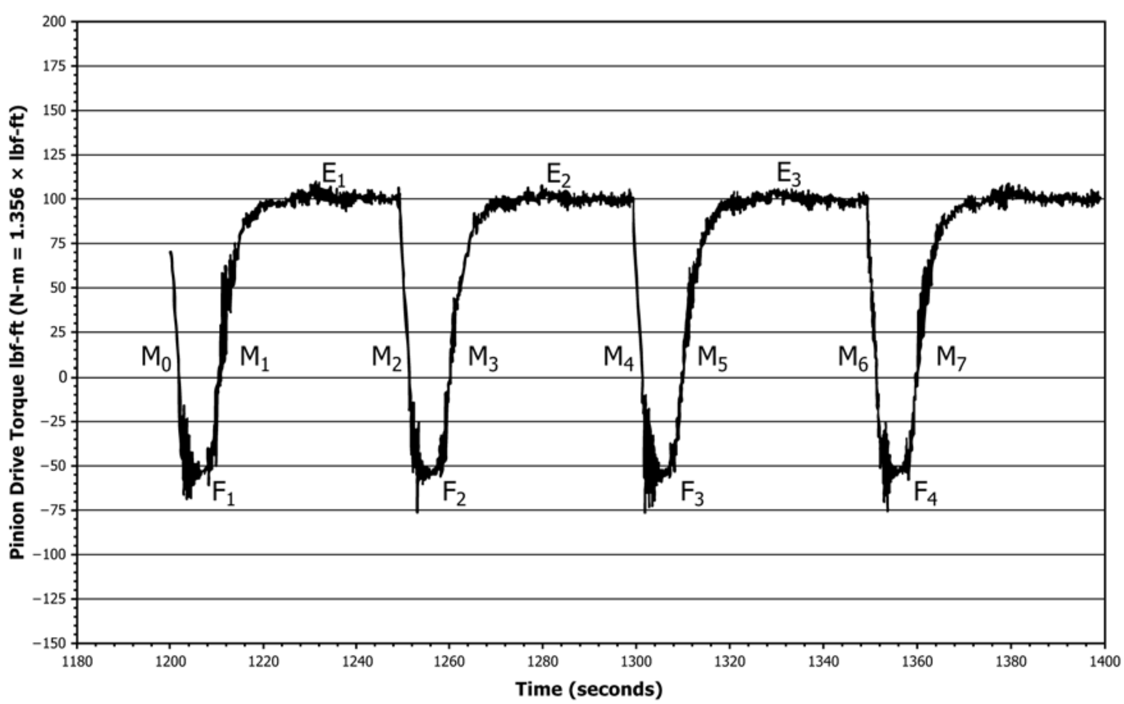

FIG. A6.18 Conditioning 4—Pinion Torque (Exploded View)

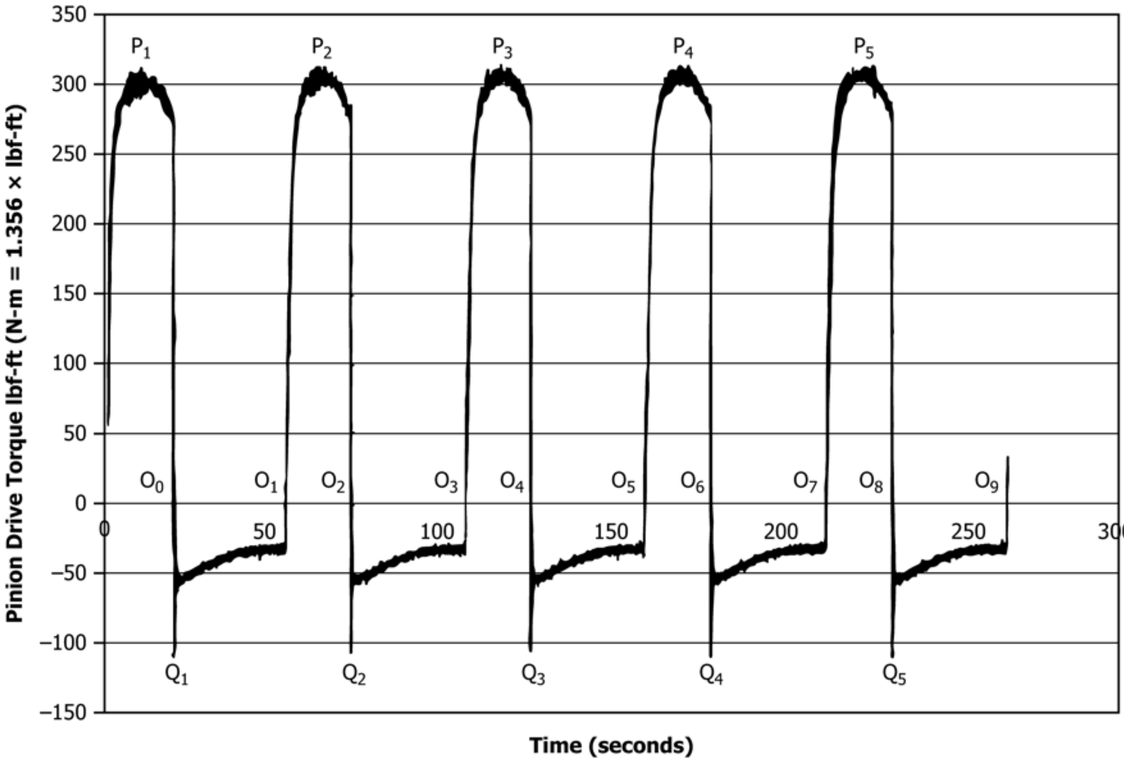

FIG. A6.19 Shock Series One—Pinion Torque (5 Shocks)

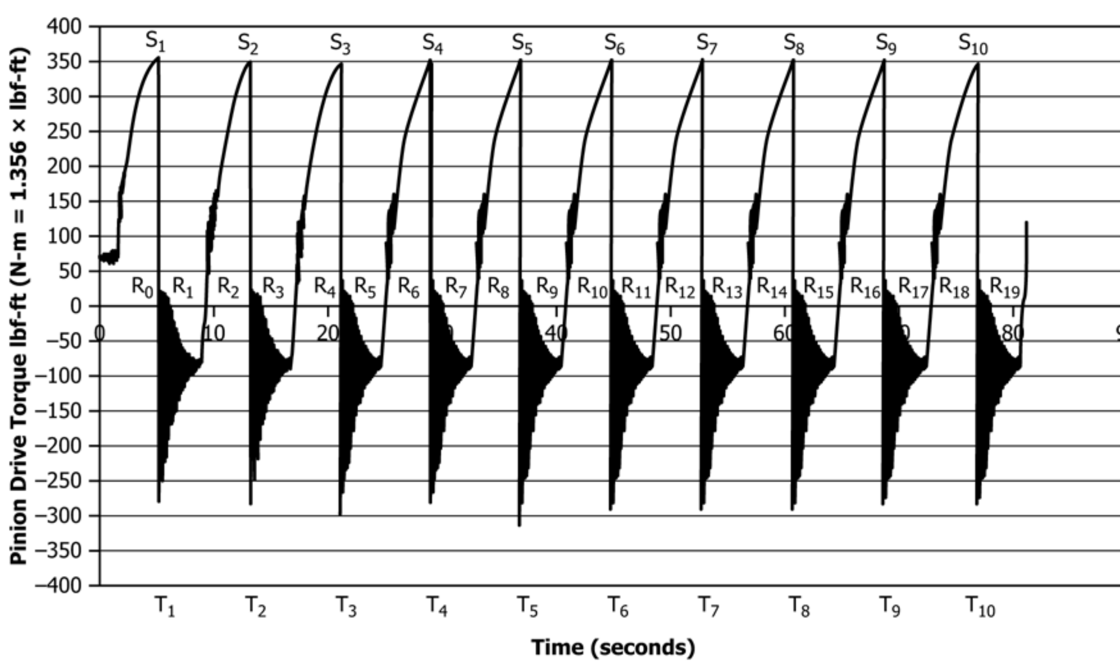

FIG. A6.20 Shock Series Two—Pinion Torque (10 Shocks)

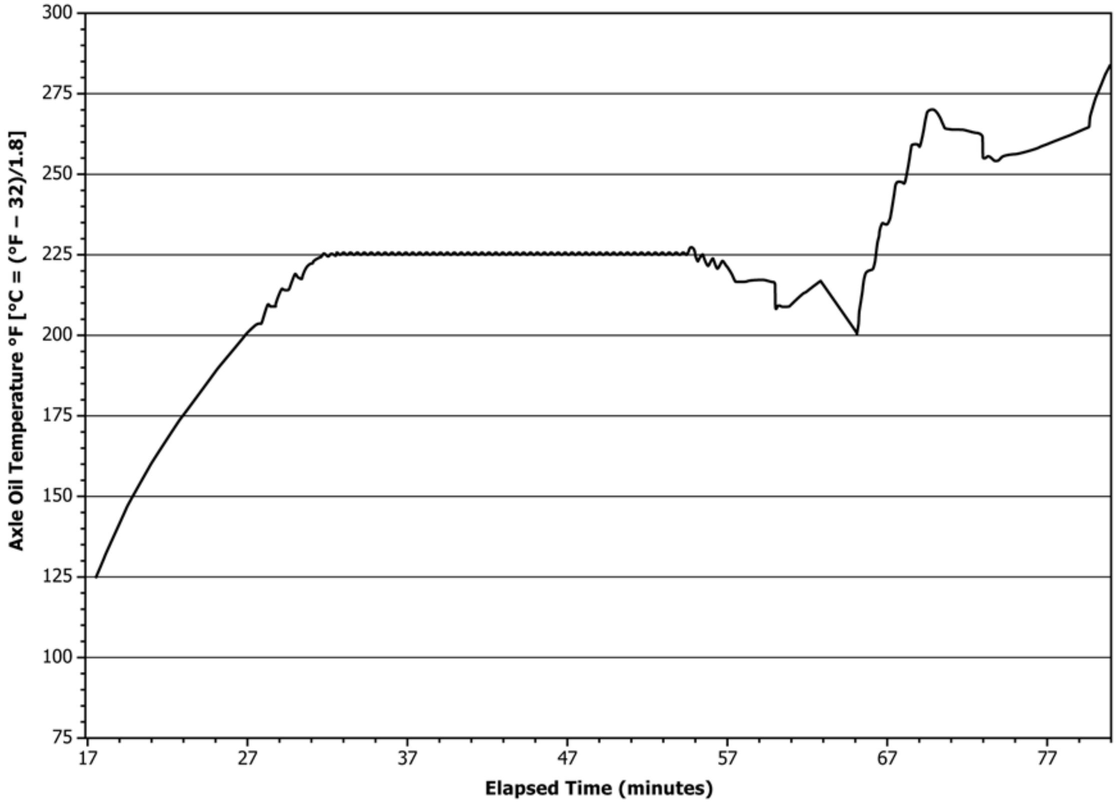

FIG. A6.21 Axle Oil Temperature

A7. L-42 TEST REPORT FORMS AND DATA DICTIONARY

A7.1 The required report forms and data dictionary are available on the ASTM Test Monitoring Center Web Page at http://astmtmc.cmu.edu/ or can be obtained in hardcopy format from the TMC.

Form 0 Test Report Cover
Form 1 Test Result Summary Page
Form 2 Conditioning Phase Operational Data Summary Sheet
Form 3 Shock Series Operational Data Summary Sheet
Form 4 Measurement Summary Sheet
Form 5 Down Time and Comments Sheet
Form 6 Conditioning Phases 1 & 2—Wheel Speed vs. Time Graph
Form 7 Conditioning Phases 3 & 4—Wheel Speed vs. Time Graph
Form 8 Shock Series 1—Wheel Speed vs. Time Graph
Form 9 Shock Series 2—Wheel Speed vs. Time Graph
Form 10 Conditioning Phases 1 & 2—Pinion Torque vs. Time Graph
Form 11 Conditioning Phases 3 & 4—Pinion Torque vs. Time Graph
Form 12 Conditioning Phases 2—Pinion Torque vs. Time Graph (Exploded View)
Form 13 Conditioning Phases 4—Pinion Torque vs. Time Graph (Exploded View)
Form 14 Shock Series 1—Pinion Torque vs. Time Graph (5 shocks)
Form 15 Shock Series 2—Pinion Torque vs. Time Graph (10 shocks)
Form 16 Axle Oil Temperature Graph

A8. TEST VALIDITY CALCULATIONS AND LIMITS

A8.1 For a test to be operationally valid it shall not exceed the limits outlined in this annex.

A8.2 *Unscheduled Shutdowns*—Only one unscheduled shutdown allowed per test. The shutdown can only occur during Conditioning 1, Conditioning 3, or anytime the driveline is disengaged as allowed or required by the test procedure. Downtime cannot exceed 15 min. Any other unscheduled shutdowns invalidate the test.

A8.3 *Test Length*—Calculate and report total test time starting from the beginning of Conditioning 1 to the end of Shock 2. Test length shall not exceed 80 min. Downtime is not to be included in the test length time.

A8.4 Coast Side Torque Limits

A8.4.1 Non-reference and Discrimination oil test, Shock Series 1 average coast side torque values shall be within ±15 % of the average Shock Series 1 coast side torque value of the average of the three tests from the most recent operationally and statistically valid reference oil calibration sequence for the test to be considered operationally valid. Each test in a calibration sequence is considered operationally valid if the average Shock Series 1 coast side torque values are within ±15 % of the average of the three acceptable calibration sequence tests.

A8.4.2 Non-reference and Discrimination oil test, Shock Series 2 average coast side torque values shall be within ±10 % of the average Shock Series 2 coast side torque value of the average of the three tests from the most recent operationally and statistically valid reference oil calibration sequence for the test to be considered operationally valid. Each test in a calibration sequence is considered operationally valid if the average Shock Series 2 coast side torque values are within ±10 % of the average of the three acceptable calibration sequence tests.

A8.5 Deviations from Test Operating Parameters

A8.5.1 Axle oil temperature is considered a critical operating parameter during the gear conditioning phase of this test. Axle speed and pinion torque are considered critical operating parameters during the steady state portion of the conditioning phase of the test.

A8.5.2 Calculate the percent deviation as follows:

$$percent\ out = \sum_{i=1}^{n}\left(\frac{Mi}{0.5R} \times \frac{Ti}{D}\right) \times 100 \qquad (A8.1)$$

where:

Mi = magnitude of test parameter out from specification limit at occurrence, *i*,
R = test parameter specification range,
Ti = length of time the test parameter was outside of specification range at occurrence, *i*. (*Ti* is assumed to be no less than the recorded data-acquisition frequency unless supplemental readings are documented.)
D = test or test phase duration in same units as *Ti*.

A8.5.3 The deviation percentages for the critical operating parameters are shown in Table A8.1.

A8.5.4 Calculate axle oil temperature percent deviation after 220 °F (104.4 °C) is reached for the entire conditioning phase of the test.

A8.5.5 Calculate r/min percent deviation after 570 r⁄min (60 rad⁄s) is reached for the gear conditioning 1 portion of the test.

A8.5.6 Calculate pinion torque percent deviation after 50 lbf-ft (68 N·m) is reached for the gear conditioning 1 portion of the test.

A8.5.7 Calculate r/min percent deviation after 810 r⁄min (85 rad⁄s) is reached for the gear conditioning 3 portion of the test.

A8.5.8 Calculate pinion torque percent deviation after 60 lbf-ft (81 N·m) is reached for the gear conditioning 3 portion of the test.

TABLE A8.1 Critical Operating Parameter Limits

Parameter	Entire Conditioning Phase Limits	Conditioning Phase 1 Limits	Conditioning Phase 3 Limits
Axle Oil Temperature	5 %	...	...
Axle Speed	...	5 %	5 %

A9. PRETEST CONTACT PATTERN REQUIREMENTS

A9.1 Record coast side pattern as received from manufacturer. Contact patterns shall be L2F+1, L2F0, L2F-1, L3F+1, L3F0, and L3F- 1 for gear batch B6L544/P4L806. These contact patterns are only recommended for all other gear batches.

SUMMARY OF CHANGES

Subcommittee D02.B0 has identified the location of selected changes to this standard since the last issue (D7452 – 16) that may impact the use of this standard. (Approved May 1, 2017.)

(1) Revised Fig. A6.1 because of figure numbering error for cover plate temperature sensor locating device.

Subcommittee D02.B0 has identified the location of selected changes to this standard since the last issue (D7452 – 15) that may impact the use of this standard. (Approved April 1, 2016.)

(1) New Introduction section included.
(2) Section 9, Calibration, completely rewritten.
(3) Table 2 Precision data updated.
(4) Section 13, Report, completely rewritten.
(5) New Annex A1 – Annex A4 added; subsequent Annex sections renumbered.
(6) Former Annex A4 (Role of ASTM Test Monitoring Center and the Calibration Program) was deleted.