

NAVISTAR, INC.		
CEMS (CORPORATE ENGINEERING MATERIAL SPECIFICATION)		NUMBER: CEMS BT-20
TITLE: Four-Square Test For Gear Lubricants		CURRENT ISSUE DATE: August 2009
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<i>This specification may involve hazardous materials, equipment, and procedures. This specification does not purport to address all of the safety issues associated with its use. The user is responsible to consult appropriate safety and health practices and to determine the applicability of regulatory limits prior to use.</i>		
Change Notice: Replaced "International Truck and Engine Corporation" with "Navistar, Inc." per corporate directive.		

1.0 SCOPE

This method covers a test procedure used for screening load carrying properties of combination Hydraulic Transmission fluids.

2.0 APPARATUS

- 2.1 Materials Engineering approved Four-Square Test Machine.
- 2.2 Brush Surfindicator Model No. MS 1400 or equivalent.
- 2.3 An adequate torque control system or device.

3.0 MATERIAL

- 3.1 15 gallons (57 liters) of test fluid.
- 3.2 5 gallons (19 liters) of reference fluid "A" (see "Calibration").
- 3.3 5 gallons (19 liters) of reference fluid "B" (see "Calibration").
- 3.4 CP toluidine, toner dark, powder No. RT 6155, mixed to a paste consistency with SAE Grade 20 motor oil.
- 3.5 Paper filter element International part number 381257R91, one required for each fluid used.
- 3.6 Transparent mending tape, Scotch Magic Transparent or equivalent.
- 3.7 Bull pinion and brake shaft, International part number 375698R1, one required for each test.
- 3.8 Bull gear, International part number 375699R1, one required for each test.
- 3.9 Pinions and gears used in this test will meet the requirements of AGMA Class 7 and will be inspected for compliance to blueprint specifications prior to testing. Surface finish as measured at three points on the pitch line of a pinion tooth will be 27 microinches (0.7 mm) AA, max, prior to testing.

4.0 CALIBRATION

The torque load levels used during the test must be calibrated using laboratory reference fluids. These reference fluids can be any convenient fluids satisfying the requirements for "A" and "B" listed below.

- 4.1 Reference fluid "A" will be one which produces a surface finish greater than 50 μ inches (1.3 μ m) AA at a stress produced by the first test load of 278 ksi (1.915 GPa) or the second test load 295 ksi (2.035 GPa) Hertz contact stress when tested at a temperature of $180 \pm 5^\circ\text{F}$ ($82.5 \pm 3^\circ\text{C}$).
- 4.2 Reference fluid "B" must produce a surface finish less than 35 μ inches (0.9 μ m) AA after completion of all stress levels at test temperature of $230 \pm 5^\circ\text{F}$ ($110 \pm 3^\circ\text{C}$).

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4.3 Steps (1) through (11) in the test procedure are required for calibration purposes. Slight changes of torque levels may be permitted to obtain proper calibration. Check calibration periodically to insure that valid data is being obtained.

5.0 PROCEDURE

5.1 Drain the oil from the apparatus, including oil well and heater, after each individual test.

5.2 When changing to a reference fluid or a different test fluid, clean the reserve oil well, magnetic filter and filter housing and install a new paper filter element. Flush the system by pumping two gallons (7.6 liters) of the new test fluid through the primary oil circulating pump, drain from the bottom of the heater. This insures a clean uncontaminated supply of the new fluid for the next test.

5.3 Install new test gear and pinion. Use spherical roller bearings on the test pinion to allow adjustment necessary to obtain proper alignment.

5.4 Load at 1000 inch pounds (113 N·m) pinion torque. Coat pinion and gear teeth with the paste compound (CP toluidine toner dark, powder No. RT 6155 mixed with oil). Rotate gears through mesh and check for center tooth contact. If contact pattern is off center, shim outer extremities of front or rear bearing bars to provide proper contact. Coat pinion again and check contact pattern. Continue this procedure until uniform contact is obtained. All traces of the paste compound must be removed from the gear teeth prior to addition of the test fluid.

5.5 Install new fluid and maintain level such that 1.5 inches (38 mm) of the bull gear dips into the reserve oil well. Connect the secondary oil system and adjust flow to deliver 5.8 to 6.7 ml/s to the top of the bull gear, 12 teeth prior to engagement.

5.6 Obtain and record the original surface finish of the pinion teeth using a Brush Surfindicator in micro-inches (micrometers) AA.

5.7 Load to a Hertz contact stress of 220 ksi (1.515 GPa) [4854 inch pounds pinion torque (548.4 N·m)]. Run 18 000 pinion cycles at 300 rpm for break-in purposes. Break-in procedure is started with oil at ambient temperature. No temperature control is utilized during break-in. Inspect pinion and gear, determine involute surface finish at three points on the addendum of a pinion tooth and record visual appearance and pinion involute surface finish data upon completion of the step. Pitting or tooth breakage terminates a particular test and necessitates retesting. If surface finish is greater than 50 minches (1.3 mm) AA, test may be terminated.

5.8 Increase torque to first test load, a Hertz contact stress of 278 ksi (1.915 GPa)[7746 inch pounds pinion torque (875.2 N·m)]. Increase oil temperature to $230 \pm 5^{\circ}\text{F}$ ($110 \pm 3^{\circ}\text{C}$). This temperature and the 300 rpm speed will be maintained throughout all steps of the test. The lubricant is circulated through an automatic heat exchange system at a rate of 5 gpm (335 ml/s) minimum. Run 126 000 pinion cycles. Inspect pinion and gear as in (5.7).

5.9 Increase torque to second test load, a Hertz contact stress of 295 ksi (2.035 GPa) [8720 inch pounds pinion torque (985.2 N·m)]. Run 126 000 pinion cycles. Inspect pinion and gear as in (5.7).

5.10 Increase torque to third test load, a Hertz contact stress of 311 ksi (2.145 GPa) [9695 inch pounds pinion torque (1095.4 N·m)]. Run 126 000 pinion cycles. Inspect pinion and gear as in (5.7).

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