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Standard Test Method for Evaluating the Thermal Stability of Manual Transmission Lubricants in a Cyclic Durability Test¹

This standard is issued under the fixed designation D5579; 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 thermal stability of fluids for use in heavy duty manual transmissions when operated at high temperatures.

1.2 The lubricant performance is measured by the number of shifting cycles that can be performed without failure of synchronization when the transmission is operated while continuously cycling between high and low range.

1.3 Correlation of test results with truck transmission service has not been established. However, the procedure has been shown to appropriately separate two transmission lubricants, which have shown satisfactory and unsatisfactory field performance in the trucks of one manufacturer.

1.4 Changes in this test method may be necessary due to refinements in the procedure, obsolescence of parts, or reagents, and so forth. These changes will be incorporated by Information Letters issued by the ASTM Test Monitoring Center (TMC).² The test method will be revised to show the content of all the letters, as issued.

1.5 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.

1.5.1 *Exception*—When materials, products, or equipment are available only in inch-pound units, SI units are omitted.

1.6 *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.*

1.7 This test method is arranged as follows:

	Section
Scope	1
Referenced Documents	2
Terminology	3
Summary of Test Method	4
Significance and Use	5
Apparatus	6
Test Transmission	6.2
Transmission Mounts	6.3
Oil-Circulating System	6.4
Oil Return Hole	6.5
Air Pressure Controls	6.6
Drive System	6.7
Instrumentation	6.8
Thermocouple Placement	6.9
Reagents and Materials	7
Safety	8
Preparation of Apparatus	9
Cleaning of Parts	9.1
Assembly	9.2
Calibration	10
Transmission and Test Stand Calibration	10.1
Reference Oils	10.2
Reference Oil Test Frequency	10.3
Instrumentation Calibration	10.4
Shift Time Calibration	10.5
Operating Procedure	11

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

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² ASTM Test Monitoring Center, 6555 Penn Ave., Pittsburgh, PA 15206-4489. This edition incorporates revisions in all Information Letters through No. 09-3:11-1.

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



System Flush and Charge	11.1
Test Operation	11.2
Shut-Down Procedure	11.3
Transmission Disassembly	11.4
Determination of Test Results	12
Failure Criteria	12.1
Shifter Fork Wear	12.2
Test Validity Determination	12.3
Report	13
Precision and Bias	14
Keywords	15
Test Validity Calculations and Limits	Annex A1
HTCT Test Report Forms and Data Dictionary	Annex A2
Manual Transmission Cyclic Durability Test Parts Inspection and Wear Measurements	Annex A3

2. Referenced Documents

2.1 ASTM Standards:³

D235 Specification for Mineral Spirits (Petroleum Spirits) (Hydrocarbon Dry Cleaning Solvent)

D7422 Test Method for Evaluation of Diesel Engine Oils in T-12 Exhaust Gas Recirculation Diesel Engine

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

2.2 SAE Standard:

SAE J308 Axle and Manual Transmission Lubricants⁴

2.3 Military Standard:

MIL-L-2105 Lubricating Oil, Gear, Multipurpose⁵

2.4 Other Standard:

GO-H Mack Trucks Oil,Gear: Multi-Purpose⁶

3. Terminology

3.1 Definitions:

3.1.1 wearwear, n—the loss of material from a surface, generally occurring between two surfaces in relative motion, and resulting from mechanical or chemical action or a combination of both. **D7422**

3.2 Definitions of Terms Specific to This Standard:

3.2.1 dual-range transmissiondual-range transmission, n—a type of transmission in which the driver first shifts through all of the mainbox gear ratios in low range, and then shifts to high range and shifts through the mainbox again. The section containing the high-low range is the compound section.

3.2.2 friction diskfriction disk, n—a steel circular plate to which a friction material has been bonded.

3.2.3 glazedglazed, adj—the condition of the friction disks when precipitates have filled the pores in the friction material, polishing the surface, and changing the frictional properties.

3.2.4 reaction diskreaction disk, n—a steel disk that mates with the friction disk during synchronization.

3.2.5 shift timeshift time, n—the period of time required, when shifting from high range to low range, for the countershaft speed to increase from (500 to 1700) r/min; or when shifting from low range to high range, for the countershaft speed to decrease from (1700 to 500) r/min.

3.2.6 synchronizersynchronizer, n—a pack of friction and reaction plates used to match the speeds of the low- and high-range gears prior to engagement.

3.2.7 unsynchronized shiftunsynchronized shift, n—a shift in which the speed of the mating gears is not matched to the speed of the transmission output shaft by the synchronizer.

4. Summary of Test Method

4.1 Prior to each test run, the transmission is disassembled and all parts, including the case and the oil-circulating and heating systems, are thoroughly cleaned. The transmission is rebuilt with a new synchronizer assembly, including measured shifter fork, friction, and reaction disks. All other worn or defective parts are replaced.

4.2 The rebuilt transmission is installed on a test stand.

4.3 The transmission and oil system are flushed with the test oil in accordance with the flush procedure.

4.4 The flush oil is drained, and the test oil is measured and charged to the transmission.

4.5 The transmission is started and operated in low range until the oil temperature reaches the test operating range.

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.

⁴ Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001.

⁵ Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098.

⁶ Available from Volvo Powertrain, North America, 13302 Pennsylvania Ave., Hagerstown, MD 21742.

4.6 The transmission is automatically cycled between low and high range until two unsynchronized shifts occur or the desired length of test is reached without failure. The time required to shift from high range to low range is recorded each hour.

4.7 At the conclusion of the test, the test parts are removed and visually inspected. The shifter fork and friction plates are measured again to determine wear.

5. Significance and Use

5.1 This test method is used to evaluate automotive manual transmission fluids for thermal instability, which results in deterioration of synchronizer performance.

5.2 This test method may also be utilized in other specifications and classifications of transmission and gear lubricants such as the following:

- 5.2.1 (final API designation of PG-1),
- 5.2.2 Military Specification MIL-L-2105,
- 5.2.3 SAE Information Report J308 Axle and Manual Transmission Lubricants, and
- 5.2.4 Mack Truck GO-H Gear Lubricant Specification.

6. Apparatus

6.1 Table 1 is a list of the make and model of recommended instruments and equipment.

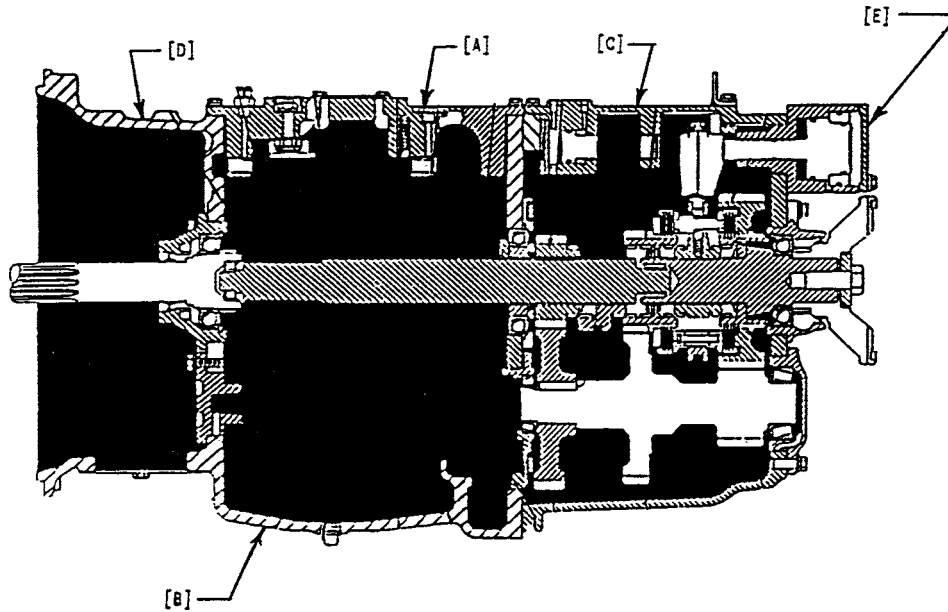
6.2 *Test Transmission*—The test transmission is a MACK T2180, configuration 11KBA51431 (see Fig. 1). Some parts in the transmission are to be removed and some are to be added before testing, as listed in Table 2. The main box shift rail cover can be replaced with an aluminum plate to facilitate transmission cleaning at end of test.

6.3 *Transmission Mounts*—The transmission is mounted as shown in Fig. 2.

6.4 *Oil-Circulating System*—The system heats the oil to the specified operating temperature of $250 \pm 5^\circ\text{F}$ ($121^\circ\text{C} \pm 2.7^\circ\text{C}$) and maintains this temperature throughout the duration of the test. The power density of the heater is not high enough to cause degradation of the oil (22 to 25 W/in.^2 (3.4 W/cm^2 to 3.9 W/cm^2)). The oil flow rate is between 6 and 10 gal/min (23 L/min to 38 L/min). A layout of the oil-circulation system is shown in Fig. 3. A detailed drawing of the recommended oil heating chamber is

TABLE 1 Recommended Test Stand Components

Item	Manufacturer	Part No.
Panel Meters		
Tailshaft rpm	Newport	P-6031D20D
Countershaft rpm	Newport	P-6031D20D
Shift time	Newport	P-6031D20D
Coast down time	Newport	P-6031D20D
Control Indication		
Temperature controller	Omron	ESEX-AF
Temperature indicator	Newport	INF-0-0-0-0-JF
Cycle counter	Redington	P2-1006-115AC
Cycle timer	Omron	H5BR-B-AC100-240
T/C selector switch	Thermo Electric	33112
Oil psi gage/safety	Murphy	A-20EO, O-30 psi
Air supply gage	U.S. Gage	P44U, O-160 psi
Air regulator	Norgren	RO-8-300 RNMA
Shift solenoid	Asco	8317G35, 3-way solenoid
Mag. pickup	Electro	3010AN
12 VDC Power supply	Sola	SLS-12-017
Air pressure switch	Penn	P61AG-1
Relays—AC	Potter & Brumfield	KUP14A15
Relays—DC	Potter & Brumfield	KUP14D15
Mechanical Components		
Air lines	Mack	101AX24R, $\frac{3}{8}$ in. OD
Pump	Brown & Sharp	No. 2
Heater element	Chromalox	MOT330A, 220v, 1Ph
Oil lines	Aeroquip	EC-350, No. 12
U Joint yoke	Mack	1710 Series, 38MU3413M
Drive shaft	Rockwell	1710 Series, 52 in. collapsed
Drive motor	General Electric	25-hp Induction Motor, 1760 rpm
High-Speed Recording System		
Pressure transducers	Sensotec	A-5/1034, 0-100 psi
Oscillograph	Astro-Med	Dash 4



NOTE 1—Left side view.

NOTE 2—See Table 2 for references to letters in brackets.

FIG. 1 Transmission Modified for Testing

TABLE 2 Transmission Parts to Be Added or Removed Before Testing

NOTE—Letters in brackets, [], refer to locations indicated on Fig. 1.

Parts to Be Removed		
Rails, forks, springs, and ball from the mainbox shift cover [A]		
All main box gearing [B]: Main shaft gears and thrust washers Countershaft assemblies Sliding clutches	Mack part numbers 320KB3136 (2)320KB3137A	or Volvo part numbers 25101998 (2)25503685
Compound [C] Splitter clutch Splitter piston Splitter fork	Mack part number 320KB3141 Mack part number 336KC333 Mack part number 575KB3378	or Volvo part number 25125890 or Volvo part number 25502825
Bell Housing [D] All clutch related parts Shafts	Mack part number 604KC277A, 604KC34B	or Volvo part number 25085391 N/A
Yoke	Mack part number 301KD43B	or Volvo part number 25128328
Parts to Be Added		
Speedometer plug	Mack part number 37KC12	or Volvo part number N/A
Speedometer washer	Mack part number 37AX419	or Volvo part number 20704759
Orifice to range valve	Mack part number 63AX3466	or Volvo part number 25107528
Replace cast iron piston housing cover with fabricated steel cover [E]		

shown in Fig. 4. The total oil capacity of the test system is 5.25 gal (19.87 L) with the oil level in the transmission at the lower edge of the fill hole. If the system capacity is too small, increase by lengthening oil hoses. When the system capacity is too great, decrease by shortening hoses, if it is practical to do so; otherwise, install an inert (stainless steel) block in the transmission main box sump to raise the oil level. Route the oil lines so that they will empty completely when draining the system.

6.5 *Oil Return Hole*—A hole shall be drilled and tapped in the compound case for the oil to return after flowing through the heat exchanger. The location and size of this hole are shown in Fig. 5.

6.6 *Air Pressure Controls*—The transmission is shifted by air pressure applied to alternating sides of the range shift piston. The air pressure is provided by a pilot valve, which is cycled by a solenoid valve at a rate of 5 cpm. These cycles are recorded by a counter, which provides the cycles to mis-shift data for the pass/fail criteria of the test. A typical air control system is shown in Fig. 6.

6.7 *Drive System*—In the truck operation, opposing torques help the synchronizer to complete the shift. In the test stand, the transmission is driven from the rear by an electric motor and belt drive with no loading on the input pinion. The torques, therefore,

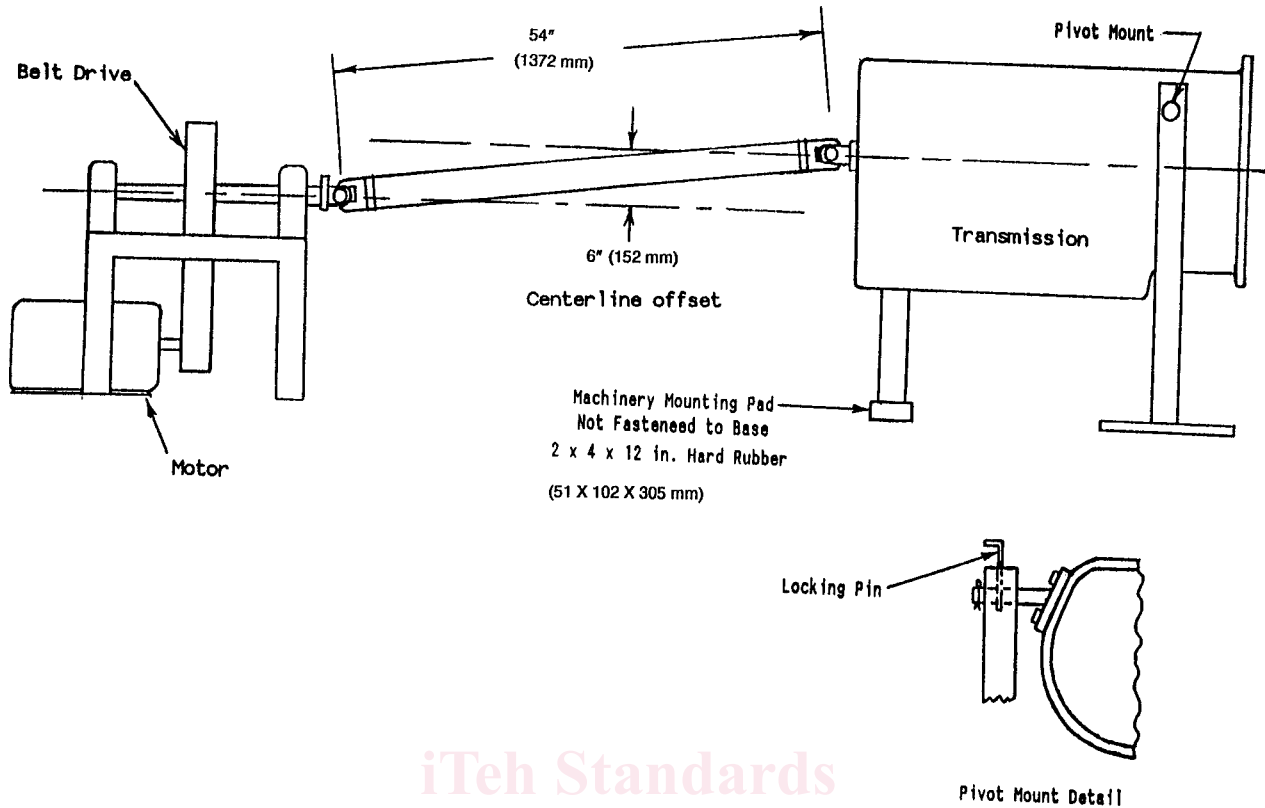


FIG. 2 Typical Layout of Drive System

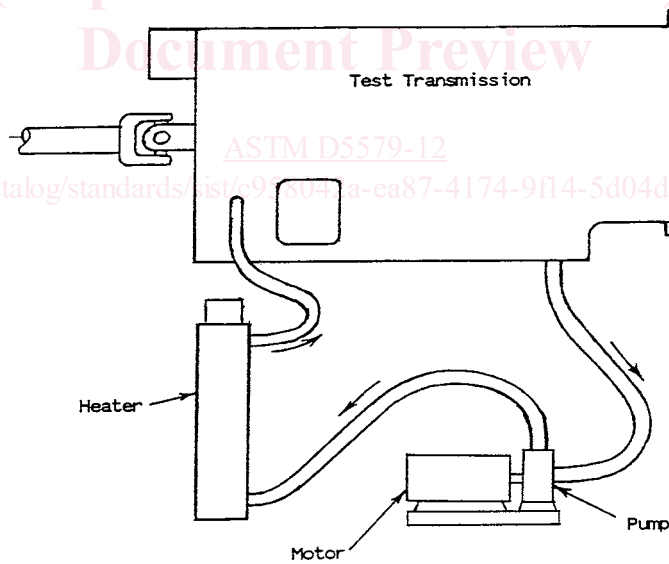
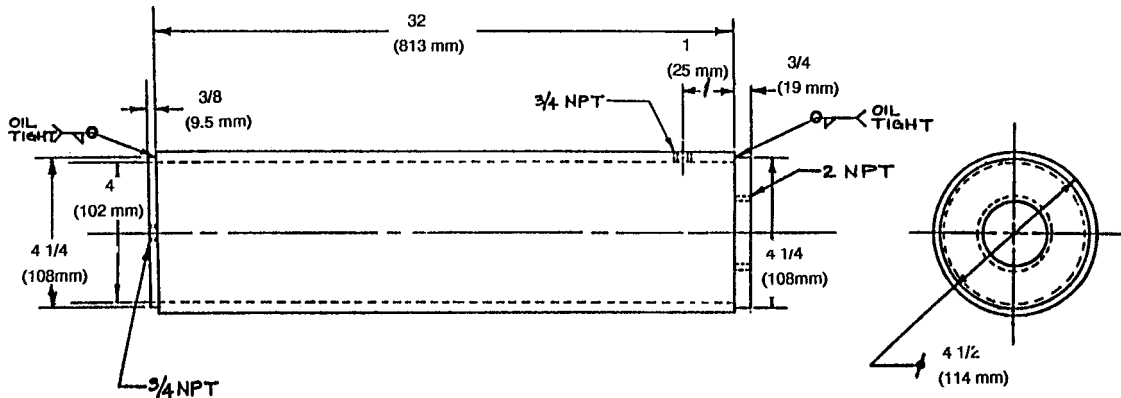


FIG. 3 Schematic of Oil System

are not present, and shifting can be delayed. To help the synchronizer shift smoothly without the opposing torque, a vibration in the drive line is intentionally excited. The driveline is set out of phase by rotating the yoke at one end of the shaft with respect to the other by a one spline tooth offset (22°). The transmission output shaft is offset from the shaft of the motor or jack shaft, thereby placing the driveline at an angle. A layout showing the offset of the transmission relative to the jack shaft is shown in Fig. 2.

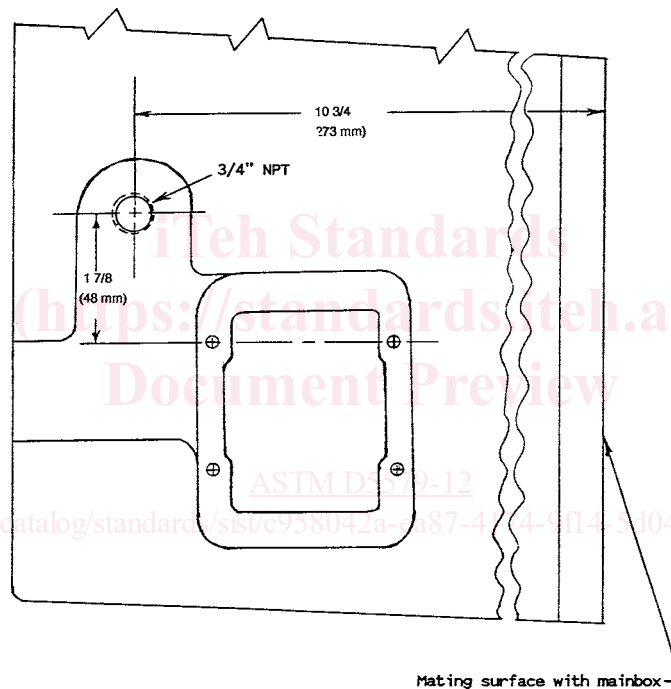
6.8 *Instrumentation*—Sensors and displays, either on the test console or in a data logging computer, are to be supplied as follows:

- 6.8.1 Oil sump temperature,
- 6.8.2 Countershaft speed,
- 6.8.3 Tail shaft speed,



NOTE 1—Material 1018 is similar material.
 NOTE 2—All dimensions are in inches, unless otherwise noted.

FIG. 4 Typical Oil Heater Chamber



NOTE—Figure is not drawn to scale.
 FIG. 5 Oil Return Hole Location

- 6.8.4 Air pressure (system),
- 6.8.5 Air pressure (dynamic during shifting), and
- 6.8.6 Coast down time.

6.9 *Thermocouple Placement*—Transmission sump temperature is measured in the compound section of the transmission with a thermocouple and conventional display equipment. Drill and tap the compound case to accept the thermocouple at a position located along the centerline of the transmission 8.0 in. (203 mm) forward of the back wall of the main case. Position the tip of the thermocouple to extend 1.5 in. (38 mm) into the sump. As a means of ensuring that the oil is not exposed to excessive heat in the heater, place an additional thermocouple to measure the oil temperature leaving the heater as shown in Fig. 7.

7. Reagents and Materials

7.1 *Oil*—Approximately 12 gal (45.4 L) of test oil is required. The integrity of the test oil is the responsibility of the oil supplier.
 7.2 *Solvent*—Use only mineral spirits meeting the requirements of Specification D235, Type II, Class C for Aromatic Content (0-2% vol), Flash Point (142°F/61 °C, min), and Color (not darker than +25 on Saybolt Scale or 25 on Pt-Co Scale).
 (Warning—Combustible. Health hazard.) Obtain a Certificate of Analysis for each batch of solvent from the supplier.