

CHANNELING CHARACTERISTICS

1. SCOPE

1.1 This method is used for determining the channeling characteristics of lubricants at low temperature. It consists of storing the sample for 18 hours at the temperature required by the specification, cutting a channel in the lubricant with a metal strip, and determining whether the lubricant flows together to cover the bottom of the container within 10 seconds.

2. SAMPLE

2.1 Approximately 650 ml. of lubricant to be tested.

3. APPARATUS

3.1 Steel strip, square end (channeling tool), approximately 1/8 by 3/4 by 6 inch.

3.2 Thermometer, low cloud and pour (ASTM E1-67).

3.3 Container, flat bottom, approximately 3-5/8 inch ID by 4-1/2 inches high, with 1 inch (minimum) legs, and with cover to support thermometer in center and steel strip at side of container. (See Figure 1.)

3.4 Heating bath, 115° to 118°F.

3.5 Cooling bath (nonliquid), capable of maintaining the specified temperature within 2°F, size sufficient to accommodate container with 1 inch (minimum) clearance on all sides.

4. PROCEDURE

4.1 Prepare test setup as follows:

(a) Fill container to within 1/2 inch of top with specimen, place in heating bath, and allow sample to reach 115°F. (If a liquid bath is used, adjust bath level to level of sample.)

(b) When sample reaches 115°F, cover container and remove from bath.

(c) While the sample is still hot, position thermometer so that its bulb is approximately in the center of sample, and insert steel strip in sample approximately 1/2 inch from side wall of container so that it rests squarely on the

bottom. (See Figure 1.) Immediately place the sample in the cooling bath.

4.2 Store container in cooling bath without interruption for 18 ± 2 hours. Begin timing the storage period immediately after placing the sample in the cooling bath.

4.3 At end of storage period, remove container from cooling bath, and within 30 seconds cut a channel in the sample as follows:

(a) Check sample temperature and make sure that it is within $\pm 2^\circ\text{F}$ of specified storage temperature.

(b) Without moving steel strip, remove cover and thermometer from container.

(c) Note time to nearest second, and within 5 seconds scrape the vertically-held steel strip all the way across bottom of container.

4.4 Within 10 seconds after cutting the channel (par. 4.3), check to determine whether sample has flowed back and completely covered bottom of container. If it has, report it as nonchanneling; if not, report it as channeling.

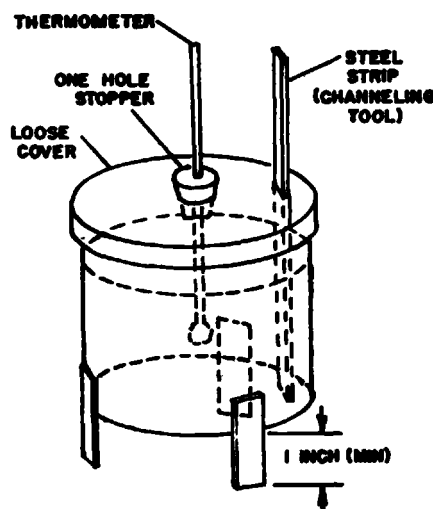


FIGURE 1.—Test setup.

SEPARATION CHARACTERISTICS OF UNIVERSAL GEAR LUBRICANTS

1. SCOPE

1.1 This method is used for determining the separation characteristics of universal gear lubricants during storage. It consists essentially of storing a lubricant sample for 30 or 60 days, centrifuging it until a sediment forms, and then determining the amount of sediment.

2. SAMPLE

2.1 Approximately 250 ml. of the lubricant (preferably freshly compounded) to be tested.

3. APPARATUS

3.1 Centrifuge, swing diameter (tip-to-tip of whirling tubes) of 15 to 17 inches, 1500 rpm, or equivalent. (See Method 3003.9.)

Note. An equivalent centrifuge must be capable of having its speed adjusted according to the following formula:

$$\text{r.p.m.} = \sqrt{\frac{16}{d}} \times 1500$$

d = diameter (tip to tip) of whirling tubes, in.

3.2 Centrifuge tubes (2), cone-shaped, 100-ml, with stoppers. (See Method 3003.9.)

3.3 Balance, sensitivity 1 mg.

3.4 Oven, $220^{\circ} \pm 5^{\circ}\text{F}$.

4. MATERIALS

4.1 Naphtha, aliphatic (TT-N-95).

4.2 Cleaning solution, glass (concentrated sulfuric acid saturated with potassium or sodium dichromate, technical grade).

4.3 Distilled water.

5. PROCEDURE

5.1 Clean two centrifuge tubes as follows:

- Rinse with naphtha.
- Clean with glass-cleaning solution.
- Rinse with distilled water.
- Allow tubes to air-dry.

5.2 Weigh both cleaned centrifuge tubes to the nearest milligram.

5.3 Place 100 ml of the sample in each centrifuge tube, stopper tubes, and then store both

centrifuge tubes in darkness for 30 days at room temperature ($85^{\circ} \pm 15^{\circ}\text{F}$).

5.4 Remove the centrifuge tubes from their storage compartment and mount them in the centrifuge, being careful not to agitate the separated materials.

5.5 Centrifuge the tubes for five minutes, and note whether a compact solid separates from the lubricant. (If it does not separate after five minutes of centrifuging, return the tubes to storage for an additional 30 days.)

5.6 Continue the centrifuging operation in 5-minute increments until a compact solid forms in the bottom of the tube, or until the volumes of the liquid layers remain constant for three consecutive readings. If a compact solid forms, process it as described in paragraph 5.7; if liquid layer forms, process it as described in paragraph 5.8.

5.7 Determine the percentage (by weight) of nonpetroleum solid matter in the sample, as follows:

(a) Decant the supernatant oil from the tube, then invert and allow the tube to drain for one hour.

(b) Wash the residue in each tube with aliphatic naphtha until it is free of oil.

(c) Place the tubes in an oven at $220^{\circ} \pm 5^{\circ}\text{F}$ (104°C) until the residue is dry.

(d) Weigh each tube to the nearest milligram, and compute the average gain in weight of the tubes.

(e) Compute and report the percentage (by weight) of the nonpetroleum solid material in the sample.

5.8 Determine the percentage (by volume) of nonpetroleum liquid in the sample, as follows:

(a) Note the volume (to the nearest 0.05 ml) of nonpetroleum liquid in each tube.

(b) Compute and report the percentage (by volume) of the nonpetroleum liquids present.

CORROSION PROTECTION BY UNIVERSAL GEAR LUBRICANTS IN THE PRESENCE OF WATER

1. SCOPE

1.1 This method is used for determining the protective characteristics of universal gear lubricants on ferrous metals in the presence of water. It consists of rotating two sandblasted steel strips in a mixture of the test lubricant and water at 180°F for four hours, and rating the lubricant by visual evaluation of the rust on the strips.

2. SAMPLE

2.1 Approximately 400 grams of the lubricant to be tested.

3. APPARATUS

3.1 Motor, stirring, 550 \pm 25 rpm.

3.2 Shaft, stirring, drill rod, 5/32 inch diameter, threaded at the immersion end for attachment of steel test strip (blade) by nuts.

3.3 Bath, constant-temperature, 180° \pm 1°F, (to accommodate beaker (par. 3.4) approximately three-quarters immersed).

3.4 Beaker, Pyrex, 400 ml.

3.5 Desiccator, containing desiccant.

3.6 Forceps, laboratory.

3.7 Drill, No. 19 (0.1660-inch).

4. MATERIALS

4.1 Steel strips (2), low-carbon, (1015 to 1020), (QQ-S-698) 1 by 2 by 0.0239 inches.

4.2 Sand, sandblast, clean, sharp, dry, nearly white. Grain size limits as follows:

Sieve No.	Percent Pass
10.....	100
20.....	90 minimum
48.....	10 maximum

4.3 Cleaning solution, glass (concentrated sulfuric acid saturated with potassium or sodium dichromate, technical grade).

CAUTION

This solution is highly corrosive and must be handled with caution. Proper eye and skin protection should be used.

4.4 Naphtha (MIL-N-15178).

4.5 Petroleum ether (O-E-751).

4.6 Ethyl alcohol, 95 percent (MIL-E-463).

4.7 Acetone (O-A-51).

5. PROCEDURES

5.1 Prepare the steel strips as follows:

(a) Drill a hole in the center of each strip, using a No. 19 (0.1660 inch) drill.

(b) Bend two diagonally opposite corners of each strip upwards along lines from the middle of the leading edge to the corner of the trailing edge at an angle of 15° \pm 2 degrees as measured along the trailing edge. (See Figure 1.)

(c) Rinse thoroughly in naphtha.

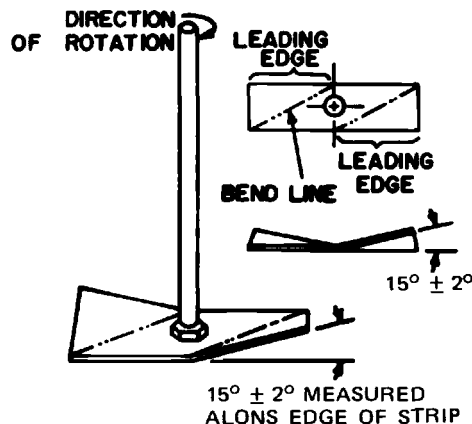


FIGURE 1.—Stirring shaft and strip assembly.

(d) Sandblast each side of each strip to remove the original surface and leave a fresh uniformly abraded surface.

CAUTION

Handle only with forceps after sandblasting.

(e) Remove all of sand from each strip by tapping it against a smooth hard surface (or with clean, dry, compressed air), and store it in desiccator until ready for use. (Use the strips preferably the same day or within a maximum of seven days.)

5.2 Heat the bath to 180° \pm 1°F.

5.3 Clean beaker, stirring shaft (and nuts) as follows:

(a) Rinse with naphtha.

(b) Rinse with glass-cleaning solution.

(c) Rinse with distilled water.

(d) Rinse with ethyl alcohol or acetone.

(e) Allow to air dry.

5.4 Place 200 g. of the sample and 5 ml. of distilled water in the 400-ml. breaker, and immerse the beaker in the bath to three-fourths of its depth.

5.5 Using clean forceps to handle the steel strip and clean tools to secure the nuts, mount one of the strips on the stirring shaft so that the tips of the strip are bent toward the motor end of the shaft.

5.6 Attach the shaft to the motor, and position the assembly so that the center of the strip is in the center of the beaker and is 1 ± 0.1 inch from the bottom of the beaker.

5.7 Start the stirrer rotating at 500 ± 25 r.p.m. and observe the temperature of the lubricant until it reaches $180^{\circ} \pm 0.1^{\circ}\text{F}$. When the test temperature is reached, note the time and continue the rotation for four hours.

5.8 At the end of 4 hours, stop the rotation,

remove the stirring shaft from the beaker, and using forceps, disassemble the strip from the shaft.

5.9 Using forceps to handle the steel strip, wash it in petroleum ether, and immediately examine it for indications of rust.

5.10 Report the degree of rusting of the steel strip as follows:

(a) None.

(b) Light (only a few rust spots).

(c) Moderate (rust streaks).

(d) Severe (approximately one-half the surface covered with rust).

5.11 Repeat the operations in paragraphs 5.5 to 5.10 inclusive, using the second steel strip in the same sample.

5.12 If rust is noted on only one of the steel strips, repeat the entire test, using fresh lubricant and new steel strips.

TEST PROCEDURE FOR DETERMINING
MOISTURE-CORROSION CHARACTERISTICS
OF UNIVERSAL GEAR LUBRICANTS

(CRC Designation L-21-445)

SCOPE

1. This procedure is intended for use in determining the moisture-corrosion characteristics of universal gear lubricants.

APPARATUS

2. The apparatus (CRC Designation EL-21-445) shall consist of the following:

(a) Axle Test Unit: Built up from parts for a passenger-car rear axle. For list of parts required and directions for assembly, see section A1. (With the exception of the housing, which may be reconditioned, all parts must be new.)

(b) Test Stand and Driving Mechanism: For description of apparatus required, see section A2.

(c) Temperature-Control Apparatus: For dimensions and description of heat-insulating enclosure for test unit, see section A3.

(d) Heating Apparatus: A 500-watt electric heater of the radiant type.

(e) Storage Rack: Constructed to permit storing the test unit in position similar to that which it would occupy if installed in a car.

PREPARATION OF TEST UNIT

3. Equipment used in the conduct of this test shall be prepared in the manner described below:

(a) Prior to a test, the rear-axle housing and the differential-carrier assembly shall be cleaned thoroughly in the manner described below:

(1) Wash all gear lubricant from rear-axle housing and differential-carrier assembly, using a suitable solvent.

(2) Immerse the parts in a 1 percent solution of sodium hydroxide in water at a temperature of from 175° to 195°F (79.4° to 90.6°C) for 1 hour.

(3) Rinse the parts with water until free of caustic.

(4) Dry the parts by rinsing with methanol, followed by air-blowing to remove the methanol.

(b) Assembly of all parts of the test unit shall then be completed, and the unit placed on the test stand and connected with the driving mechanism.

(c) The heat-insulating enclosure shall be installed on the test unit.

TEST PROCEDURE

4. The test procedure to be employed is as follows:

(a) Distilled water in the amount of 28 ml is put into the axle housing, which is then filled to the level plug with the gear lubricant to be tested. This requires 3 pints.

(b) The propeller shaft is rotated for a period of 4 hours at a speed of 2400 ± 25 rpm, during which time the lubricant is maintained at a temperature of $180^{\circ} \pm 2^{\circ}\text{F}$ ($82.2^{\circ} \pm 1.1^{\circ}\text{C}$) by application of heat from the radiant-heater unit. The 4-hour test interval is measured from the time the specified temperature is reached, and control of temperature is maintained by adjusting the position of the heater unit.

(c) At the end of the 4-hour period, the drive is stopped, the heat-insulating enclosure is removed, and the axle test unit is placed on the storage rack without draining the lubricant. There it is allowed to remain for a 10-day period at room temperature.

(d) At the end of the 10-day storage period, the lubricant is drained, and the axle disassembled for inspection.

REPORTING RESULTS

5. The rating of the lubricant shall be based upon visual inspection for rusting of the gears, the pinion-gear bearing, the differential-carrier bearings, and the differential-gear thrust surfaces.

Appendix I

Apparatus

AXLE TEST UNIT

A1. (a) The parts required for one axle test unit with the manufacturer's parts no. are listed in Table LX. (These parts may be secured from the Chevrolet Motor Division, General Motors Corp., Detroit, Michigan.)

(b) The tubular ends of the rear-axle housing shall be cut off at a point 12-1/2 in. each side of the center of the opening for the differential-carrier assembly. The ends of the tube shall be sealed.

(c) The axle test unit shall be assembled in accordance with instructions in the Chevrolet Shop Manual, 1942 edition, section 4, p 1-9. (Copies of the 1942 Chevrolet Shop Manual may be obtained from the Chevrolet Motor Division, General Motors Corp., Detroit, Michigan.)

TABLE LX
REQUIRED PARTS AND NUMBERS

Parts	No. Required	Manufacturer's Part No.
Rear-axle-housing assembly.....	1	605336
Propeller-shaft housing and differential-carrier assembly.....	1	605335
Axle-housing-cover with filler plug.....	1	475308
Axle-housing-cover gasket.....	1	593017
Axle-housing to differential-carrier gasket...	1	593012
Rear-axle ventilator.....	1	3664539
Pinion-shaft-bearing lock screw.....	3	358073
Check nut for lock screw.....	3	124934
Propeller-shaft-housing bushing, front.....	1	3652601
Propeller-shaft-housing bushing, rear.....	1	3652328
Shaft packing washer seal.....	1	3652523
Differential case.....	1	593009
Differential side bearing.....	2	127861
Differential-bearing adjusting nut.....	2	472542
Adjusting-nut lock.....	2	472539
Ring gear and pinion.....	1	604397
Ring-gear screw.....	10	596529
Ring-gear-screw lock washer.....	10	$\frac{3}{8}$ in.
Pinion-shaft rear bearing.....	1	125630
Pinion-shaft rear-bearing lock ring.....	1	377722
Shaft-bearing lock sleeve.....	1	3656896
Pinion-shaft front bearing.....	1	905306
Pinion-shaft-bearing shim (one 0.015 in., one 0.018 in.).....	2	3657740
Pinion-shaft-bearing lock nut.....	1	595904
Propeller shaft.....	1	3657335
Propeller-shaft coupling pin.....	1	3657332

TEST STAND AND DRIVING MECHANISM

A2. (a) A part of the test consists of supporting the test unit in approximately the position it would occupy in a passenger car, and rotating the propeller shaft at a given speed.

(b) The test stand shall consist of a suitable frame on which the test unit may be secured in a level position by clamping the tubular portion of each side of the unit.

(c) The driving mechanism shall consist of an electric motor, 1 hp or larger, fitted with a pulley for double V-belt to a counter shaft which is to be run at 2400 \pm 25 rpm. The countershaft may be mounted above the motor, and shall be fitted at its driving end with a sleeve having a splined hole

to receive the splined end of the propeller shaft of the test unit. A tubular rubber driving connection may be provided between the countershaft and the splined sleeve to allow for slight misalignment between countershaft and propeller shaft.

(d) When assembled, the countershaft and propeller shaft shall be at approximately the same angle to the horizontal as the propeller shaft would be when installed in a car.

HEAT-CONTROL APPARATUS

A3. (a) To bring the test unit up to the specified temperature and hold it steadily at that point, a heat-insulating enclosure is required.

(b) The enclosure shall be made of masonite or suitable equivalent, lined with hair felt. It shall consist of a rear box-like part having interior measurements of 19 in. long (in line with the axle housing) by 11 in. wide (in line with the propeller shaft) by 15 in. deep vertically, joined to a front part having tapered sides which extend 14 in. from the rear part (19 in. x 15 in.) and terminate in a front side 5 in. wide by 8 in. deep vertically.

The enclosure shall be divided on its horizontal center line, and provided with openings on four sides as follows:

- (1) 2-1/2-in. diameter at midpoint of the front side, for the propeller shaft
- (2) 8-in. diameter at midpoint of the rear side, for the heating apparatus
- (3) 3-in. diameter at midpoint of each 11 in. x 15 in. end of the rectangular section, for the tubular axle housing.

(c) It is necessary to arrange the heat-insulating enclosure so that the radiant heater may be placed in line with the 8-in. opening in the enclosure.

CORROSION PROTECTION BY GEAR LUBRICANTS IN THE PRESENCE OF MOISTURE

1. SCOPE

1.1 This method is used for determining the corrosion preventive properties of gear lubricants. It duplicates normal service conditions wherein moisture condenses on the metal parts during cyclic ambient temperatures. The procedure is applicable to fresh oil samples and to used oil drawn from previously operated gear-cases.

Note 1. Although developed for extreme pressure lubricants, this method is adaptable to chemically less active mineral-base or synthetic lubricants.

1.2 The method is performed as either a one-day test or a seven-day test, as required by the applicable specification. The one-day test consists of four hours of operation followed by 18 hours of storage in a controlled-temperature storage box. The seven-day test consists of four hours of operation followed by 162 hours of storage in the controlled-temperature storage box.

2. SAMPLE

2.1 Approximately 2.5 pints of the lubricant to be tested.

3. APPARATUS

3.1 Test unit, Spicer differential assembly (part No. SKA 58391-1X, Dana Corp., Toledo, Ohio, or equal) securely mounted so that the pinion shaft is horizontal and the pinion axis is 6-3/4 inches above the test stand table top.

Note 2. For a seven-day test a new unit is required; for a one-day test a used unit with a new cover plate may be employed.

(a) Pressure-relief valve, (James Bond Clark, Model 259B-2PP, or equal) set for 1 psi shall be provided for venting the test unit during operation. It should be mounted by a street elbow screwed into the coverplate fill hole. A pipe plug shall be provided for closing the vent opening of the relief valve.

(b) Axle seals (2), similar to those shown in Figure 1, for plugging the axle-shaft openings during operation.

3.2 Driving mechanism. The test setup shall include a driving mechanism consisting of an electric motor of approximately 1-1/2 hp at 2500 rpm, a pulley arrangement for producing a

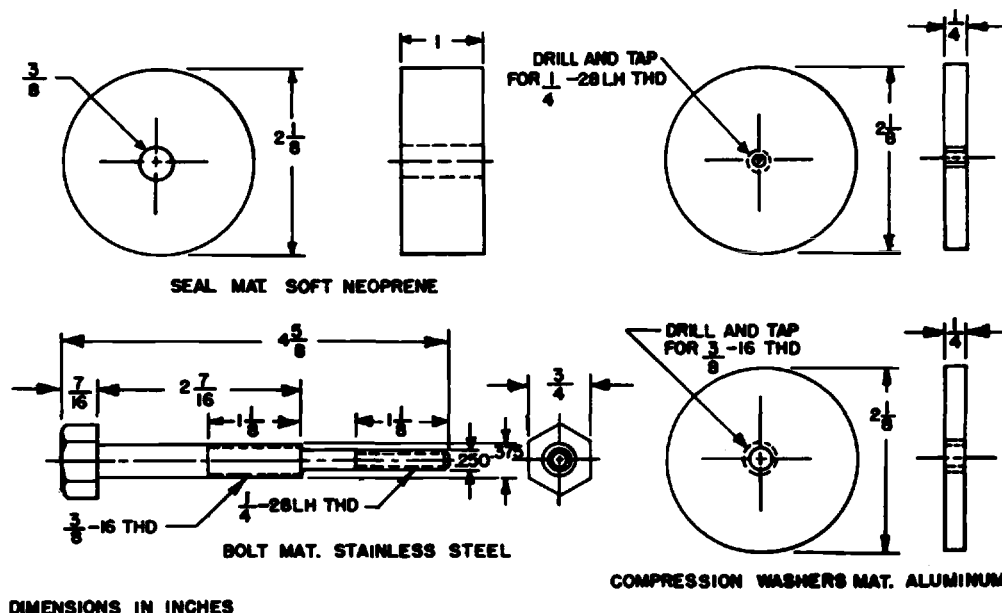


FIGURE 1.—Axle seals.

pinion speed of 2500 rpm and a means of measuring the pinion speed.

3.3 Temperature recording and controlling equipment. The test setup shall include a means of maintaining the test unit within a specific temperature range during operating, and of continuously recording the temperature. The equipment shall include a temperature probe, a temperature recording device, two heat lamps, and an electric fan.

(a) Temperature probe, preferably a resistance bulb (Foxboro Model E-742, or equal), installed in the differential housing through the drain plug so that at least one inch of the probe is immersed in the lubricant and the sensitive portion of the probe is approximately 1/2 inch from the ring-gear face.

(b) Temperature recording and controlling device with automatic controls (Foxboro Dynalog Model 9135W-M2-"754S1-11" or equal) connected to the temperature probe. The device must be capable of maintaining a temperature of $180^{\circ} \pm 2^{\circ}\text{F}$, within the test unit by alternately operating the heat lamps and the fan.

(c) Heat lamps and electric fan. Two 250-watt heat lamps and an electric fan, operated alternately by the temperature recording device, shall be placed as shown in Figure 2.

3.4 Controlled temperature storage box. The test equipment shall include a heated enclosure for maintaining the test unit at a uniform temperature during specified storage periods. The enclosure shall be capable of providing a uniform circulation of heated air for maintaining

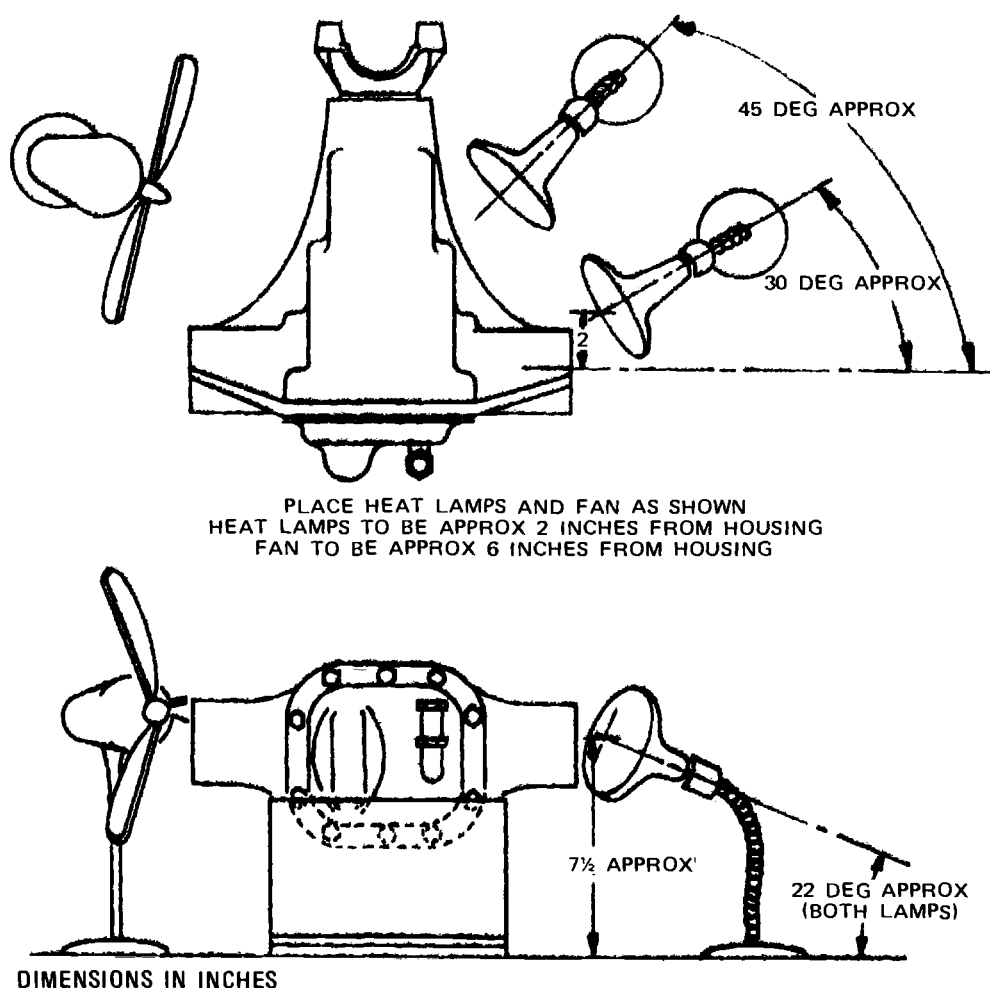


Figure 2.—Heat lamp and fan arrangement.

more than 5-lb-in. Adjust by adding or removing shims as necessary.

3.5 Sandblasting equipment.

5.2 Prepare the unit for test as follows:

(a) Disassemble the test unit, and clean all parts with dry-cleaning solvent P-D-680, Type 2.

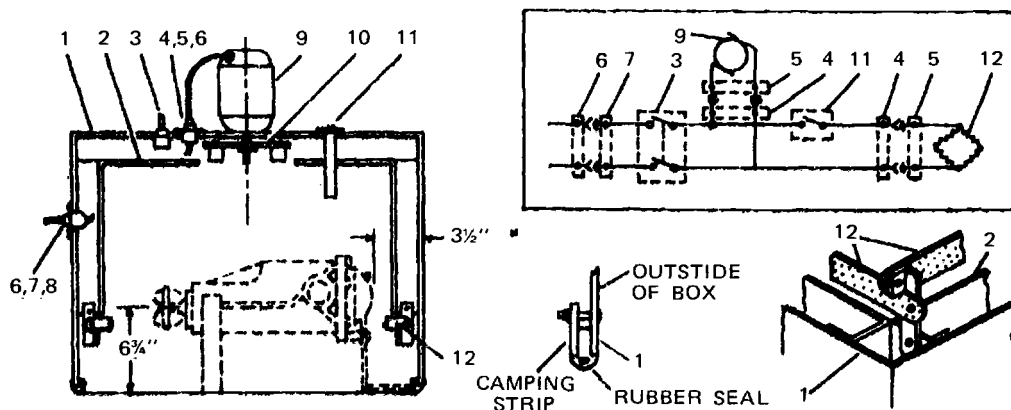
Note 3. If a used test unit is being employed for a one-day test, it is not necessary to disassemble the unit. Simply remove the cover plate, spray out the unit carefully with dry-cleaning solvent, and inspect it. Then proceed with step 5.2(d).

(b) Carefully inspect all parts for evidence of corrosion, and record the location and extent of corrosion present.

Note 4. The unit should be discarded if corrosion is noted on the ring or pinion gears, or on any bearings. The cover plate must be discarded if not completely rust-free.

(c) Reassemble the test unit except for the cover plate. Mount unit in position for testing. Connect driving mechanism and install temperature control system.

(b) Check the pinion shaft torque. The break torque must be 7 to 10-in; the turn torque not



1. Outer box (24-1/2 by 24-1/2 by 18 inch), aluminum, welded seams.
2. Inner baffle (21 by 21 by 11 inch), aluminum, welded seams
3. Toggle switch (Cutler-Hammer No. 7560-K5, or equivalent)
4. Plug, female (Amphenol No. 61F, or equivalent)
5. Connector, male (Amphenol No. 61M11, or equivalent)
6. Shells (Amphenol No. 61-61, or equivalent)
7. Plug, male (Amphenol No. 61M, or equal)
8. Connector, female (Amphenol No. 61F11, or equivalent)
9. Fan Motor, 1/80-hp (Dayton Electric Co. Model 4K102, or equivalent)
10. Fan impeller, aluminum, 6-inch diameter, 6 blades (1-1/2 by 1-1/4 inch)
11. Thermostat (Fenwall Cat. No. 17752, or equivalent)
12. Heating element, 110-V, 500-W (Chromalox strip heaters No. S3450, or equivalent)

(d) Sandblast cover plate until all of the original surface has been removed.

CAUTION

After blasting, avoid handling sand-blasted surface and protect from all foreign materials.

(e) Pour one quart of dry-cleaning solvent over cover plate, and allow to drain and air-dry.

Note 5. Do not spray solvent or blow air into cover plate since entrained moisture may be present.

(f) When the cover plate is dry, pour a small amount of the test oil over the entire sand-blasted area, and immediately install on test unit.

(g) Insert the axle seals; leave one of the seals loose to vent the housing while adding oil and water. Install street elbow in cover plate fill hole.

(h) Remove the relief valve and fill the test unit with 2.5 pints of the test lubricant through the street elbow.

5.3 Operate the test unit as follows:

(a) Turn on the driving mechanism, and bring the pinion speed to 2500 rpm. Note and record the time, and the temperature of the lubricant.

(b) Add one ounce (29.6 ml) of distilled water to the lubricant in the test unit, and re-install the relief valve. Immediately tighten the axle seals.

(c) Adjust the temperature control equipment to maintain a lubricant temperature of $180^{\circ} \pm 2^{\circ}\text{F}$, and allow the unit to warm up.

(d) When the lubricant temperature reaches 180°F ., record the time and install the pipe plug in the relief valve vent opening, and continue to operate the test unit for four hours at 2500 rpm.

5.4 At the end of four hours of operation, disconnect the motor from the test unit, and remove the heat lamps and the fan. Immediately cover the unit with the controlled-temperature storage box. (See Figure 4.) Turn on the circulating fan, but do not connect the heaters until the temperature within the box reaches approximately 140°F .

5.5 When the enclosure temperature reaches 140°F ., connect the heaters and store the test unit at $125^{\circ} \pm 2^{\circ}\text{F}$, for the stipulated time.

5.6 At the end of the specified storage period, drain the lubricant and remove the cover plate.

5.7 If conducting a one-day test, record the percentage of the area corroded on the cover plate above the oil level. Also indicate the intensity and color of the corrosion products. Report the results on a test report form similar to that shown in Figure 4.

5.8 If conducting a seven-day test, record and report conditions noted in paragraph 5.7. Also disassemble the test unit, inspect all parts for corrosion, and report the conditions on the report form.

LABORATORY TEST QUESTIONNAIRE AND FINAL SUMMARY OF RESULTS	
A. GEAR LUBRICANT IDENTIFICATION 1. Company _____ Brand Name _____ 2. Formula No. _____ Viscosity Grade _____	B. GEAR TEST IDENTIFICATION 1. Test run at _____ 2. Under Code No. _____ Test No. _____ 3. Date of Start _____ Finish _____ 4. Test Duration _____ Day
C. EVALUATION OF TEST PARTS	
1. Before Test: _____ 2. After Test a. Cover Plate: _____ c. Pinion Gear: _____ e. Differential Spider Gears: _____	
b. Ring Gear: _____ d. Bearings: _____ f. Housing and Miscellaneous Parts: _____	
D. GENERAL OPERATING CONDITIONS	
1. Bearing Preloads a. Case-carrier assembly interference, inches: _____ b. Pinion torque, lb-in: _____ break _____ turn _____ c. Full differential assembly, lb-in: _____ break _____ turn _____	3. Motoring Phase a. Time: Start _____ Finish _____ b. Average Pinion Speed _____ RPM c. Oil Temperature, °F: _____ Avg _____; Max _____; Min _____
2. Warm up a. Time: Start _____ Finish _____ b. Temperature, °F: _____ Start _____ Finish _____	4. Storage Phase a. Time: Start _____ Finish _____ b. Storage Temperature, °F: Avg _____
Remarks: _____ _____ _____	
Date: _____	
by: _____	

FIGURE 4.—Typical report form.

A CRC group is currently active in developing a new moisture corrosion test to replace the L-33. The following describes a modification of the L-33 as accepted in the interim by the Army Materiel Command.

OUTLINE

The test lubricant and one ounce of distilled water are mixed in a new unloaded hypoid differential carrier assembly by driving the pinion gear with an electric motor at 2,500 rpm for four hours with the bulk oil temperature at 180 F. The sealed assembly is then enclosed by a heated, double-walled, aluminum box and stored for an additional 162 hours at 125 F with no rotation. The carrier assembly is disassembled at the end of the test and the components rated for stains, rust and corrosion, with particular emphasis on the cover plate which is sandblasted before the start of the test. Requirements for passing the test include having less than 1% area rust on the cover plate and no rust on the internal gears and bearing surfaces (functional parts).

EQUIPMENT DESCRIPTION

The portable test stand is self-contained with the exception of a wall-mounted temperature recorder/controller. The major components of the test apparatus are:

A. Gear Carrier and Cover Assembly:

Available from Dana Corporation, Axle Division,
Dana Part No. 26217X, includes No. 32538 cover plate.

B. Variable Speed Pulley and Mounting Accessories:

1. Dodge "Dyn-Adjust" Belt
Series 19 - 1-3/16" x 13/32" pitch length
2. Slide motor base, "Dyn-Adjust" No. 20-C.
3. Dodge Taper lock pulley with bushing No. 1960, 1-3/16" bore.
4. Dodge "Dyn-Adjust" SL sheave with bushing No. 19SL,
3:1 speed range, 7/8" bore.

C. Driving Motor:

U.S. Motors, 1-1/2 hp, enclosed , 3,600 rpm, 7/8" dia.
shaft.

D. Pressure Relief Valve

James, Pond and Clark
Model 259B-2PP, set for 1 psi
Brass, 1/4"-18 NPT

E. Fan and Heat Lamps

Two 250-watt heat lamps with individual mounting stands.
Household-type electric fan with 12" dia. blades.
Heat lamps and fan to be mounted as shown in Figure 1.

F. Temperature Controller/Recorder

Honeywell recorder, Model No. 452C1L-33-P1-75.
Rosemount Engineering Co. temperature probe, Model 104MC-
7AEA, with mating connector (platinum).

G. Sandblasting Material

99.8% SiO₂, Moh hardness of 7.
American Foundryman's Soc. grain fineness No. 26.
Available from: Wedron Sand Co.
135 S. LaSalle St.
Chicago, Illinois
Wedron Sand No. 4098

H. Axle Seals

Make from materials as shown in Figure 2.

I. Storage Box

The box is constructed according to drawings supplied with the Armour Research Foundation Report (see Section X). The particulars regarding construction of the box and the recirculating fan blade should be closely followed.

The electrical wiring should be connected to allow the recirculating fan to run with and without the strip heaters being on.

LUBRICANT REQUIREMENTS

One gallon of test fluid is required for the test. The capacity of the carrier assembly is 2.5 pints. The remaining oil is used for coating the test parts during assembly and for pouring over the cover plate after it has been sandblasted before test.

EQUIPMENT STANDARDIZATIONA. Reference Fluid

There are no official reference oils; however, RGO-110 (SAE 90) should give borderline results when the test is run as specified in this procedure (7-day duration).

B. Repeatability-Reproducibility

To be determined.

C. Quality Control

Strict attention to differential build-up procedure is essential to controlling test repeatability.

MECHANICAL PROCEDURES

- A. Place a new differential assembly in a bench-mounted holding fixture. Remove and inspect the cover plate. The cover plate must be rust-free to be used in the test.
- B. Remove the carrier bearing caps and lift the carrier assembly from the housing.
- C. Remove the spider gears from the carrier assembly.
- D. Remove the pinion gear from the housing.
- E. Drill and tap the housing for the temperature probe. The location of the probe is shown in Figure 3.
- F. Spray each component individually with Stoddard solvent and thoroughly air-dry. Make certain that the grease applied to bearings by the manufacturer has been completely removed.
- G. Carefully inspect all parts for rust.. Discard the ring gear, pinion gear or bearings if there is any rust on them. Light surface rust on other parts may be removed with fine emery paper or a wire brush. Record the extent and location of any rust found and removed on the data sheet. The parts should be recleaned with Stoddard solvent after the rust has been removed.
- H. Install the pinion gear and support bearings in the housing. Thoroughly coat the housing, gear, shaft, and bearings with the test fluid during assembly.

- I. Determine and record on the data sheet the pinion shaft torque. The break torque should be 7-10 in-lb; the turning torque should be 5 in-lb or less. The torque may be adjusted by adding or removing shims from the pinion shaft as necessary.
- J. Install the spider gears in the carrier and place the assembly in the housing. Use a new 1" paint brush to cover all parts and surfaces with test oil during assembly. Install temperature probe in housing.
- K. Determine and record on the data sheet the break and turning torque of the assembled unit. The break torque should be 15 ± 3 in-lb; the turning torque should be 10 ± 3 in-lb. If necessary, adjust the carrier preload by adding or removing shims behind the carrier bearings as required.
- L. Make a cover plate gasket from a manila folder of sufficient size. It is important that this material be used because of its effect on corrosion at the cover plate/housing interface.
- M. Thoroughly clean a new rust-free cover plate using Stoddard solvent and a fiber brush. Sandblast the plate using approx. 1 quart of new sand (specified in III.G.) and 100 psi air pressure with a 1/8" dia. nozzle. It is important that the inside of the plate be evenly and completely resurfaced.

After the sandblasting is finished, do not touch the surface. Clean the cover by pouring Stoddard solvent over the plate and allow it to stand until dry. (Do not use compressed air for drying as it may contain moisture.) Rinse the plate again using acetone and allow it to stand until dry.
- N. Pour approximately one quart of the test oil over the sand-blasted surface of the cover plate. The entire surface must be wetted. Allow the excess oil to drain from the cover and bolt it to the axle housing.
- O. Install the axle shaft plugs in the housing, but do not tighten. The plugs should be inserted in the housing until they touch the carrier bearings.
- P. Install the completed assembly on the test stand. Connect the drive shaft, variable speed pulley drive, and temperature probe.
- Q. The test should be started the same day the cover plate is installed.
- R. Install the fan and heat lamps as shown in Figure 1.

OPERATIONAL PROCEDURES

- A. Add 2.5 pints of test oil to the assembly through the cover plate fill hole.
- B. Adjust the temperature controller to 180 F.
- C. Start the driving motor and adjust the variable speed pulley to give a pinion speed of 2500 ± 25 rpm. Use a strobe light to check the speed. Record the time and the initial oil temperature on the data sheet.
- D. Add one ounce of distilled water to the lubricant. Immediately tighten the axle shaft seals and install the relief valve in the cover plate.
- E. Some lubricants may foam enough, after the addition of the water, to leak past the relief valve (set at 1 psi). When this occurs, loosen the axle seal on the side opposite the heat lamps to vent the housing until the leakage stops. Immediately tighten the axle seal. Repeat this procedure, if necessary, minimizing the time the axle seals are loosened, until the temperature reaches 180 F.
- F. Install a pipe plug in the open end of the relief valve when the lubricant temperature reaches 180 F. Record the time on the data sheet. Continue the motoring phase for four hours at 180 ± 2 F.
- G. Record the time when the four-hour motoring phase has been completed; disconnect the drive shaft from the test unit; remove the heat lamps and fan from the test stand. Immediately cover the assembly with the storage box (see VII.I.). Turn on the circulating fan. When the oil temperature reaches 140 F, turn on the heater switch and record the time on the data sheet (storage phase, start).
- H. Control the test oil temperature at 125 ± 2 F indirectly by maintaining the air temperature in the box at 125 F with the Fenwal controller. Once the Fenwal has been correctly adjusted, it should not be necessary to readjust it for subsequent tests.
- I. The storage phase is continued for 162 hrs. or approx. seven days. A shortened storage phase lasting only 18 hours may be run as a screening test if desired. The procedure for shortened (1 day) test is identical to that for the seven-day test except for the length of the storage time.

- J. Record on the data sheet the time when the 162-hour storage phase has been completed. Remove the differential assembly from the test stand and place it in the holding fixture. Do not turn the pinion shaft. Carefully remove the cover plate. Drain the oil from the housing. Indicate the fluid level on the ring gear and pinion, using a suitable marking pencil.
- K. Remove the carrier bearing caps and lift the carrier assembly from the housing. It is not necessary to remove the spider gears.
- L. Remove pinion gear, bearings and races from the housing.
- M. Take the disassembled unit to the inspection room (Rm. 460) for rating and photographing.

INSPECTION PROCEDURES

A. Rating of Test Parts

Before rating, parts are to be sprayed lightly with Stoddard solvent, then allowed to stand until dry. This will remove the test oil so that an accurate rust rating can be determined. On the cover plate only, dry compressed air may be used to avoid stain lines from the solvent.

The following parts should be rated, indicating the amount, intensity, color, and location of any corrosion products. (Indicate whether the product is rust, sludge, stain, etc., if possible. Indicate the area percent of surface rust on the cover plate.)

1. Cover plate
2. Pinion gear
3. Spider gears
4. Ring gear
5. Bearings
6. Housing

An oil is considered to pass the test when there is less than 1% area surface rust on the cover plate and no rust on the gears or bearing surfaces. Light stain on these parts may be acceptable.

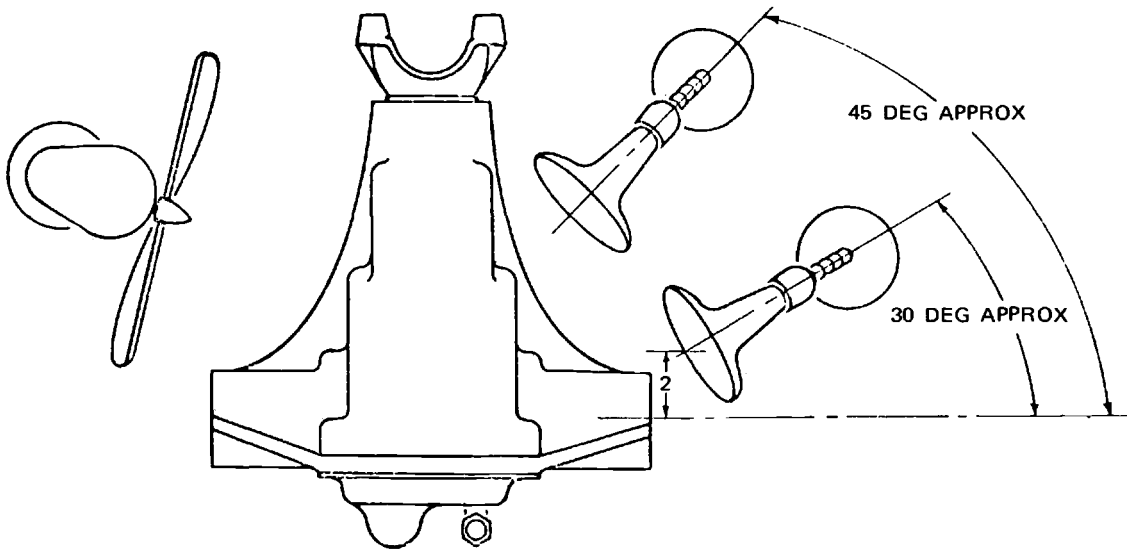
B. Photographs

The following color photographs should be taken immediately after the test is completed to avoid additional rust, corrosion, or discoloring of the test parts:

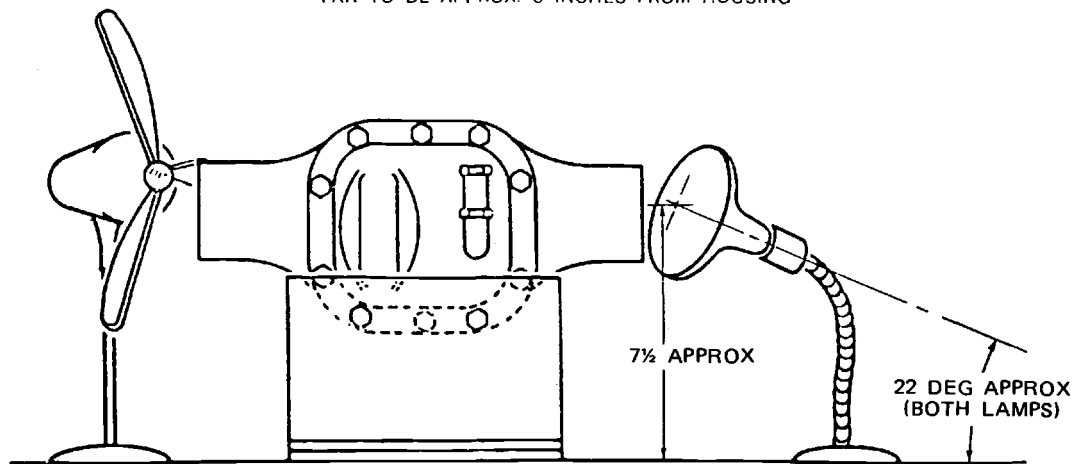
1. Cover plate.
2. Worst carrier bearing cap and outer race.
3. Ring gear, carrier, and support bearing (from ring gear side).
4. Ring gear, carrier, and support bearing (opposite side from #3).
5. Pinion gear and bearing.
6. Differential housing.

C. Disposition of Test Parts

1. After rating and photographing is completed, individually coat each component with a rust preventive oil such as Mobilarma 245. Mobilarma 245 is a solvent-based, thin-film rust preventive product with water-displacing properties which meets Aeronautical Material Spec. 3065-C. Allow excess oil to drain from the part. The cast iron housing may be discarded.
2. Wrap each part in a chemically treated, corrosion-inhibiting paper (NO_x Rust Vapor Wrapper, available from Daubert Chemical Co., Oakbrook, Ill.) and seal with masking tape.
3. Place the wrapped pieces in a 12" x 30" plastic bag; add 4 or 5 rust inhibiting discs (No Wrap Rust Inhibitor Discs, 350 cu. in. size, Chippewa Paper Products Co., Inc., Chicago, Ill.); and tie the end of bag.
4. Pack in suitable box for storage or shipment, as requested by test sponsor.



PLACE HEAT LAMPS AND FAN AS SHOWN
HEAT LAMPS TO BE APPROX. 2 INCHES FROM HOUSING
FAN TO BE APPROX. 6 INCHES FROM HOUSING



DIMENSIONS IN INCHES

Figure 1
Heat Lamp and Fan Arrangement

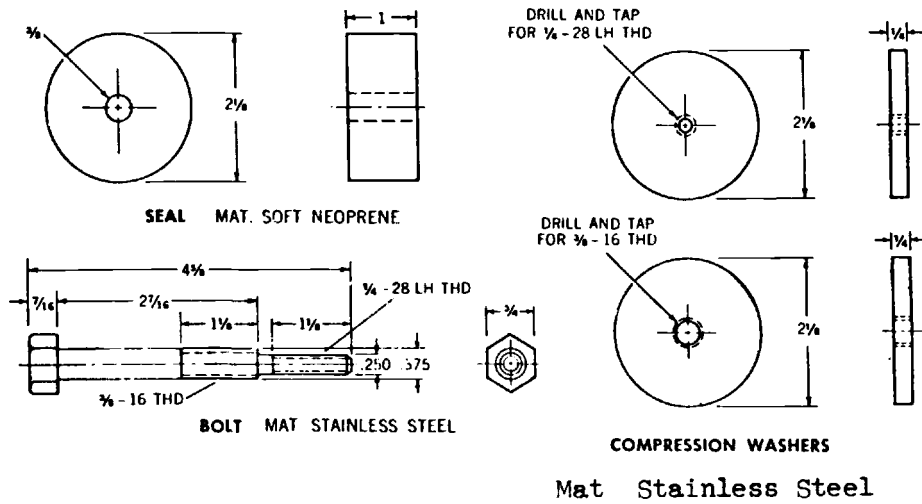
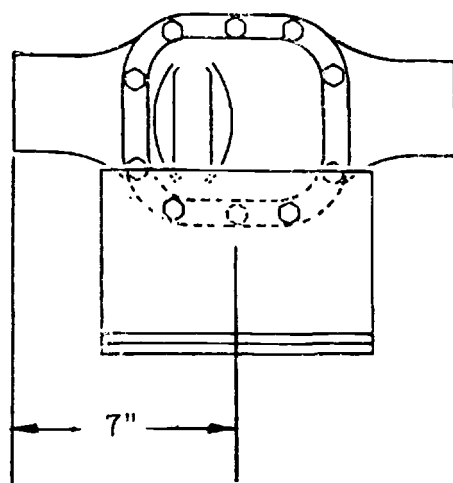
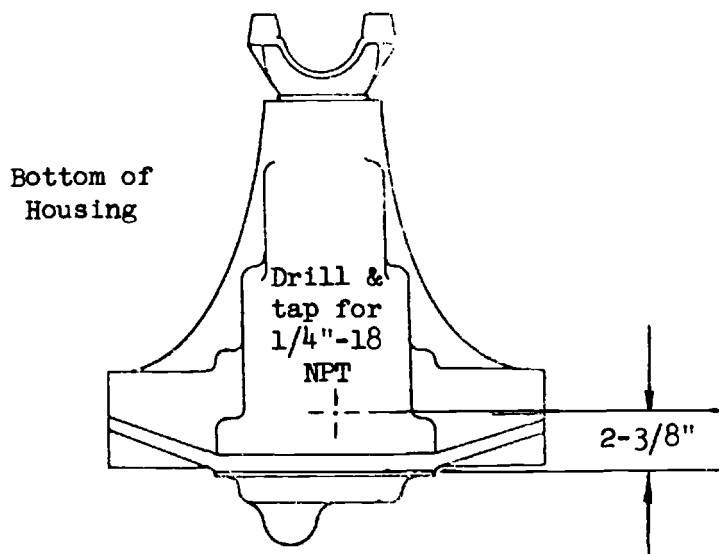


Figure 2
Axle Seals



Note: Temperature probe should be approx. 1" from ring gear teeth.

Figure 3

Temperature Probe Location

REPORT FORM

Test Fluid _____ Lab No. _____
Run No. _____ Charge No. _____
Requestor _____ Date _____
ETL Approval _____ Date _____

Operating Conditions

Test Duration _____ Day(s)
Pinion Torque, lb.-in. Break _____ Turn _____
Full Assembly Torque, lb.-in. Break _____ Turn _____
Warm-up Time: Start _____ Finish _____
Temp: Start _____ Finish _____
Motoring Phase Time: Start _____ Finish _____
Average Pinion Speed RPM _____
Oil Temperature, °F: Avg _____ Max _____ Min _____
Storage Phase Time: Start _____ Finish _____
Oil Temperature, °F: Avg _____ Max _____ Min _____

Data Summary

Before Test Condition: _____

After Test Condition: _____

Cover Plate: _____

Pinion Gear: _____

Spider Gears: _____

Ring Gear: _____

Bearings: _____

Housing: _____

FALEX PIN CORROSION TESTAPPLICATION

This procedure is used to determine the probability of rusting of gear housing assemblies where a lubricant containing potentially corrosive chemicals is used and where moisture is present. The method also indicates the effectiveness of inhibitors which may have been added to the lubricant to prevent rust formation.

APPARATUS REQUIREDFalex E. P. Tester

A Falex or other similar machine where loading may be controlled to produce an oil bath temperature of 210 ± 10 F is required.

Falex Pin and Bushings

The pin and bushings referred to in this procedure are the same as the standard steel test shaft and bushings used in Ford Laboratory Test Method BJ 1-1.

Forceps

A clean pair of forceps is required for handling the pin and bushings as at no time during the test should they be touched with the hands, which may leave a moisture film on the part and cause rusting.

Oven

A drying oven at 180 ± 2 F is required. Draining the lubricant from the pins at this temperature simulates axle drainage conditions from that part of a differential ring gear above the oil after a test.

Bell Jar

A Bell jar (6 - 7 in. I.D. and 9 - 10 in. high) placed over a 12 in. by 12 in. glass plate is necessary to expose the sample pins at a relative humidity of 60 - 90%. The ground edge of the Bell jar should be coated with stopcock grease to effect a tight seal when placed on the glass plate.

Thermometer

If the oil bath of the Falex machine is not equipped with a thermocouple-thermometer, a glass thermometer (0-300 F) must be placed in the test cup near the bushings and pin so that the bulb end is completely immersed in the oil.

Gooch Crucible

A porcelain Gooch crucible is required for draining excess oil from the pin.

REAGENTS REQUIRED

Naphtha
Petroleum Ether
Butyl Cellosolve
Phosphoric Acid (20% solution by volume)

PROCEDURE

1. Clean standard pin and bushings by brushing in naphtha to remove all traces of rust-proofing grease and oil and air dry.
2. Examine and select pins and bushings which have no flaws or surface roughness.
3. Clean pin and bushings (use forceps) in petroleum ether and dry with a clean, soft towel.
4. Pour oil into E.P. test cup and heat to approximately 200 F.
5. Assemble the pin and bushings in the machine with forceps.
6. Load the machine sufficiently to maintain an oil bath temperature of 210 ± 10 F and run the test for 25 min.

Note: 1. Heat generated by friction between pin and bushings causes a release of the chemical additives such as occur in the frictional contact of gears in service.

(Continued)

- Note: 2. If seizure of the pin or excessive scoring occurs, the test shall be run at a lower load. If necessary, a source of external heat should be applied to maintain the oil bath temperature.
7. With a clean forceps, remove the pin from the machine, place on end at a slight angle in the Gooch crucible, place the crucible on a watch glass and heat in an oven at 180 ± 2 F for 30 min.
 8. Place the crucible containing the pin on a 12 in. by 12 in. glass plate in an area free of corrosive fumes.
 9. Place a 150 ml beaker of tap water on center of plate, cover with a Bell jar for 24 hr. at room temperature. Make sure that an air tight seal is formed between Bell jar and plate, and that no water is splashed onto pin.
 10. Remove pin with forceps, wash in petroleum ether to remove traces of lubricant.
 11. Wash in butyl cellosolve to remove oxidized oil deposits. Severe deposits of oxidized oil may be removed by long soaking in butyl cellosolve followed by a gently rubbing with a soft cloth moistened in butyl cellosolve.
 12. Inspect visually for iron oxide rust deposits. Brownish deposits may be due to varnish or oxidized residue. A spot test may be made by using a drop or two of 20% phosphoric acid on a part of the brown deposit. Iron rust will be dissolved by this treatment.
 13. If specimens are required for future reference, coat with clear lacquer or mount in Lucite or other clear plastic.

THERMAL OXIDATION STABILITY OF GEAR LUBRICANTS

1. SCOPE

1.1 This method is used for determining the deterioration of lubricants under severe oxidation conditions. It consists of placing a sample of the lubricant in a gearcase in which two spur gears and a test bearing are operated under load while heat is applied and air is bubbled through the lubricant.

2. SAMPLE

2.1 Approximately 160 ml. of the gear lubricant to be tested.

3. APPARATUS

3.1 **Test apparatus.** The test apparatus (Fig. 1) shall include a gear case assembly, a temperature-control system, a generator, and a regulated air supply as described in the publication "Development of a Thermal Oxidation

Stability Test for Gear Lubricants", Project No. DA 593-21-060, Contract No. DA-23-072-ORD-1144, dated June 1958.

(a) Gear case assembly. The gear case assembly, similar to that shown in Figure 2, shall house a new test bearing and a pair of test gears, driven by a motor rated at 3/4 hp at 1725 rpm.

(b) Temperature control system. The test setup shall include means for maintaining the temperature of the test lubricant in the gearcase at $325^{\circ} \pm 1^{\circ}\text{F}$ ($162.8 \pm 0.6^{\circ}\text{C}$). It shall include an insulated heater case, a circulating blower, a thermistor probe, and an indicating controller. (See Figure 3.)

(c) Generator. The test setup shall include a 12-volt, 45-ampere generator (Delco Remy Buick Model 1102101, or equivalent) for apply-

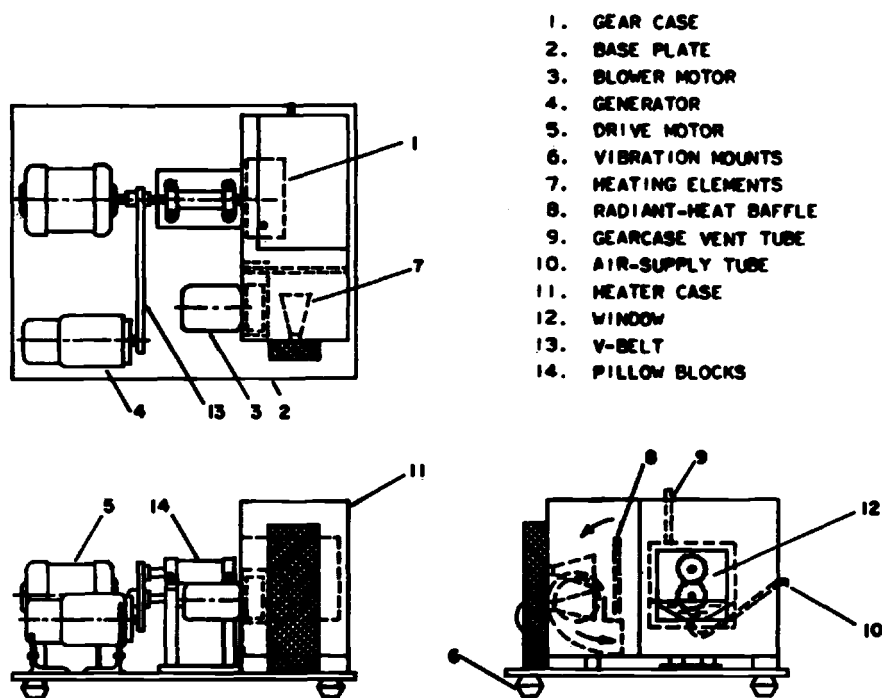


FIGURE 1.—Lubricant stability test apparatus.

- | | | |
|-----------------|------------------------|-------------------|
| 1. Gear case | 6. Vibration mounts | 11. Heater case |
| 2. Base plate | 7. Heating elements | 12. Window |
| 3. Blower motor | 8. Radiant-heat baffle | 13. v-belt |
| 4. Generator | 9. Gear case vent tube | 14. Pillow blocks |
| 5. Drive motor | 10. Air-supply tube | |

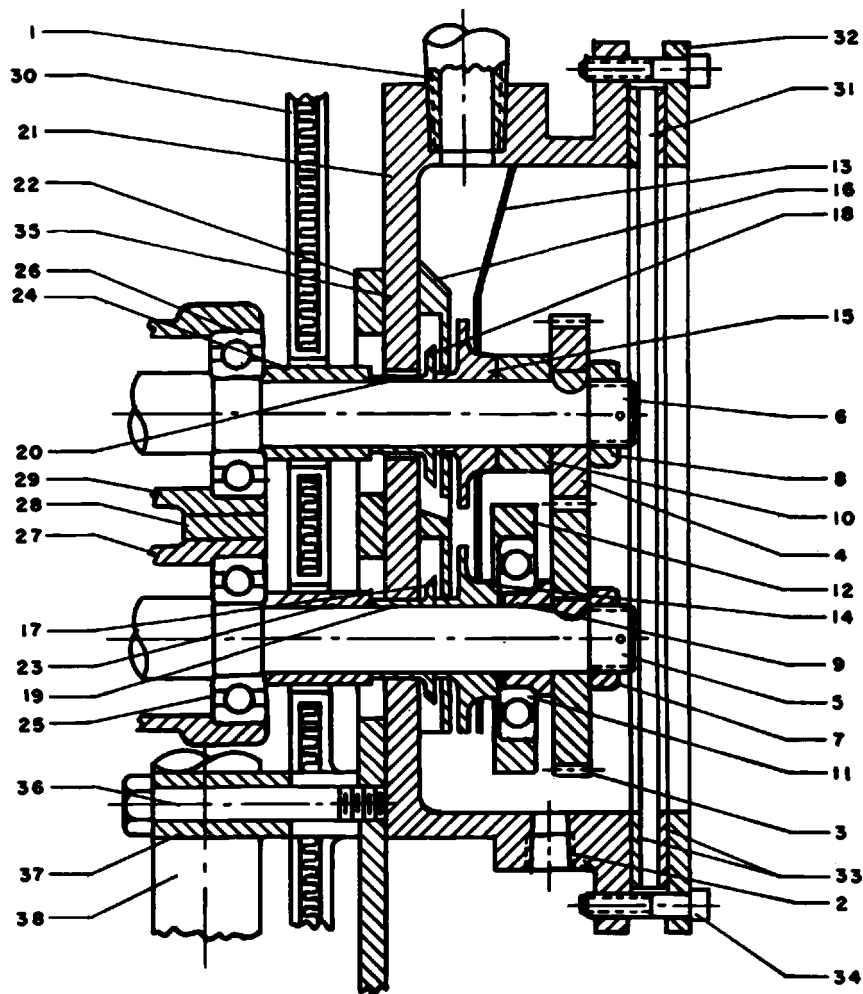


FIGURE 2.—Gear case assembly (cross section).

- | | |
|----------------------------------|---|
| 1. Vent tube | 21. Gear case |
| 2. Case air inlet | 22. Gear-case support |
| 3. Test gear, 50-teeth | 23. Retainer bushing, lower |
| 4. Test gear, 34-teeth | 24. Retainer bushing, upper |
| 5. Gear shaft, driving | 25. Pillow block bearing, lower |
| 6. Gear shaft, driven | 26. Pillow block bearing, upper |
| 7. Gear retaining nut, RH thread | 27. Pillow block, lower |
| 8. Gear retaining nut, LH thread | 28. Spacer, pillow block |
| 9. Test bearing bushing | 29. Pillow block, upper |
| 10. Spacer bushing | 30. Heater case |
| 11. Test bearing | 31. Window, gear-case |
| 12. Test bearing clamp | 32. Retainer, gear-case window |
| 13. Baffle plate | 33. Gaskets, gear-case window, 1/16 inch |
| 14. Outer slinger, lower | 34. Capscrew, gear-case window retainer, with lock-washer |
| 15. Outer slinger, upper | 35. Gasket, seal-plate |
| 16. Seal plate | 36. Bolt, case support to pillow block support |
| 17. Inner slinger, lower | 37. Bolt tube |
| 18. Inner slinger, upper | 38. Pillowblock support |
| 19. Slinger bushing, lower | |
| 20. Slinger bushing, upper | |

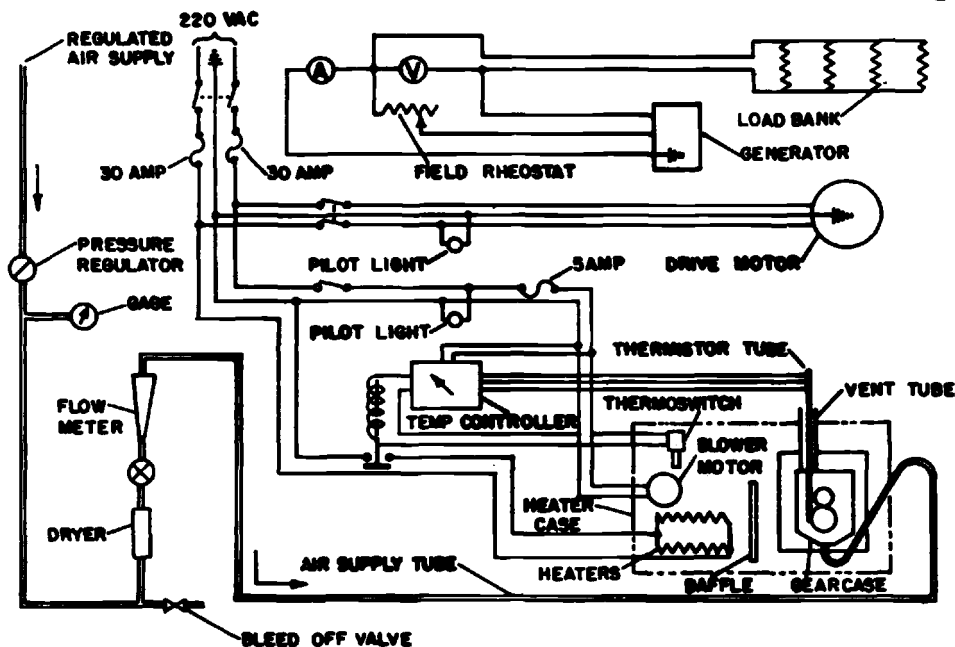


FIGURE 3.—Test setup (schematic diagram).

ing a load (128-watts generator output) to the test gears. The generator shall have means for regulating the field supply, and provisions for determining the output.

(d) Regulated air supply. The supply for bubbling air through the lubricant under test shall include a source of compressed dry air at 1 psi, a flow-meter capable of measuring a flow of 1 ± 0.1 liters per hour, and suitable valves for regulating the flow.

3.2 Silicon carbide cloth, 150-grit.

3.3 Inspection fixture, test bearing.

3.4 Dial indicator.

3.5 Shim stock, 3/8-inch wide, of various thicknesses.

4. MATERIALS

4.1 Catalyst. The catalyst shall consist of cold rolled electrolytic copper, sheared to 1-1/8 by 1-13/16 inch from stock 1/16 inch thick.

4.2 Special cleaner, capable of removing lacquer, sludge, etc., and inert to copper, steel, and stainless steel.

4.3 Solvent, dry-cleaning (P-D-680; Type 2).

4.4 Toluene.

Note 1. Caution. Toluene is toxic. Do not breathe its fumes nor allow it to come into contact with the skin.

4.5 Precipitation naphtha.

5. PROCEDURE

5.1 Assemble the test apparatus as in Figure 1.

5.2 Prepare the gear case assembly as follows:

(a) Remove and clean the gear case window and all internal parts of the gear case assembly (except the test gears and the test bearing) with the special cleaner (4.2) using a nylon-bristle brush, or a long pipe cleaner. Then wash with dry-cleaning solvent.

CAUTION

Since the proper operation of this apparatus depends upon the maintenance of numerous accurately machined surfaces, do not use steel brushes, abrasive cloths, or the like.

(b) Polish the sides of the test gears with the silicon carbide cloth, and wash with dry-cleaning solvent. Carefully examine the gear

teeth for nicks and burrs. Gears with major imperfections must be discarded, but very small imperfections may be polished out with a fine stone.

(c) Wash the test gears and test bearing with dry-cleaning solvent; then wash all the parts in toluene, and allow to air-dry.

(d) Polish the catalyst on all six sides with the silicon carbide cloth and wipe with absorbent cotton pads moistened with precipitation naphtha. Then wash with precipitation naphtha and allow to air-dry. Weigh the catalyst immediately before installing it in the catalyst holder.

Note 2. If it is desirable to preserve the catalyst with deposits for later observation and still have a catalyst weight loss as an indication of the copper activity of the lubricant, the copper catalyst may be cut in half lengthwise and only one half weighted. Both halves are installed in the catalyst holder and at the end of the test the pre-weighed half is cleaned and again weighed, while the other half is preserved with the deposits intact.

CAUTION

Handle the catalyst only with tweezers or ashless filter paper.

(e) Measure and record the play of the outer race of the test bearing by clamping the inner race firmly on the bearing inspection fixture, and observing the movement of a dial indicator when the outer race is displaced with moderate finger pressure.

(f) Assemble the gear case assembly, except for the test bearing, the test gears, and the gear-case window. Use a new seal plate gasket for each test, and safety wire the seal plate bolts with stainless-steel wire.

(g) Install the test bearing so that the manufacturer's number faces the front of the case. Tighten the capcrew of the test-bearing clamp, and safety wire the capscrows of the test-bearing clamp and the gear shafts with stainless-steel wire. Install the test gears so that the manufacturer's number faces the front of the case.

(h) Determine the gear backlash by rotating 3/8-inch wide shim-stock strips of various thicknesses through the gears. The gear backlash is equal to twice the thickness of the thickest strip that can be rotated through the gears by light hand pressure.

(i) Install the gear-case window, using new cork gaskets.

5.3 Measure and record the acid number, and the pentane and benzene insolubles of the test lubricants. Pour 120 ml. of the lubricant through the vent tube into the gear case.

5.4 Rotate the driving-gear shaft four times by hand to coat the test gears and the test bearing.

5.5 Record the time, and turn on the main drive motor. Adjust the temperature control system to maintain the temperature of the lubricant at $325^{\circ} \pm 1^{\circ}\text{F}$ ($162.8 \pm 0.6^{\circ}\text{C}$).

5.6 Adjust the air flow rate to 1.11 liters per hour at 1 psi.

5.7 Adjust the field supply to the generator for an output of 128 watts.

5.8 After 30 minutes of operation, turn off the drive motor. Obtain a sample of the lubricant by placing a glass tube in the gear case vent tube and drawing the lubricant through it into a reverse flow viscometer. Without filtering the lubricant determine the viscosity of the lubricant at 210°F by Method 305.6. After the determination is complete, return the lubricant to the gear case.

5.9 Resume operation, and at 10-hour intervals determine the viscosity as in paragraph 5.8 until the viscosity specified in the detailed specifications is obtained. The test is then complete.

5.10 Determine the results of the test as follows:

(a) Record the time required for the lubricant to attain the specified viscosity.

(b) Drain the lubricant into a clean sample jar through the air supply tube fitting. Determine and record the acid number, and the pentane and benzene insolubles of the lubricant.

(c) Remove the glass cover; measure and record the gear backlash.

(d) Without disturbing the deposits on the various internal parts of the gear case assembly, carefully remove them for inspection.

(e) Inspect the deposits on the various components, and on the catalyst. Rate the deposits for color (light brown, brown, dark brown, black, etc.), hardness (very soft, soft, medium, hard, or very hard), thickness (estimated in

thousandths of an inch) and type, such as lacquer (which cannot be wiped off), or sludge (which can be wiped off).

(f) Inspect and describe the condition of the gear surfaces for any abnormalities.

(g) Carefully remove all deposits from the catalyst. Weigh the catalyst to determine the

copper activity of the lubricant. Refer to Note 2.

(h) Determine the test bearing wear, using the inspection fixture and dial indicator as in paragraph 5.2(e).

LOAD-CARRYING CHARACTERISTICS OF UNIVERSAL GEAR LUBRICANTS IN AXLES UNDER CONDITIONS OF HIGH SPEED

1. SCOPE

1.1 This procedure is intended for use in determining the load-carrying characteristics of universal gear lubricants in axles under conditions of high speed.

2. APPARATUS

2.1 The apparatus shall consist of the following:

2.1.1 *Axle*.—The test unit shall be a new Chevrolet hypoid third member assembly (3657302)¹ 9-37 ratio. This assembly shall be installed in the axle housing of a Chevrolet passenger vehicle, for which it was designed.

3. PREPARATION OF EQUIPMENT

3.1 Equipment used in the conduct of this test shall be prepared in the manner described below:

Clean the axle housing and axle shafts thoroughly by spraying with or dipping in a petroleum solvent and drying with dry air.

Install the assembly in vehicle.

Fill the housing with the test lubricant.

Check tire inflation to 28 pounds.

4. TEST CONDITIONS AND PROCEDURE

4.1 The test conditions and procedure for the road test shall be as outlined below. The same procedure may be followed on a chassis dynamometer, provided that the roll torque throughout the entire speed range and the kinetic energy of the rolls at 70.2 m. p. h. are

¹ Rebuilt third member assemblies shall not be used, and no change in any of the tooth contacts or bearing adjustments shall be made. Third member assemblies especially selected by the manufacturer for test work shall be used.

NOTE 1.—Orders shall be placed with Chevrolet-Gear & Axle, Division of General Motors Corp., 1340 Holbrook Avenue, Detroit 12, Mich., Attn: Engineering Department. They shall specify "Third Member Assemblies for Oil Tests, to be checked by the Gear Engineering Department." For the third member assembly the part number is 657302; and for the complete rear axle assembly, the part number is 3657300.

identical with the effective road conditions and proven for any given installation by check evaluations:

Run 5 to 25 miles at not over 25 m. p. h.

Engage the clutch in high gear and accelerate (full throttle) to 40 m. p. h. Upon reaching 40 m. p. h., close the throttle and coast to 10 m. p. h. with clutch engaged. Repeat for a total of four times.

Gradually accelerate in high gear to 60 m. p. h. Upon reaching 60 m. p. h., open the throttle wide and accelerate to 80 m. p. h. Immediately close the throttle completely, and coast to 60 m. p. h. with clutch engaged. Repeat the drive and coast between 60 and 80 m. p. h., for a total of 10 times.

Return the vehicle to the inspection point under the same conditions outlined in the first subparagraph of 4.1.

Drain the test lubricant, and remove the third member assembly.

If under inspection there is no scoring of the ring-gear and pinion-gear teeth in the original test, a duplicate test shall be made using fresh lubricant and a new and unused third member assembly. If scoring of the ring gear or pinion teeth occurs in any test and is attributed to abnormal conditions, that test shall be voided, and the test shall be rerun using fresh lubricant and a new and unused third member assembly.

5. INSPECTION

5.1 The inspections shall be made as follows:

Examine pinion and ring gear surfaces on drive and coast sides of teeth for evidence of scoring, scuffing, ridging, rippling, pitting, or other unusual surface characteristics. Examine pinion and carrier bearings, spacer block, and differential gear pins for evidence of wear, corrosion, or pitting.

Assemblies for Oil Tests, to be checked by the Gear Engineering Department." For the third member assembly the part number is 657302; and for the complete rear axle assembly, the part number is 3657300.

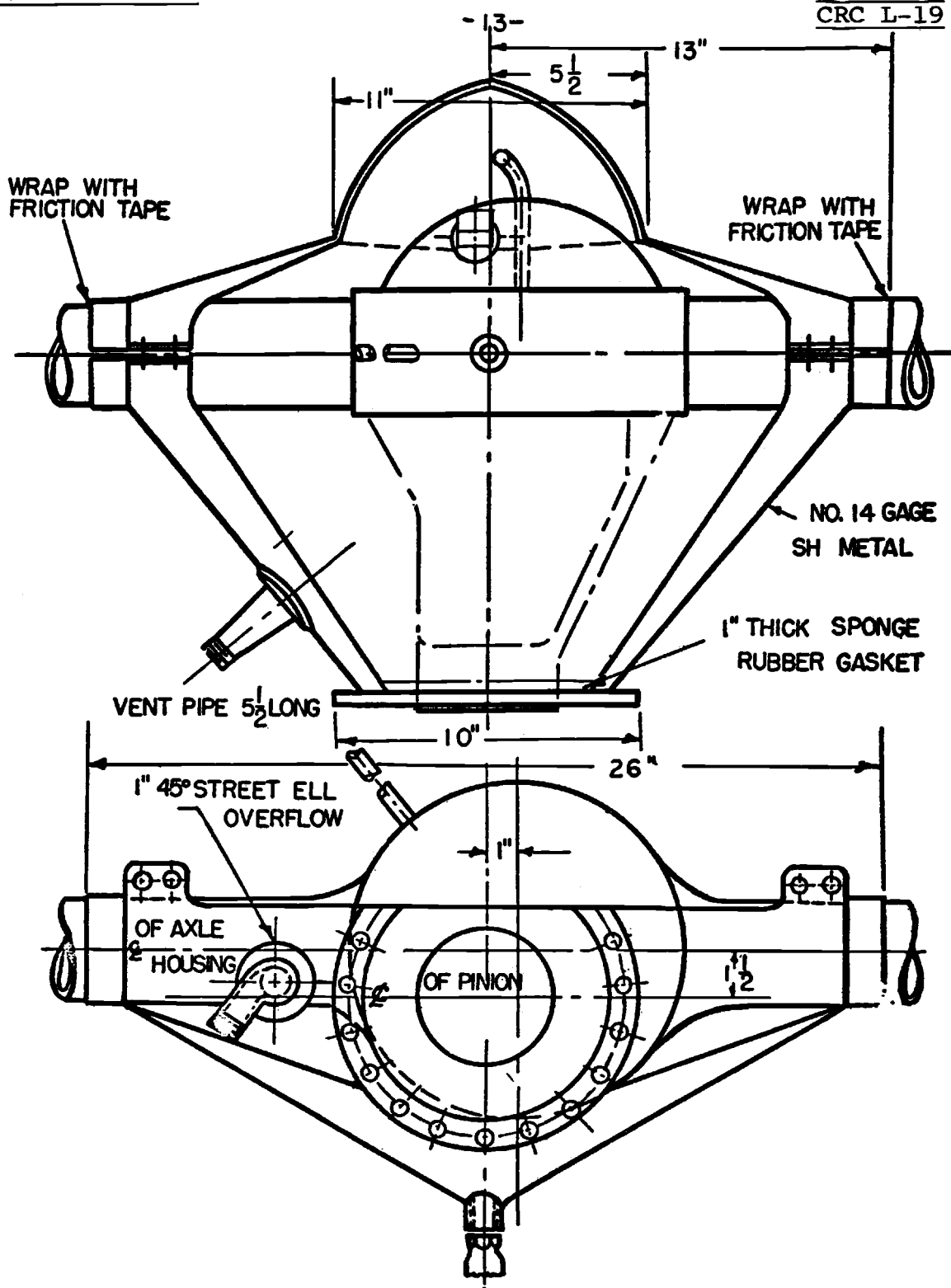


FIGURE 1A.—Water pan for axle test.

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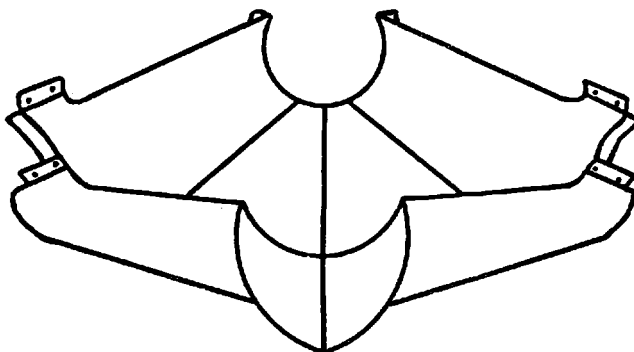
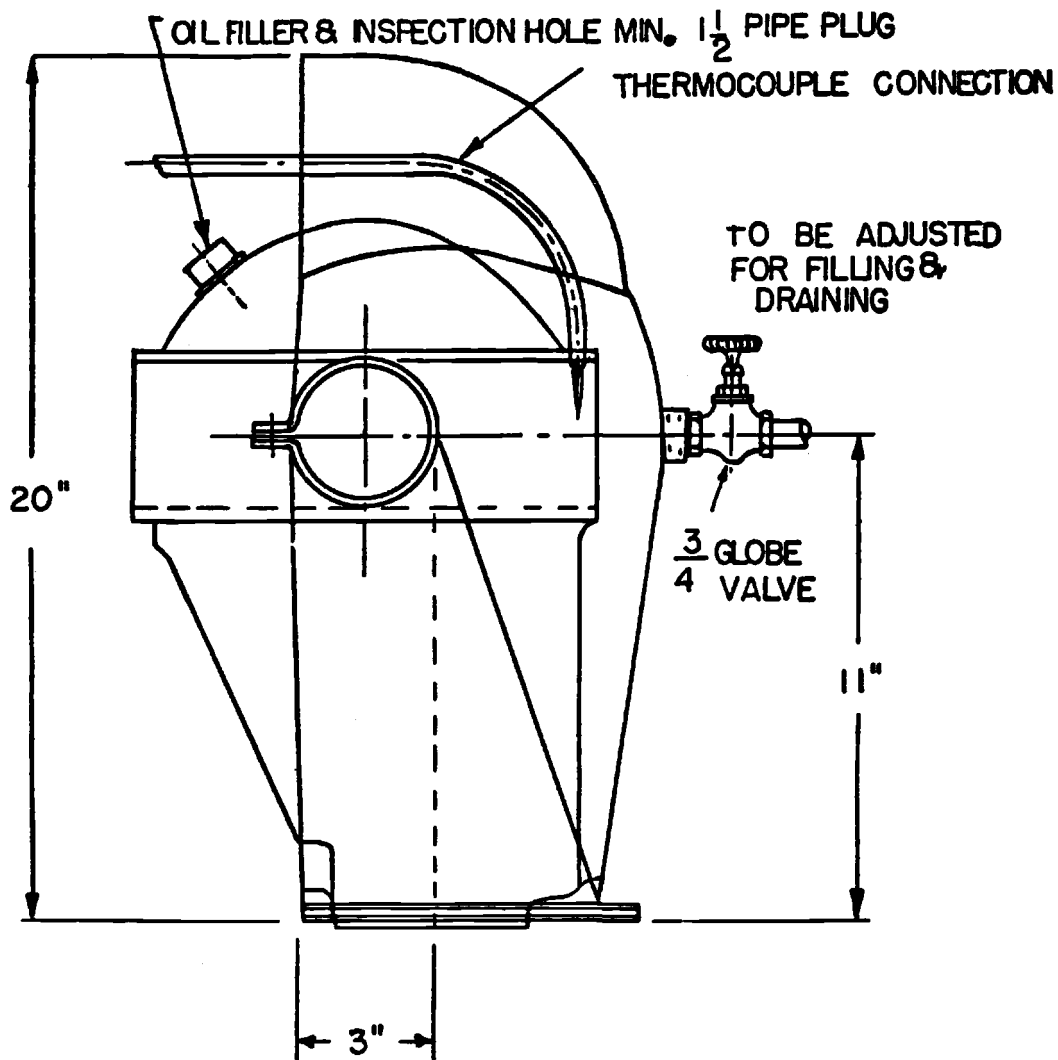


FIGURE 1B.—Water pan for axle test.

PERFORMANCE OF GEAR LUBRICANTS IN AXLES AT LOW SPEED AND HIGH TORQUE

1. SCOPE

1.1 This method is used for determining the load-carrying, wear, stability, and corrosion characteristics of gear lubricants in axles under conditions of low speed and high torque.

2. SAMPLE

2.1 Approximately 2 gallons of the gear oil to be tested.

3. APPARATUS

3.1 **Test unit.** The test unit shall consist of a new, 3/4-ton Army truck, hypoid rear-axle carrier, 5:83 to 1 ratio (Dodge part No. 930215, Chrysler Corp., Engineering Division, Detroit, Michigan). No change in any of the tooth contact or bearing adjustments shall be made.

CAUTION

Rebuilt carriers shall not be used. Only units especially selected by the manufacturer for this test work shall be used. Therefore, when ordering, specify a "special carrier for oil tests, to be checked by Gear Engineering Department", and designate whether the gears shall be phosphate coated or uncoated, as required by the applicable specification.

3.2.2 **Axle housing.** The carrier shall be installed in the axle housing (part No. 929922) for which it was designed. The housing shall be provided with a vent and an inspection opening as specified below. All other openings which might allow water leakage must be sealed with a suitable sealing compound (Permatex No. 2, or equivalent).

Note 1. When sealing, pay particular attention to all studs holding the carrier to the axle housing, the oil filler hole, drain, and inspection plugs, and to the thermocouple and vent fittings.

(a) **Axle vent.** The axle shall be vented to atmosphere throughout the entire test. The vent shall be arranged so that no water can enter the axle housing.

(b) **Inspection opening.** The axle-housing cover shall be modified to include an inspection

opening of sufficient size (approximately 1-1/2 inch pipe size) and so located above the level of the cooling-pan edge that the ring-gear tooth-contact surfaces can be readily inspected by removing the plug or cover.

3.3 **Temperature control.** The test setup shall include a means of maintaining the lubricant at a specified temperature. This shall include a thermocouple, a temperature recording instrument, and a cooling bath.

(a) **Thermocouple.** A thermocouple shall be installed in the axle housing in such a manner that the junction will be on the centerline of the housing, one inch from the tooth side of the ring gear and one inch from the bottom of the housing. This thermocouple shall actuate a temperature-recording instrument and control an automatic cooling bath.

(b) **Temperature-recording instrument.** A temperature-recording instrument (Leeds and Northrup Micromax, Model S-40000, or equivalent) shall be provided for recording the temperature of the lubricant in the axle housing.

(c) **Cooling bath.** A water bath shall be provided for controlling the temperature of the lubricant in the axle housing. The bath shall consist of an electrically operated water-control valve, and spray nozzles arranged to spray cooling water over the top of the axle housing, and a water pan installed around the axle. The water-control valve shall start and stop the flow of water, and shall be actuated by the thermocouple through the temperature-recording instrument. (Cloths may be laid over the top of the housing to prevent splashing and to assist in the uniform distribution of the coolant.) The water level in the pan shall be fixed by a suitable overflow, located at about the centerline of the pinion shaft. An outlet in the bottom of the water pan shall be provided, of such size that, when the water supply is cut off, the pan will be drained in approximately 20 to 30 seconds. After the water level is adjusted, the drain shall remain open throughout the test run. The water supply shall be sufficient to keep the pan full to

the overflow point while water is running out the bottom drain.

3.4 Dynamometer. An axle dynamometer with suitable control equipment shall be used. The control equipment shall have sufficient sensitivity of adjustment and control to permit maintenance of a uniform ring-gear torque to within 2 percent and a uniform speed to within 1 percent. The dynamometer shall have a revolutions counter so that the number of revolutions of the ring gear during the test may be recorded.

4. MATERIALS

4.1 Preservative oil conforming to MIL-L-3150.

4.2 Sealing compound, Permatex No. 2 or equivalent.

5. PROCEDURE

5.1 Prepare the apparatus for the test as follows:

(a) Determine and record the torques required to break and to turn the pinion shaft of the completely assembled test unit. (This should not exceed 100 lb-in.)

(b) Connect the dynamometer to the axle.

(c) Fill the axle housing to the correct level with the test lubricant.

(d) Install cooling water pan.

(e) Set the revolutions counters to zero (or record the readings).

(f) Determine (and adjust manually) the amount of water required to maintain the level at the overflow point with the bottom drain open. (Starting and stopping the flow as required to maintain the stipulated temperatures shall be controlled thereafter by the automatic electric water-control valve.)

(g) Set the temperature control to maintain a lubricant temperature of 200° to 250°F, (93.3° to 121.1°C), by turning on the water supply automatically at 250°F and off at 200°F.

(h) Determine the dynamometer field voltages required for ring-gear torques of 6000 and 32,311 lb-in. at 62 rpm.

5.2 Check the operation of the test unit as follows:

(a) Start dynamometer and apply initial load of 6000 lb-in. ring-gear torque at 62 rpm with no flow of cooling water.

Note 2. The direction of rotation shall be that required for forward movement of the vehicle using the axle.

(b) Continue operation until oil temperature reaches 140°F (60°C). Then stop the dynamometer. (Time normally required for this run is approximately 20 minutes.)

(c) Record total ring-gear revolutions.

(d) Inspect ring-gear tooth-contact surfaces through inspection hole. If contact is satisfactory, record as such, and proceed with test as defined in paragraph 5.3. If contact is unsatisfactory, install a new carrier assembly and start a new test.

5.3 Operate the test unit under full load as follows:

(a) Start dynamometer and apply test load of 32,311 lb-in. ring gear torque at 62 rpm with cooling water shut off.

(b) Allow the temperature of the oil to rise to 250°F (121.1°C), then turn on the automatically controlled water supply, and allow the oil temperature to cycle between 200° and 250°F. (The oil temperature shall be recorded continuously during the test by the temperature-recording apparatus.)

Note 3. The duration of the temperature cycle cannot be controlled, since it is dependent upon the tightness of the carrier bearings and pinion-shaft oil seal, and upon the properties of the test lubricant. The normal time to cool the axle from maximum to minimum temperature under the specified procedure is from 10 to 15 minutes.

(c) Continue full-load operation for 30 hours with oil temperatures cycling in the range of 200° to 250°F.

Note 4. Preferably the test run shall be continuous; not more than four stops during which the oil is allowed to cool to room temperature are permissible.

5.4 At the conclusion of the 30-hour run, stop the test and record total ring-gear revolutions.

5.5 Immediately disconnect the axle from the dynamometer, and while the unit is hot, determine and record the torque (lb-in.) required to rotate the pinion shaft by hand.

5.6 Remove the water pan, and drain oil from the axle housing into a clean, clear-glass container. Set aside for subsequent inspection.

5.7 Allow the axle to cool to room temperature, and again determine pinion-shaft torque.

5.8 Remove axle shafts and set them aside for inspection. Determine pinion torque.

5.9 Remove carrier unit from axle housing.

5.10 Remove ring-gear and differential assemblies from carrier, and again determine pinion-shaft torque. (This gives pinion-bearing and oil-seal friction only.)

5.11 Completely disassemble differential and pinion-shaft assemblies for inspection. Do not clean parts but immediately dip them in a preservative oil (MIL-L-3150).

CAUTION

In conducting the investigation, care shall be taken in examining parts to avoid staining cleaned and polished surfaces by perspiration from the inspector's hands or moisture from other sources

5.12 Inspect the test unit as described in the following paragraphs, and report the results on a form similar to that shown in Figure 1.

CAUTION

In conducting the investigations, care shall be taken in examining parts to avoid staining cleaned and polished

surfaces by perspiration from the inspector's hands or moisture from other sources.

(a) Examine the axle shafts, axle housing, carrier housing, ring-gear, pinion, differential and differential pins for discoloration, rust, condensation, or other deposits.

(b) Examine the tooth surfaces on the drive sides of the pinion and the ring gear for any burnishing (including character), scratches, wear, surface fatigue (character and extent), scoring, discoloration, and corrosion.

Note 5. Gear-tooth surface conditions, such as burnishing, are defined in Table I.

(c) Examine the bearings for discoloration, corrosion, deposits, and wear.

(d) Examine the differential pins for evidence of removal of copper plating from the surfaces.

Note 6. Do not confuse discoloration of the copper with removal of the metal.

5.13 Examine the used lubricant, comparing it with new lubricant for evidence of water, foreign material, sludge, and discoloration. If inspection reveals any unusual condition, retain the used lubricant for chemical analysis.

Table I.--Gear-tooth surface condition terminology

Condition	Definition
Burnish-----	Alteration of original surface to a dull or brightly polished condition.
Scratching-----	Formation of random irregular grooves in the direction of sliding of the surfaces, such as is caused by abrasive particles.
Wear-----	Removal of metal (without evidence of surface fatigue or scoring) with partial or complete elimination of toolmarks. Also development of a discernible shoulder ridge at bottom of contact area near root or at toe or heel end of pinion tooth.
Surface Fatigue-----	Rippling--More or less regular pattern resembling ripples on water, or fish scales (evident under oblique lighting). Condition may be accompanied by ridging. Ridging--Series of parallel raised and polished diagonal ridges partially or completely across tooth surface of hypoid gear. Pitting--Formation of small irregular cavities resulting from breaking out of small surface areas. Spalling--Breaking out (more extensive than pitting) of irregular flakes of tooth surface.
Scoring -----	Displacement of metal from one tooth to another to produce a matte finish.
Discoloration-----	Any alteration in normal color of finished steel surfaces.
Corrosion-----	General discoloration, accompanied by roughening not attributable to mechanical action.
Deposits-----	Pasty, gummy, or brittle material adhering to or collecting around working parts.

LABORATORY TEST QUESTIONNAIRE AND FINAL SUMMARY OF RESULTS

A. GEAR LUBRICANT IDENTIFICATION

1. Company _____ Brand Name _____
 2. Formula No. _____ Viscosity _____

B. GEAR TEST IDENTIFICATION

1. Test run at _____
 under their code no. _____
 2. Date of start _____
 Date of completion _____

C. EVALUATION OF TEST PARTS

1. For load-carrying ability and wear.

- | | Pinion
Gear | Ring
Gear |
|---------------------------------|----------------|--------------|
| a. Gear-tooth surface condition | _____ | _____ |
| (1) Burnish | _____ | _____ |
| (2) Wear | _____ | _____ |
| (3) Surface fatigue | _____ | _____ |
| (a) Rippling | _____ | _____ |
| (b) Ridging | _____ | _____ |
| (c) Pitting | _____ | _____ |
| (d) Spalling | _____ | _____ |
| (4) Score | _____ | _____ |
| (5) Discoloration | _____ | _____ |
| (6) Corrosion | _____ | _____ |
| (7) Deposits | _____ | _____ |
| b. Backlash | | |
| (1) Initial _____ | | |
| (2) After tests _____ | | |
| (3) Avg. increase _____ | | |

2. For stability and corrosion (indicate extent and nature of deposits, discoloration, corrosion, or rusting)

- a. Axle shafts _____
 b. Axle housing _____
 c. Carrier housing _____
 d. Pinion assembly _____
 e. Ring-gear assembly _____
 f. Bearings _____
 g. Differential assembly _____
 h. Differential pins _____

3. For stability

- a. Pinion-shaft torque, lb-ft (before test)
 (1) Full axle assembly: break _____ turn _____
 b. Pinion-shaft torque, lb-ft (after test)
 (1) Full axle assembly (hot): break _____ turn _____
 (2) Full axle assembly (cool): break _____ turn _____
 (3) Axle shafts removed: break _____ turn _____
 (4) Pinion assembly: break _____ turn _____

D. GENERAL OPERATING CONDITIONS

1. Break-in run (6000 lb-in ring-gear torque)

- a. Revolution counter reading: start _____ finish _____
 Total _____ Avg. rpm _____
 b. Time: start _____ finish _____
 Total time, minutes _____
 c. Oil temperature: start _____ finish _____

2. Test run (32, 311 lb-in ring-gear torque)

- a. Revolution counter reading: start _____ finish _____
 Total _____ Avg. rpm _____
 b. Time: start _____ finish _____
 Total time _____
 hours _____ minutes _____

(Note: If test is divided into 2 to 4 runs with cooling off period between runs, record time of start and finish of each test period.)

3. Remarks _____

- c. Room temperature, max _____ min _____ avg. _____
 d. Cooling-water temperature, avg. _____
 e. Gear-lubricant temperature, avg. max _____ avg. min _____
 f. Axle temperature cycles, number _____
 Duration (minutes), max _____ min _____ Character (uniform, smooth, variable, rough, etc.) _____

4. Photographic evidence. Show by photographs: (1) tooth surface condition of pinion gear and ring gear; (2), any evidence of deposits, corrosion, or rusting.

- g. The complete temperature-time chart shall be attached to and become a part of this report.

FIGURE 1. - Typical report form.

PERFORMANCE OF GEAR LUBRICANTS IN AXLES
UNDER HIGH SPEED AND SHOCK LOADING**1. SCOPE**

1.1 This method is used for determining the anti-scoring properties of gear lubricants under high-speed and shock conditions.

Note 1. This method differs from CRC Designation L-19-645 in that the peak torques are about two to three times higher.

2. SAMPLE

2.1 Approximately 2 gallons of the gear lubricant to be tested.

3. APPARATUS

3.1 Test unit. The test unit shall consist of a Spicer Model 44-1 rear axle, 45 to 11 ratio, uncoated gears (part No. SKA-66032-3, Dana Corp., Toledo 1, Ohio). No change in factory adjustments shall be made.

Note 2. When ordering, specify a "Spicer rear axle for L-42 testing; ring pinion ratio, 45:11; no surface treatment".

(a) **Rear cover plate.** The rear cover plate of the test unit shall be modified as shown in Figure 1 to provide an inspection opening and to accommodate a thermocouple.

(b) **Axle shafts.** Ford axle shafts (part No. AB4234-E) shall be used with this test unit.

3.2 Axle supports. The axle shall rest on two suitable supports and shall be anchored by four U-bolts. (See Figure 2.) Each support shall consist of a wide-flange beam (6 in. by 6 in. by 15-1/2 lb per linear foot) 28-3/4 inches long. The flanges shall be set at right angles to the axle.

3.3 Temperature control. The test setup shall include a means of maintaining the lubricant at a specified temperature. This shall include a thermocouple, a temperature-recording instrument, and a cooling bath.

(a) **Thermocouple.** The thermocouple shall be installed in the rear cover plate, and positioned as shown in Figure 1.

(b) **Temperature-recording instrument.** The temperature-recording instrument shall continuously record the temperature of the lubricant throughout the test.

(c) **Cooling bath.** A water bath shall be provided for controlling the temperature of the lubricant in the axle housing. The water-control

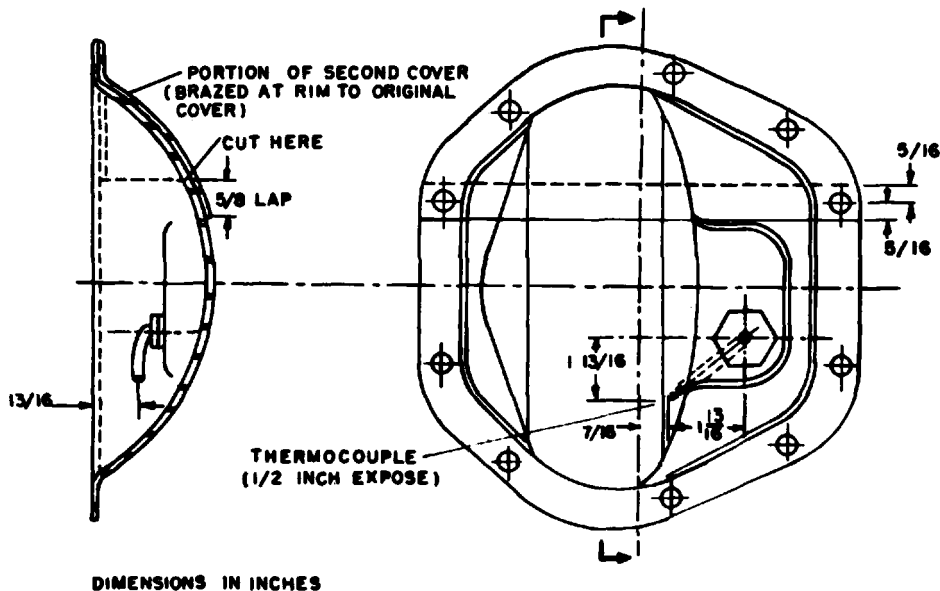


FIGURE 1.—Rear cover plate.

valve shall start and stop the flow of water, and shall be actuated by the thermocouple through the temperature-recording instrument.

3.4 Torque measuring equipment. The test equipment shall include means for measuring the load applied to the test unit during the test. It shall consist of the following:

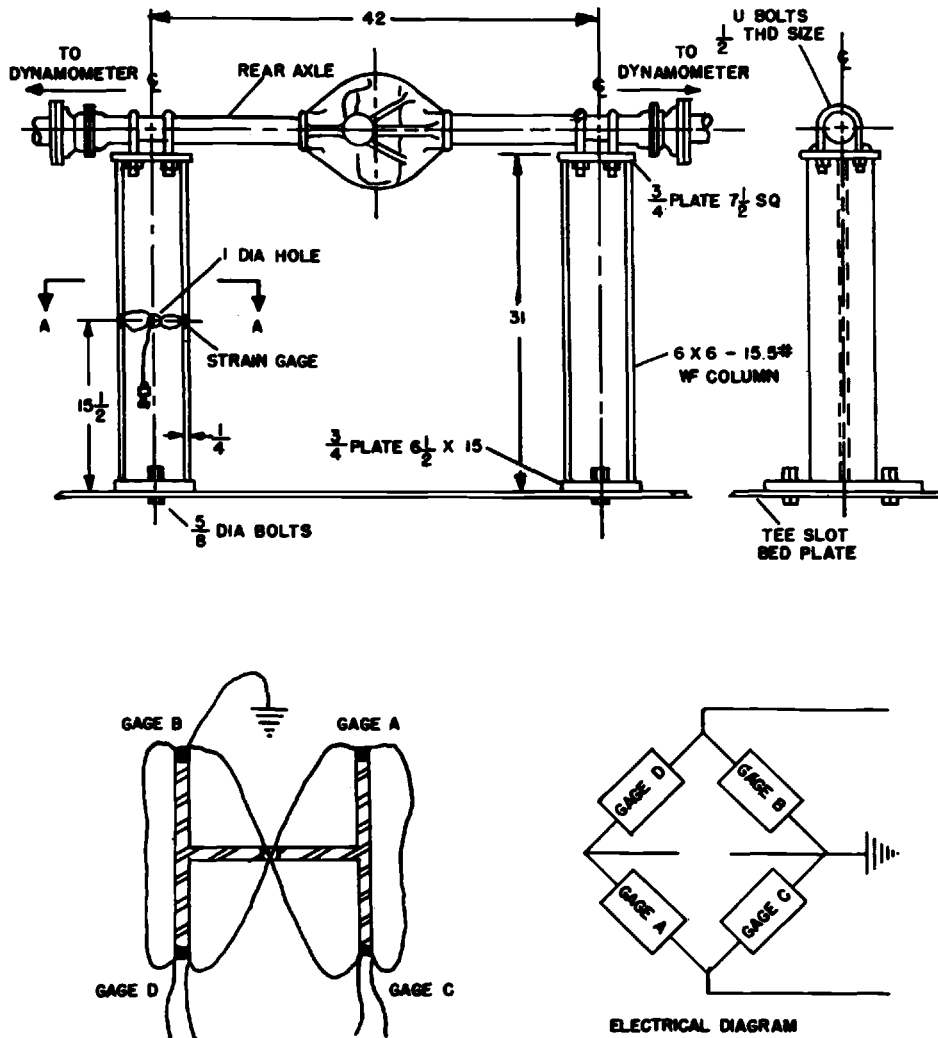
(a) Strain gages (4), electric-resistance (Baldwin type A-7 or C-7, or equivalent) shall be mounted on one of the axle supports as shown in Figure 2.

(b) Amplifier. (Brush Model BL-520, or equivalent.)

(c) Oscillograph. (Brush Model BL-201, or equivalent.)

(d) Dynamometers. Two axle dynamometers (Midwest Dynamatic, Model 3232, or equivalent) with suitable control equipment, shall be used. The minimum average inertia loads shall be as follows: Coast-side load, 950 lb-ft; drive-side load, 1100 lb-ft. The minimum average peak torque loads shall be as follows: Coast-side load, 1600 lb-ft; drive-side load, 2300 lb-ft.

Note 3. The Midwest dynamometer has a 0.05-inch air gap. Its moment of inertia is 1731 in-lb-sec², or 4640 lb-ft².



DIMENSIONS IN INCHES

FIGURE 2.—Axle mounting arrangements.

3.5 Power source. The power source shall include:

(a) Chevrolet (1956) V-8 powerglide engine. The engine shall be mounted on suitable stands, supported at six points by flexible mounts at the front, the bell housing, and the rear of the transmission case. The engine ignition timing and cam dwell shall be adjusted in accordance with the manufacturer's specifications. The carburetor idle-speed adjustment shall be set so that the engine will stall when the hand throttle is closed while the transmission is in neutral.

(b) Four-barrel carburetor. Carter Model WCFB2366SA, part No. 3726255.

(c) Inlet manifold. Part No. 3728588.

(d) Camshaft. Part No. 3728779 (casting No. 3728284).

(e) Heads. Part No. 3729786 (casting No. 3837064).

(f) Valve springs, single. Part No. 3836331.

(g) Clutch disk. Part No. 3836011.

(h) Clutch pressure plate. Part 3837155.

(i) Bell housing. Part No. 3729996.

(j) Four-speed truck transmission. Part No. 591703.

(k) U-joint flange. Part No. 591700.

(l) U-joint yoke. Part No. 605056.

(m) Drive shaft. Shelby welded 1040 steel tubing (3.5 inch OD, 0.093 wall thickness, 58-1/2 inches long from end of spline to eye of U-joint), dynamically balanced up to 5000 rpm.

(n) Throttle actuator. (Sperry type H or F hydraulic transmitter and receiver, or equivalent.)

4. MATERIALS

4.1 Dry cleaning solvent conforming to specification P-D-680, Type I or II.

CAUTION

Dry cleaning solvent is both toxic and flammable. Do not breathe its fumes or allow it to come in contact with the skin. Keep flames away from the dry cleaning solvent.

5. PROCEDURE

5.1 Prepare the apparatus for the test as follows:

(a) Sketch and describe (or photograph) the nature and extent of the contact area; and on a form similar to that shown in Figure 3, record

the torques required to break and to turn the pinion shaft of the completely assembled test unit.

(b) Spray clean the gears and the interior of the case, using dry-cleaning solvent (P-D-680).

(c) Pre-lubricate the pinion and the carrier bearings with a small amount of the test lubricant.

(d) Measure and record the backlash at four positions (15 teeth apart), and check the ring-gear runout.

Note 4. The backlash should be between 0.004 and 0.009 inch; the runout should not exceed 0.003 inch. If the measurements are not within these limits, return the unit to the factory. DO NOT CHANGE THE ORIGINAL FACTORY ADJUSTMENTS.

(e) Install the test unit on the test stand supports.

(f) Connect the unit to the dynamometers by means of axle shafts, and connect the pinion to the drive shaft.

(g) Fill the axle housing with three pints of the test lubricant.

5.2 Break-in. Break in the test unit as follows:

(a) Set the temperature control equipment to maintain a lubricant temperature of $225^{\circ} \pm 5^{\circ}\text{F}$ ($107.2^{\circ} \pm 2.8^{\circ}\text{C}$).

(b) With the engine warmed up, and with no load applied to the dynamometers, start in first gear (low-low). When the axle speed reaches approximately 80 rpm, shift into second, operating the clutch and throttle so that shifting is smooth and without bucking. Continue shifting smoothly into third and fourth at 150 to 240 rpm, respectively.

(c) After shifting into high gear, accelerate to an axle speed of 600 rpm with a manifold pressure of 12 to 14 inches of mercury, apply a 40 lb-ft load to each dynamometer, and run the unit for ten minutes.

(d) After ten minutes, slowly (five seconds) close the throttle to decelerate the axle speed to 400 rpm. Then slowly (five seconds) open the throttle to accelerate to 600 rpm. Do not remove the 40 lb-ft load during this operation.

(e) Repeat step (d) three more times.

(f) Increase the axle speed to 850 rpm, apply a 52 lb-ft load, and run the unit for 20 minutes under these conditions.

(g) After 20 minutes, slowly (five seconds) accelerate and decelerate through four cycles between 850 and 700 rpm axle speed, as in step (d).

(h) Disengage the clutch, allow the axles to stop, shut off the cooling water, and check the instrument balance.

(i) Allow the unit to cool under static conditions until the lubricant temperature has reached 200°F (93.3°C). Then continue with the high-speed operation portion of the test.

5.3 High-speed operation. Operate the unit under high speed conditions with inertia loading only, as described below. Record the torque values, and obtain zero load trace at the beginning and end of the operation.

(a) When the temperature of the lubricant has reached 200°F (93.3°C) and with no load applied to the dynamometers, start the unit in first gear and shift smoothly into second, third, and high gears when the axle speeds reach 80, 150, and 250 rpm, respectively.

(b) After shifting into high gear, accelerate to 550 rpm with a manifold pressure of 12 to 14 inches of mercury.

(c) Next, open the throttle rapidly to accelerate to an axle speed of 1100 rpm. Then close the throttle rapidly to decelerate to 550 rpm.

(d) Repeat step (c) four more times.

(e) With the throttle closed, de-clutch, shift into neutral, and allow the axles to coast to a stop.

Note 5. After shifting into neutral, a light load may be applied to the dynamometer fields for decelerating the axles.

(f) Without draining the lubricant from the axle housing, remove the inspection cover, and observe and record the nature, extent, and location of the drive and coast contact areas, as well as any disturbances to the ring-gear tooth faces.

(g) Allow the temperature of the lubricant to drop to 280°F (137.8°C) under static conditions, then continue with the shock operation portion of the test.

Note 6. If the temperature of the lubricant did not rise to 280°F during the high-speed operation portion of the test, start the shock portion as soon as possible to avoid any unnecessary cooling.

5.4 Shock operation. Operate the unit under shock (peak torque) condition, as described below, record the torque values, and obtain zero load trace at the beginning and end of the operation.

(a) With no load applied to the dynamometers, start in first gear and shift smoothly into second and third when the axle speeds reach 80 and 150 rpm respectively.

(b) Accelerate in third gear (1.71 to 1 ratio) to 550 rpm with a manifold pressure of 12 to 14 inches of mercury.

(c) Apply a 131 lb-ft load to each dynamometer, and open the throttle rapidly to accelerate to 650 rpm. Then close the throttle rapidly to decelerate to 550 rpm.

(d) Repeat step (c) nine more times.

(e) With the throttle closed, de-clutch, shift into neutral, and allow the axles to coast to a stop.

5.5 Calibrate the axle torque as follows:

(a) Install a special capstan on the engine crankshaft to apply calibrating torque.

(b) Lock both dynamometer rotors to their stators.

(c) Shift the transmission into first gear, and turn the crankshaft until approximately 500 lb-ft torque is applied to each dynamometer. Record the deflection and the exact dynamometer scale readings.

(d) Turn the crankshaft until approximately 1000 lb-ft torque is applied to each dynamometer. Record the deflection and the exact dynamometer scale readings.

(e) Release the load, and disengage the transmission. Check the recorder zero.

(f) Shift the transmission into reverse, and record the deflection and the exact dynamometer scale readings when the crankshaft is turned to apply torques of approximately 500 and 1000 lb-ft to each of the dynamometers.

(g) From the values thus obtained, plot the pen deflections against the torque readings for coast and drive loadings. Use this graph to convert the dynamic pen deflections into lb-ft.

Note 7. If the clutch is released slowly, the torque recorder may indicate a definite amount of zero shift. This zero shift may be avoided by releasing the clutch rapidly.

5.6 Disconnect the dynamometers and the drive shaft, and record the backlash at four points (15 teeth apart).

5.7 Disassemble the test unit, and photograph the nature, extent, and location of the drive and coast contact areas on both the ring

gear and the pinion. Also record the nature and extent by which any disturbance to the ring-gear tooth faces may differ from that observed prior to the test.

PERFORMANCE OF GEAR LUBRICANTS IN AXLES AT HIGH SPEED, LOW TORQUE, FOLLOWED BY LOW SPEED, HIGH TORQUE

1. SCOPE

1.1 This method is used for determining the load-carrying, wear, and extreme-pressure characteristics of gear lubricants in axles under conditions of high-speed low-torque operation and low-speed high-torque operation, using a single set of gears.

Note 1. This test method differs from CRC Designation L-20-545 in that it requires a high-speed run on the gears prior to the high-torque run. Also, the high-torque test is more severe.

2. SAMPLE

2.1 Approximately 2 gallons of the gear lubricant to be tested.

3. APPARATUS

3.1 **Test unit.** The test unit shall consist of a new, 3/4 ton Army truck, hypoid rear-axle carrier, 5.83 to 1 ratio (Dodge part No. 930215, Chrysler Corp., Engineering Division, Detroit, Mich.). No change in any of the tooth contact or bearing adjustments shall be made.

CAUTION

Rebuilt carriers shall not be used. Only units especially selected by the manufacturer for this test work, shall be used. Therefore, when ordering, specify a "special carrier for oil tests, to be checked by Gear Engineering Department," and designate whether the gears shall be phosphate coated or uncoated, as required by the specification.

3.2 **Axle housing.** The carrier shall be installed in the axle housing (part No. 1194063) for which it was designed. The housing shall be provided with a vent and an inspection opening as specified below. All other openings which might allow water leakage must be sealed with a suitable sealing compound (Permatex No. 2, or equivalent).

Note 2. When sealing, pay particular attention to all studs holding the carrier to the axle housing, the oil filler hole, drain, and inspection plugs, and to the thermocouple and vent fittings.

(a) *Axle vent.* The axle shall be vented to atmosphere throughout the entire test and cooling-off period. The vent shall consist of a single opening in the left-hand axle housing (as viewed from the rear cover side) into which is fitted a 1/8-inch IPS 90-degree street elbow. The vent shall be arranged so that no water can enter the axle housing.

(b) *Inspection opening.* The axle-housing cover shall be modified to include an inspection opening of sufficient size (approximately 3-1/2 inch pipe size) and so located above the level of the lubricant that the ring-gear tooth-contact surfaces can be readily inspected by removing the plug. (See Figure 1.)

3.3 **Temperature control.** The test setup shall include a means of maintaining the lubricant at a specified temperature. This shall include a thermocouple, a temperature recording instrument, and a cooling bath.

(a) *Thermocouple.* A thermocouple, preferably a hairpin type, shall be installed in the axle housing in such a manner that the junction will be on the centerline of the housing, one inch from the tooth side of the ring gear and one inch from the bottom of the housing. This thermocouple shall actuate a temperature-recording instrument and control an automatic cooling bath.

Note 3. A shielded type thermocouple may be used provided its accuracy is equivalent to that of the hairpin type.

(b) *Temperature-recording instrument.* A temperature-recording instrument (Leeds and Northrup Micromax, Model S-40000, or equivalent) shall be provided for recording the temperature of the lubricant in the axle housing.

(c) *Cooling bath.* A water bath shall be provided for controlling the temperature of the lubricant in the axle housing. The bath shall consist of an electrically operated water-control valve, and spray nozzles arranged as shown in figure 2 to spray cooling water over the rear cover of the axle housing. The water-control valve shall start and stop the flow of water, and

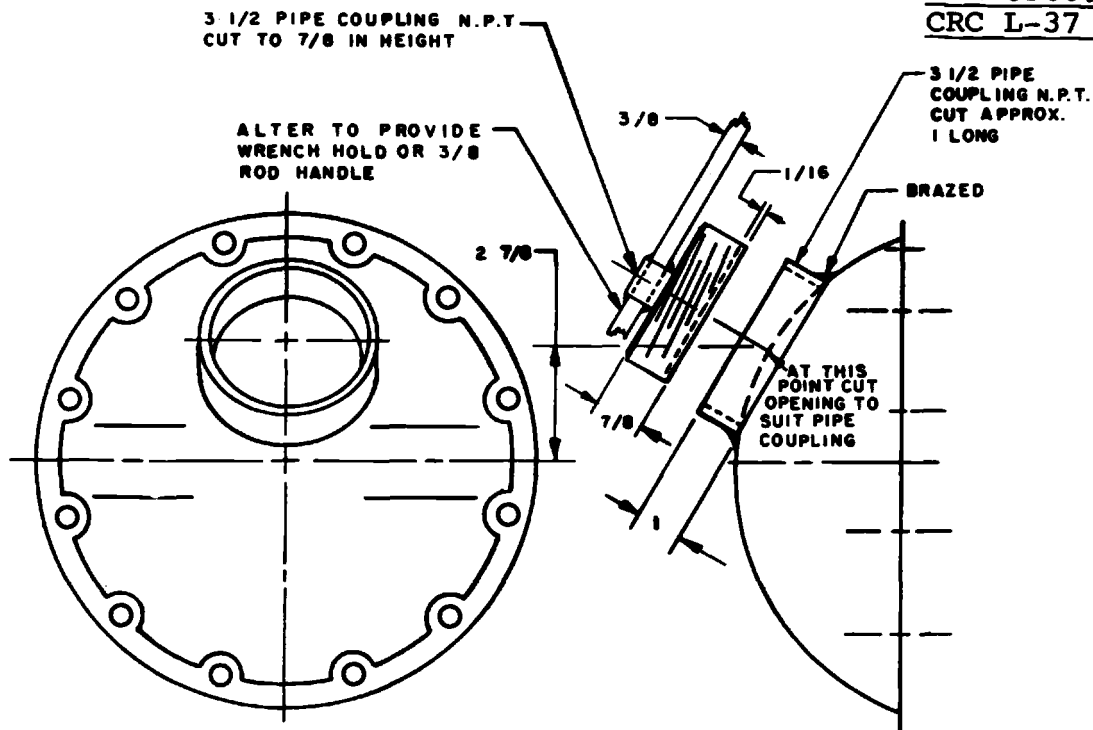


FIGURE 1.—Rear cover plate.

shall be actuated by the thermocouple through the temperature-recording instrument.

Note 4. If a pan is used to direct waste water to the drain, take care that any water that collects in the pan does not touch the bottom of the housing.

3.4 Dynamometers. Two axle dynamometers (Midwest Dynamatic, Model 3232, or equivalent) with suitable control equipment shall be used. The control equipment shall have sufficient sensitivity of adjustment and control to permit maintenance of a uniform ring gear torque to within 2 percent and a uniform speed to within 1 percent. Each dynamometer shall have a revolutions counter so that the number of revolutions of the ring gear during the test may be recorded.

3.5 Power source. The power source shall consist of a six-cylinder, 235 cubic inch Chevrolet truck engine (part No. 3709971) or equivalent with standard ignition and carburetor. The engine shall have new spark plugs (Champion J-11 or AC 46-5), and shall have the generator and fan disconnected, and the air cleaner removed. The engine must be in the best possible condition; breaker points, ignition timing, valve

backlash, and valve seating must be adjusted to shop manual specifications. Also, head deposits must be removed after every third test.

Note 5. The air cleaner may be installed during the high-torque low-speed portion of the test procedure.

3.6 Transmission and coupling. The engine shall be coupled to the test unit through a 10-inch Chevrolet truck clutch, a four-speed truck transmission (part No. 591703), and a special drive shaft (4-inch OD, 0.095-inch wall thickness), and universal joints.

4. MATERIALS

4.1 Sealing compound, Permatex No. 2 or equivalent.

4.2 Dry cleaning solvent, in accord with P-D-680, Types I or II.

4.3 Preservative oil, in accordance with MIL-L-3150.

CAUTION

Dry cleaning solvent is both toxic and flammable. Do not breathe its fumes or allow it to come in contact with the skin. Keep flames away from the dry-cleaning solvent.

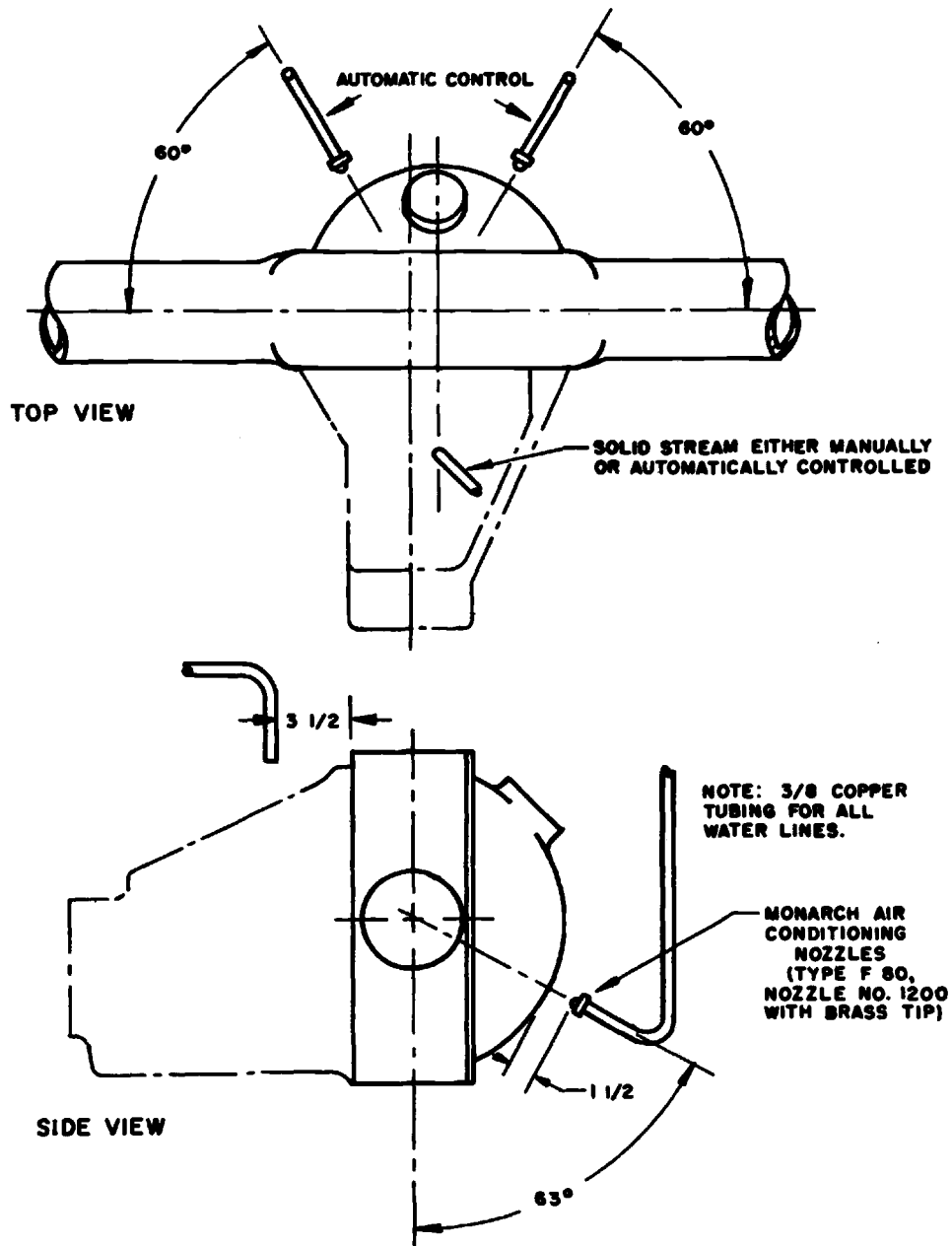


FIGURE 2.—Cooling system.

5. PROCEDURE

5.1 Prepare the apparatus for the test as follows:

(a) Wash the axle housing, axle shafts, and test unit, using dry-cleaning solvent (P-D-680), paying particular attention to the pinion bearings to remove all preservative oil. Dry by blowing with clean, dry compressed air.

Note 6. The preservative oil can be removed from the bearings by directing a spray into each of the oil passages cast in the housing of the unit.

(b) Lubricate the carrier bearings, pinion bearings, differential gears, and the ring and pinion gears, using the test lubricant.

(c) Determine and record the torques required to break and to turn the pinion shaft of the completely assembled test unit.

(d) Determine and record the backlash in the gearing.

(e) Connect the dynamometers to the axles.

(f) Fill the axle housing with five pints of the test lubricant.

(g) Set the revolutions counters to zero (or record the readings).

5.2 **High-speed low-torque operation.** Operate the test unit under high-speed low-torque conditions for 100 minutes as follows:

(a) Set the temperature control to maintain a lubricant temperature of 295° to 300°F (146.1° to 148.8°C).

(b) Determine the dynamometer field voltage required for a torque of 9460 ± 150 lb-in. at 440 ± 5 rpm.

(c) With the engine warmed up, and with no load applied to the dynamometers start the test unit in first gear (low-low). When the engine speed reaches 2000 to 2200 rpm shift to the next higher gear. Continue to shift into successively higher gears when the engine speed is 2000 to 2200 rpm until the unit is operated in direct drive (fourth gear).

(d) After shifting into high gear, apply the predetermined field voltage (for 9460 ± 150 lb-in. at 440 ± 5 rpm), open the throttle fully and record the time. Hold the variation in speed between the axles to a minimum.

Note 7. The time required to accelerate to the test condition of 440 rpm (axle speed) is about two minutes.

(e) Run the test for 100 minutes from the time of full throttle application.

(f) At the end of 100 minutes, close the throttle, and stop the equipment.

(g) Record the revolutions, average rpm, total time, and temperature of the lubricant.

(h) Without draining the lubricant from the axle housing, remove the inspection plug and examine the ring-gear tooth surfaces for burnishing, scratches, wear, surface fatigue, scoring, discoloration, corrosion, and deposits. Report the condition on a form similar to that shown in Figure 3, giving the extent, nature, and character of the condition where applicable.

Note 8. Gear-tooth surface conditions, such as burnishing, are defined in Table I.

TABLE I.—Gear-tooth surface condition terminology

Condition	Definition
Burnish.....	Alteration of original surface to a dull or brightly polished condition.
Scratching.....	Formation of random irregular grooves in the direction of sliding of the surfaces, such as is caused by abrasive particles.
Wear.....	Removal of metal (without evidence of surface fatigue or scoring) with partial or complete elimination of toolmarks. Also development of a discernible shoulder ridge at bottom of contact area near root or at toe or heel end of pinion tooth.
Surface fatigue.....	Rippling—More or less regular pattern resembling ripples on water, or fish scales (evident under oblique lighting). Condition may be accompanied by ridging. Ridging—Series of parallel raised and polished diagonal ridges partially or completely across tooth surface of hypoid gear. Pitting—Formation of small irregular cavities resulting from breaking out of small surface areas.
Scoring.....	Spalling—Breaking out (more extensive than pitting) of irregular flakes of tooth surface.
Discoloration.....	Displacement of metal from one tooth to another to produce a matte finish.
Corrosion.....	Any alteration in normal color of finished steel surfaces.
Deposits.....	General discoloration, accompanied by roughening not attributable to mechanical action. Pasty, gummy, or brittle material adhering to or collecting around working parts.

(i) As soon as practicable, replace the plug in the inspection opening, and continue the test with low-speed high-torque operation.

5.3 Low-speed high-torque operation. Operate the test units under low-speed high-torque conditions for 24 hours as follows:

(a) Set the temperature control to maintain a lubricant temperature of $275^{\circ} \pm 3^{\circ}\text{F}$ ($135^{\circ} \pm 1.6^{\circ}\text{C}$).

(b) Determine the dynamometer field voltage required for a torque of $41,800 \pm 150$ lb-in. at 80 ± 1 rpm.

(c) With the engine warmed up and with no load applied to the dynamometers, start and run the test unit in first gear (low-low).

(d) After shifting into low-low gear, apply the predetermined field voltage for 41,800 lb-in. torque, and adjust the engine speed for an axle speed of 80 ± 1 rpm. Record the time. Hold the variation in speed between axles to a minimum.

(e) Run the test continuously for 24 hours.

Note 9. No more than a total of three stops because of equipment failure, or for the purpose of checking engine oil level, shall be made during the test period.

(f) At the end of the 24 hours, stop the engine and record the revolutions, average speed in rpm, total time of test run, and the temperature of the lubricant.

(g) While the unit is hot, disconnect the drive shaft, and determine and record the torque required to break and to turn the pinion shaft of the completely assembled test unit.

(h) Allow the unit to cool, and record the torques required to break and to turn the pinion shaft.

(i) Disconnect the axle shafts, and record the pinion-shaft torques. Also determine and record the backlash in the gearing.

(j) Remove the carrier unit from the axle housing.

CAUTION

In handling the test unit, avoid staining the cleaned and polished surfaces with perspiration or with moisture from other sources.

(k) Remove the ring gear and differential assembly from the carrier.

(l) Determine and record the torques required to break and to turn the pinion shaft.

(m) Completely disassemble the differential and the pinion shaft assemblies for inspection.

5.4 Inspect the test unit as described in the following paragraphs, and report the results on a form similar to that shown in Figure 3.

(a) Examine the axle shafts, axle housing, carrier housing, ring gear, pinion, differential, and differential pins for discoloration, rust, condensation, or other deposits.

(b) Examine the tooth surfaces on the drive sides of the pinion and the ring gear for burr-nishing, scratches, wear, surface fatigue, scoring, discoloration, and corrosion.

Note 10. Gear-tooth surface conditions, such as burr-nishing, are defined in Table I.

(c) Examine the bearings for discoloration, corrosion, deposits, and wear.

(d) Examine the differential pins for evidence of removal of copper plating from the surfaces.

Note 11. Do not confuse discoloration of the copper with removal of the metal.

5.5 Examine the used lubricant, comparing it with new lubricant for evidence of water, foreign material, sludge, and discoloration. If inspection reveals any unusual condition, retain used lubricant for chemical analysis.

LABORATORY TEST QUESTIONNAIRE AND FINAL SUMMARY OF RESULTS

A. GEAR LUBRICANT IDENTIFICATION	B. GEAR TEST IDENTIFICATION																																																																																										
1. Company _____ Brand _____ _____ Name _____ 2. Formula No. _____ Viscosity _____	1. Test run at _____ Under their code no. _____ 2. Date of start _____ Date of completion _____																																																																																										
C. EVALUATION OF TEST PARTS																																																																																											
1. Ring-Gear Drive Side Inspection after completion of High-Speed Low-Torque 100-minute run. <table style="width: 100%; margin-top: 10px;"> <thead> <tr> <th style="width: 80%;"></th> <th style="width: 10%; text-align: center;">Ring Gear</th> <th style="width: 10%;"></th> </tr> </thead> <tbody> <tr> <td>a. Gear-tooth surface condition</td> <td></td> <td></td> </tr> <tr> <td> (1) Burnish</td> <td style="text-align: center;">_____</td> <td></td> </tr> <tr> <td> (2) Wear</td> <td style="text-align: center;">_____</td> <td></td> </tr> <tr> <td> (3) Surface fatigue</td> <td></td> <td></td> </tr> <tr> <td> (a) Rippling</td> <td style="text-align: center;">_____</td> <td></td> </tr> <tr> <td> (b) Ridging</td> <td style="text-align: center;">_____</td> <td></td> </tr> <tr> <td> (c) Pitting</td> <td style="text-align: center;">_____</td> <td></td> </tr> <tr> <td> (d) Spalling</td> <td style="text-align: center;">_____</td> <td></td> </tr> <tr> <td> (4) Score</td> <td style="text-align: center;">_____</td> <td></td> </tr> <tr> <td> (5) Discoloration</td> <td style="text-align: center;">_____</td> <td></td> </tr> <tr> <td> (6) Corrosion</td> <td style="text-align: center;">_____</td> <td></td> </tr> <tr> <td> (7) Deposits</td> <td style="text-align: center;">_____</td> <td></td> </tr> </tbody> </table>		Ring Gear		a. Gear-tooth surface condition			(1) Burnish	_____		(2) Wear	_____		(3) Surface fatigue			(a) Rippling	_____		(b) Ridging	_____		(c) Pitting	_____		(d) Spalling	_____		(4) Score	_____		(5) Discoloration	_____		(6) Corrosion	_____		(7) Deposits	_____		2. Pinion-Gear Drive Side and Ring-Gear Drive Side inspection after complete test. <table style="width: 100%; margin-top: 10px;"> <thead> <tr> <th style="width: 60%;"></th> <th style="width: 20%; text-align: center;">Pinion Gear</th> <th style="width: 20%; text-align: center;">Ring Gear</th> </tr> </thead> <tbody> <tr> <td>a. Gear-tooth surface condition</td> <td></td> <td></td> </tr> <tr> <td> (1) Burnish</td> <td style="text-align: center;">_____</td> <td style="text-align: center;">_____</td> </tr> <tr> <td> (2) Wear</td> <td style="text-align: center;">_____</td> <td style="text-align: center;">_____</td> </tr> <tr> <td> (3) Surface fatigue</td> <td></td> <td></td> </tr> <tr> <td> (a) Rippling</td> <td style="text-align: center;">_____</td> <td style="text-align: center;">_____</td> </tr> <tr> <td> (b) Ridging</td> <td style="text-align: center;">_____</td> <td style="text-align: center;">_____</td> </tr> <tr> <td> (c) Pitting</td> <td style="text-align: center;">_____</td> <td style="text-align: center;">_____</td> </tr> <tr> <td> (d) Spalling</td> <td style="text-align: center;">_____</td> <td style="text-align: center;">_____</td> </tr> <tr> <td> (4) Score</td> <td style="text-align: center;">_____</td> <td style="text-align: center;">_____</td> </tr> <tr> <td> (5) Discoloration</td> <td style="text-align: center;">_____</td> <td style="text-align: center;">_____</td> </tr> <tr> <td> (6) Corrosion</td> <td style="text-align: center;">_____</td> <td style="text-align: center;">_____</td> </tr> <tr> <td> (7) Deposits</td> <td style="text-align: center;">_____</td> <td style="text-align: center;">_____</td> </tr> <tr> <td>b. Backlash</td> <td></td> <td></td> </tr> <tr> <td> (1) Initial</td> <td style="text-align: center;">_____</td> <td></td> </tr> <tr> <td> (2) After tests</td> <td style="text-align: center;">_____</td> <td></td> </tr> <tr> <td> (3) Avg. increase</td> <td style="text-align: center;">_____</td> <td></td> </tr> </tbody> </table>		Pinion Gear	Ring Gear	a. Gear-tooth surface condition			(1) Burnish	_____	_____	(2) Wear	_____	_____	(3) Surface fatigue			(a) Rippling	_____	_____	(b) Ridging	_____	_____	(c) Pitting	_____	_____	(d) Spalling	_____	_____	(4) Score	_____	_____	(5) Discoloration	_____	_____	(6) Corrosion	_____	_____	(7) Deposits	_____	_____	b. Backlash			(1) Initial	_____		(2) After tests	_____		(3) Avg. increase	_____	
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FIGURE 3. - Typical report form.

MOTORED REAR AXLE TEST
TEST PROCEDURE NO. 1APPLICATION

This procedure is used to evaluate gear oil oxidation resistance, thermal stability, corrosion resistance, bearing wear and pinion seal performance, using current production rear axle assemblies.

APPARATUS REQUIRED

The following equipment is required: a rear axle carrier assembly, an electric motor, an insulated plywood box, heat lamps, temperature recording apparatus, and a measuring graduate.

Axle

A current production Ford axle is used in this procedure. No axle shafts are used. The axle housing tube is cut off approximately 10 in. from each side of the center line. Steel plates, 6 in. by 6 in. by 1/2 in., are welded at the sectioned ends of the housing tube. The "stub" axle section is mounted between two vertical plates which are securely anchored to a bed plate.

Provision is made at the bottom of the center section of the housing for a 1/4 in. pipe sampling valve and a 1/4 in. by 6 in. vertical vent tube in one of the housing arms.

Drive

A 10 hp electric motor is used for the prime mover. Provision is made either to drive the axle directly through the universal joint flange and/or by adequate pillow block and pulley arrangement to eliminate side thrust forces on the pinion bearings. Normal test speed is 3600 rpm of the pinion shaft.

Temperature Control and Instrumentation

A 1/2 in. plywood box 20 in. by 21 in. by 33 in. (5 sides) internally insulated with 1 in. fiberglass, having a hinged vertical door 19 in. by 30 in. covers the axle housing and mounting plates. Temperature control is achieved by regulating amount of door opening. At 275 F little, if any, opening

is required and temperature control within ± 2 F can be maintained. (Higher than standard temperature (275 F) will require auxiliary heat lamps placed within the box.)

A thermocouple is placed in the center of the axle sump and readings are recorded at 60 min. intervals.

Venting

Some of the gear lubricants give off noxious odors at elevated temperatures. An optional external venting system may be connected to the plywood box to prevent those odors from entering the laboratory.

PROCEDURE

1. Install the recommended charge of test lubricant for the particular axle (5.0 pints for Ford passenger car). Start motor and bring up pinion speed in slow increments to 3600 rpm (standard test speed). Maintain standard test temperature, 275 F ± 2 F, by regulating door opening on insulation box.
2. The test is run continuously without shutdown, except for weekends. The test should be completed within two weeks. Two-ounce oil samples are taken at 50 hr. intervals, with fresh fluid replacing the samples taken.
3. Oil leakage past the pinion seal is collected and the amount recorded and recharged into the axle daily.
4. The test axle is removed at the end of 150 hr. of running and stored in laboratory ambient for 168 hr. (Average conditions: 72 F Dry bulb, 40-50% relative humidity.)

ASSEMBLY AND DISASSEMBLY OF UNIT

A new axle carrier assembly, with factory preloaded carrier and pinion bearings is required for each test. The housing is cleaned with Stanasol solvent. Pinion and carrier bearing preload is measured on each new carrier before installation. Preloads at the pinion driving flange including differential bearing adjustment, range about 35 ± 10 inch lbs. Carrier bearing spread ranges 8 to 12 thousandths.

INSPECTION OF TEST PARTS

1. At the end of the test period (standard test 150 hr.) plus storage period of 168 hrs., the remaining preload on carrier and pinion bearings is measured and loss of measured pinion and carrier bearing preload is reported in inch lbs, and carrier bearing spread in thousandths of inches. Then the axle components are disassembled and the following parts visually examined:
 - a. Bearings for corrosion and surface distress.
 - b. Pinion shaft seal for hardness, cracks and deterioration.
 - c. Gear surfaces for corrosion and distress.
 - d. Axle assembly for deposits.
2. Oil samples are analyzed according to ASTM methods for the following:
 - a. Viscosity at 100 F and 210 F SUS.
 - b. Pentane insolubles - % by weight.
 - c. Benzene insolubles - % by weight.
3. The following photographs (preferably color) are required:
 - a. Carrier assembly prior to teardown.
 - b. Pinion gear and bearings.
 - c. Pinion shaft oil seal.

VEHICLE REAR AXLE SCORE TEST
TEST PROCEDURE NO. 2

OBJECTIVE To determine anti-score capabilities of various lubricants in performance vehicles.

TEST DURATION 100 Cycles, or until gear set scoring (Noise) or failure.

SAMPLE LOT SIZE A minimum of three (3) samples.

SAMPLE SPECIFICATIONS Test samples must meet design specifications.

INSTRUMENTATION Thermocouples (dipstick)
Tachometer

TEST FACILITY Any suitable test track of 2-1/2 mile straightaway.

VEHICLE

Use current model 4 door Ford Galaxie equipped with Roll Bar. Engine required is 427 cu. in. with solid lifters. Axle specified is 9.0" diameter, 3.5 Ratio, Number C7TW-4200T. Car equipped with 4-speed manual transmission¹. Car weight is standard vehicle plus one driver. Tires (9.15 X 15) must withstand² 120 mph. Equipped with roll bar and other safety equipment.

PROCEDURE FOR TESTING

Install new carrier and test lubricant in test vehicle.

Conduct a fifty (50) mile rear axle break-in at speed of 40-50 mph using light to medium throttle pressure.

Evaluate rear axle for noise rating.

¹Standard ratios are: 2.32 low, 1.69 second, 1.29 thrid.

²For similar friction characteristics use Firestone Deluxe Champion Tires.

PROCEDURE FOR TESTING (Continued)

Proceed to designated test area; and proceed as follows:

1. With car standing still in first gear, speed engine up to 3000 rpm, then drop in clutch. Proceed WOT to 4500 rpm.
2. Quickly shift into second, run WOT to 4500 rpm.
3. Quickly shift into third, run WOT to 4500 rpm.
4. Quickly shift into 4th, run WOT to 4500 rpm.
5. Decelerate to 0.0 mph using some braking. Make two of the above accelerations in the 2-1/2 mile straightaway, followed by return cooling run to original starting point at 45 mph.

Engine oil temperature is not to exceed 260 F. Approximately 8 hours required to obtain 100 drag starts. A total of one hundred (100) acceleration cycles constitute a complete test. Should axle become noisy before completing 100 drags, test is discontinued. At the completion of the test, the rear axle is again evaluated for noise characteristics. A passing gear lubricant produces a commercially quiet axle upon completion of 100 drags.

APPENDIX XIII

LIMITED-SLIP DIFFERENTIAL PERFORMANCE OF GEAR LUBRICANT

(One test used for performance evaluation)

SCOPE

1. The smoothness and quietness associated with limited-slip differential car operation are observed.

SUMMARY OF METHOD

2. A car equipped with a limited-slip differential is driven in a prescribed manner involving slow and braked tight turns, both forward and reverse.

PROCEDURE

3. (a) The limited-slip rear axle is filled with the test lubricant. Weight equivalent to four passengers, approximately 600 pounds, in addition to the driver is placed in the car. The lubricant temperature is brought to at least 150°F by driving the car for the necessary mileage at a moderate speed.

(b) With the lubricant at test temperature, the car is turned to the left and driven in a circle of approximately the minimum turning diameter, starting at 10 mph and gradually applying the brakes to bring the car to a stop while applying power. Shift into reverse and back in a similar brake-power tight turn. Turn to the right and proceed through similar forward and reverse turns. Repeat the foregoing three more times, observing the smoothness and quietness of the limited-slip differential action.

APPENDIX XIV

PRECISION OF LABORATORY TESTS FOR AUTOMOTIVE GEAR LUBRICANTS INTENDED FOR API GL-4, GL-5, and GL-6 SERVICE

Sufficient documentation is not available to provide absolute precision limits for these test procedures. However, sufficient data are available to provide the following general statements concerning the precision of these tests.

CHANNELING CHARACTERISTICS

CRC L-15 or FTM-3456.1

The National Research Council, Canada, carried out an extensive program and could find no correlation between this test and field performance.

SEPARATION CHARACTERISTICS

CRC L-22 or FTM-3455.1

No precision data are available on this test.

MOISTURE CORROSION

CRC L-13 or FTM-5315.1

No precision data have been published on this test procedure.

CRC L-21

Although no data are available, the test was replaced by CRC L-33 when it became available which indicates lack of correlation with field performance.

CRC L-33 or FTM-5326.1

The repeatability of the CRC L-33 Moisture Corrosion Test is very good for gear lubricants which exhibit good anti-corrosion characteristics. Based upon cover plate corrosion, duplicate tests conducted with a good anti-corrosion type gear lubricant should show a difference of less than 5% corrosion with respect to the total area of the cover plate. However, the repeatability of this test

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when conducted with a gear lubricant possessing marginal or poor anti-corrosion characteristics is poor and differences of as much as 50% corrosion with respect to the total area of the cover plate can be expected.

Similarly, the reproducibility of the CRC L-33 Moisture Corrosion Test is very good when conducted with a lubricant which has good anti-corrosion characteristics, but is poor when testing lubricants with poor anti-corrosion characteristics. Results from two laboratories testing a good lubricant should not differ by more than 5% corrosion with respect to the total area of the cover plate. Results from two laboratories testing a marginal or poor lubricant can be expected to differ by as much as 55% corrosion with respect to the total area of the cover plate.

FALEX PIN CORROSION

Ford BJ 5-1

No repeatability or reproducibility information is available.

MOTORED REAR AXLE TEST

Ford BJ 15-1

Precision information is not available.

THERMAL OXIDATION STABILITY TEST

FTM-2504

No precision data are available. In an initial round-robin by CRC, using RGO-120-69, a serious lack of reproducibility appeared. Test modification and continued evaluations using RGO-120-70 (a lower quality lubricant) are in progress.

CRC L-19 or FTM 6504-T

Gear units utilized for this test are no longer available. No precision data were obtained during the life of this test.

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CRC L-20 or FTM-5317.1

The gear units for this test are the same as those used for the CRC L-37 Test. No precision data have been obtained.

CRC L-42 or FTM-6507.1

The scoring tendency of CRC L-42 test gears varies considerably from one production batch to another. Therefore, evaluations of CRC L-42 High Speed and Shock Load Tests are based upon a comparison of the test results of the candidate lubricant and reference lubricants RGO-108 and RGO-110 conducted with the same production batch of test gears.

Duplicate CRC L-42 gear tests conducted at one laboratory and using test gears from the same production batch, when run with RGO-108 reference oil can be expected to show less than a 50% difference in scoring level. Duplicate CRC L-42 gear tests conducted by one laboratory on RGO-110 reference oil can be expected to show less than an 8% difference in scoring level. CRC L-42 gear tests conducted at different laboratories, but utilizing the same production batch of test gears and RGO-108 reference oil can be expected to show scoring levels which differ by no more than 72%. The same tests conducted with RGO-110 reference oil can be expected to show less than an 11% difference in scoring level.

CRC L-37 or FTM-6506.1

No reference oil was established for this test and, therefore, no precision data are available.

Vehicle Rear Axle Score Test, Ford BJ 15-1

No precision data are available.

Controlled Slip Differential

No precision data are available.