

***The following procedures cover Caterpillar TO-4***

## **Rust Control**

### **Specifications**

This procedure covers Caterpillar TO-4.

### **Objective**

The objective is to determine the corrosion protection offered by a lubricating oil by International Harvester Procedure Method BT-9.

### **Field service simulated**

This procedure simulates satisfactory performance in Caterpillar powershift transmissions, final drives, hydrostatic transmissions, torque converters, and hydraulic systems.

### **Procedure fixture**

Performance of this procedure requires procedure equipment as specified by International Harvester Procedure Method BT-9.

### **Procedure parameters**

Three procedure rods are cleaned, dipped in the procedure fluid, drained vertically for 30 minutes, placed in a bath maintained at 32°C, then covered with a water jacket exposing three inches of the rod that will be exposed to water circulated at 27°C.

### **Pass/fail criteria**

The pass/fail criteria require less than six spots of rust per linear inch. Two specimen failures in less than 175 hours shall be considered a failure.

## **Copper Corrosion**

### **Specifications**

This procedure covers Caterpillar TO-4.

### **Objective**

The objective is to evaluate the corrosiveness of lubricating oils to copper.

### **Field service simulated**

This procedure simulates satisfactory performance in Caterpillar powershift transmission, final drives, hydrostatic transmissions, torque converters, and hydraulic systems.

### **Procedure fixture**

Performance of this procedure requires procedure equipment as specified by ASTM D 130.

### **Procedure parameters**

The copper strip is immersed in procedure oil for two hours at 100°C.

### **Pass/fail criteria**

1a, slight tarnish is allowed; 1b through 4c constitutes a failure.

## **Fluid Compatibility**

### **Specifications**

This procedure covers Caterpillar TO-4.

### **Objective**

The objective is to evaluate the compatibility of different lubricating oil additive formulations with one another.

### **Field service simulated**

This procedure simulates satisfactory performance in Caterpillar powershift transmissions, final drives, hydrostatic transmissions, torque converters, and hydraulic systems.

### **Procedure fixture**

Performance of this procedure requires 100 ml centrifuge tubes and a 6,000 g high-speed centrifuge.

### **Procedure parameters**

50 ml of procedure oil and 50 ml of referenced oil are poured into a 100 ml centrifuge tube, mixed and heated to 204°C, and then cooled to room temperature. The tube is centrifuged for 30 minutes at 6,000 g. The oil in the tube is examined for precipitation of insoluble residue and separated components.

### **Pass/fail criteria**

No sedimentation or precipitation is allowed.

## **Homogeneity**

### **Specifications**

This procedure covers Caterpillar TO-4.

### **Objective**

The objective is to evaluate the compatibility of the additive with its base stock.

### **Procedure fixture**

Performance of this procedure requires 100 ml centrifuge tube and a 6,000 g high-speed centrifuge.

### **Procedure parameters**

100 ml of procedure oil is put into centrifuge tube and stoppered for 24 hours at 32°C, allowed to cool to room temperature, and then centrifuged at 6,000 g for 30 minutes. The sample is examined for sedimentation or separation of insoluble material.

### **Field service simulated**

This procedure simulates satisfactory performance in Caterpillar powershift transmissions, final drives, hydrostatic transmissions, torque converters, and hydraulic systems.

### **Pass/fail criteria**

No sedimentation or precipitation is allowed.

## Foaming

### Specifications

This procedure covers Caterpillar TO-4.

### Objective

The objective is to determine the foaming characteristics of lubricating oils at specified temperatures.

### Field service simulated

This procedure simulates satisfactory performance in Caterpillar powershift transmissions, final drives, hydrostatic transmissions, torque converters, and hydraulic systems.

### Procedure fixture

Performance of this procedure requires procedure equipment as specified by ASTM D 892.

### Procedure parameters

Lubricating oil is evaluated according to ASTM D 892. Then 500 ml of the procedure oil and 0.5 ml of distilled water are mixed with a blender at 1,000 rpm for five minutes, and then for an additional one minute at 1,300 rpm.

### Pass/fail criteria

The pass/fail criteria are as follows:

	<u>Without Water</u>	<u>With 0.1% Water</u>
Sequence I	25/0	25/0
Sequence II	50/0	50/0
Sequence III	25/0	25/0

## Flash Point

### Specifications

This procedure covers Caterpillar TO-4.

### Objective

The objective is to evaluate the flash and fire points of lubricating oils.

### Field service simulated

This procedure simulates satisfactory performance in Caterpillar powershift transmissions, final drives, hydrostatic transmissions, torque converters, and hydraulic systems.

### Procedure fixture

Performance of this procedure requires procedure equipment as specified by ASTM D 92.

### Procedure parameters

Procedure oil is heated in device as specified by ASTM D 92, Cleveland open-cup method, to flash and fire points.

### Pass/fail criteria

The pass/fail criteria are as follows:

Flash Point:	160°C or legal limit, whichever is greater
Fire Point:	175°C or legal limit, whichever is greater

## Fluoroelastomer

### Specifications

This procedure covers Caterpillar TO-4.

### Objective

The objective is to evaluate the compatibility of lubricating oils with fluoroelastomer friction material.

### Field service simulated

This procedure simulates satisfactory performance in Caterpillar powershift transmissions, final drives, torque converters, hydrostatic transmissions, and hydraulic systems.

### Procedure fixture

Performance of this procedure requires an oil bath or aluminum block aging oven capable of maintaining temperature  $\pm 1^\circ\text{C}$ , incremental extensometer capable of measuring elongation in 10% increments, ASTM D 412 and D 471 equipment, and Caterpillar 1Y0530 procedure material.

### Procedure parameters

Three procedure tubes with 150 ml of the procedure oil with three elastomer specimens submerged in the oil in each tube are aged at  $150^\circ\text{C}$  for 240 hours. The elastomer specimens are cooled for six hours, then the percent elongation at rupture is determined to the nearest 10%. Nine specimens, which have not been heat aged, are checked for percent elongation at rupture.

### Pass/fail criteria

A candidate oil is considered compatible with the 1Y0530 fluoroelastomer if the loss of elongation with the candidate oil is less than or equal to the loss of elongation with the reference oil plus 10%.

## Seals, O-Rings, and Other Elastomeric Materials

### Specifications

This procedure covers Caterpillar TO-4.

### Objective

The objective is to evaluate the compatibility of lubricating oils with various elastomer materials used in lip seals, O-rings, hydraulic piston seals, gaskets, etc.

### Field service simulated

This procedure simulates satisfactory performance in Caterpillar powershift transmissions, final drives, hydrostatic transmissions, torque converters, and hydraulic systems.

### Procedure fixture

Performance of this procedure requires ASTM D 471 equipment, oil bath, procedure tubes, reflux condensers, balance, three beakers, wetting agent, ASTM D 676 equipment, durometer, reference fluids, and seal material (fluoroelastomer).

### Procedure parameters

Determine volume and durometer reading of seal material. Immerse seal material in 100 ml of procedure fluid. Heat to  $150^\circ\text{C}$  for 70 hours. Determine volume and durometer change.

### Procedure parts evaluated

The seal material is evaluated.

### Pass/fail criteria

The pass/fail criteria are dependent on elastomer batch.

## Oxidation Stability

### Specifications

This procedure covers Caterpillar TO-4.

### Objective

The objective is to evaluate the thermal oxidation stability of lubricating oils.

### Field service simulated

This procedure simulates satisfactory performance in Caterpillar powershift transmissions, final drives, hydrostatic transmissions, torque converters, and hydraulic systems.

### Procedure fixture

Performance of this procedure requires a Hydramatic 4L60E automatic transmission be driven by an electric motor. The motor-driven converter has the stator installed in the reverse position. These components are mounted on a procedure stand capable of controlling temperatures and pressures. The input pump hub seal is replaced with a Viton<sup>®</sup> elastomer seal.

### Procedure parameters

The transmission is driven at 1755 rpm under no load at 163°C converter-out temperature for 300 hours, with air introduced at 30 cc per minute and a fluid flow rate of  $0.086 \pm 0.003$  L/s.

### Procedure parts evaluated

All of the internal transmission parts are rated for sludge, varnish, deterioration, wear, or abnormal conditions.

### Used lubricant analysis

The used lubricant analysis consists of viscosity at 40°C and 100°C, Brookfield viscosity at 0, -10, and -20°F, TAN carbonyl group absorbance, metals (iron, copper, lead, tin, aluminum); viscosity at the maximum temperature specified in Section 4, Table 3.0 of the Caterpillar TO-4 Procedure for the appropriate viscosity grade using ASTM procedures D 2983 and D 4684; and viscosity at 150°C (ASTM D 4683).

### Pass/fail criteria

The pass/fail criteria are as follows:

- No blackening or flaking of copper or copper alloys shall have occurred.
- The oil shall not gain >15% in viscosity at 100°C.
- The TAN difference between the 300-hour and the 0-hour sample shall not be greater than 7.
- The increase in carbonyl group absorbency (as measured by differential infrared) in the final sample may not exceed 0.9 over that of the 0-hour sample.
- Transmission part condition shall be equal to or better than that obtained with reference fluids.
- No varnish or sludge shall accumulate on drums, piston, valves, case, screen or pan components used for evaluation.

## Viscosity

### Specifications

This procedure covers Caterpillar TO-4.

### Objective

The objective is to evaluate the ability of a lubricant to provide acceptable viscometric properties in cold and hot ambient conditions when used in powershift transmissions and hydraulic systems.

### Field service simulated

This procedure simulates satisfactory performance in Caterpillar powershift transmissions, final drives, Hydro-static transmissions, torque converters, and hydraulic systems.

### Procedure fixture

Performance of this procedure requires equipment as specified by SAE J300.

### Procedure parameters

Using the SAE J300 procedure, low-temperature and high-temperature high shear requirements are determined.

### Pass/fail criteria

Refer to the procedure Caterpillar publication for viscosity recommendations for their different product lines.

## Gears

### Specifications

This procedure covers Caterpillar TO-4.

### Objective

The objective is to evaluate the ability of a lubricant to provide acceptable gear anti-wear performance in powershift transmissions and final drives.

### Field service simulated

This procedure simulates satisfactory performance in Caterpillar powershift transmissions, final drives, hydrostatic transmissions, torque converters, and hydraulic systems.

### Procedure fixture

Performance of this procedure requires equipment as specified by ASTM D 4998.

### Procedure parameters

An FZG gear oil procedure machine is operated for 20 hours under controlled conditions of speed (100 rpm), load (tenth stage), and temperature (121°C).

### Pass/fail criteria

A maximum of 100 mg total weight loss of the procedure gears after averaging three separate runs is required. No single run may have more than 150 mg weight loss.

## Pump Anti-Wear Performance

### Specifications

This procedure covers Caterpillar TO-4.

### Objective

The objective is to evaluate the ability of a lubricant to provide acceptable fluid pump anti-wear characteristics for powershift transmission and hydraulic pumps.

### Field service simulated

This procedure simulates satisfactory performance in Caterpillar powershift transmissions, final drives, hydrostatic transmissions, torque converters, and hydraulic systems.

### Procedure fixture

Performance of this procedure requires equipment as specified in Vickers® form M-2952-S.

### Procedure parameters

The procedure duration for each cartridge is 50 hours with a pump outlet pressure of 3,000 psi and an inlet oil temperature of 200°F.

### Pass/fail criteria

The pass/fail criteria are as follows:

- Total weight loss of all vanes from individual cartridges tested should be less than 15 mg (not including intravanes).
- Weight loss of ring from individual cartridge tested should be less than 75 mg.
- Regardless of weight loss measurements, the pump parts, especially the rings, should not have evidence of unusual wear or stress in contact areas. Examples of acceptable and unacceptable rings are shown in the Vickers® publication form M-2952-S (rev. 8/88). There may be instances when unsatisfactory performance is indicated even though the weight loss is low; for example, galling or excessive burning might not show excessive weight loss, but would be unacceptable.
- When any one cartridge out of three fails for any reason, two more cartridges should be tested. In this case, four of the five cartridges must meet the above accept/reject guidelines.

## Friction Properties Using Fluoroelastomer, Bronze, Paper Friction Material

### Specifications

This procedure covers Caterpillar TO-4.

### Objective

The objective is to procedure a fluid's friction performance characteristics and determine whether they are acceptable in use with various oil-cooled friction mechanisms in Caterpillar transmissions/final drives. Materials tested are fluoroelastomer, bronze, paper.

### Field service simulated

This procedure simulates satisfactory operation of transmissions and drivetrains when operating under the conditions specified by the manufacturer.

### Procedure apparatus

The procedure uses the Link M1158 oil/friction machine w/ oil circulating system & external air pressure source.

### Procedure parameters

A full procedure consists of six short sequences and one 25,100-cycle friction retention procedure. Duration of a short sequence procedure is a function of phase numbers for that sequence/fluid/material used and is between 1,000 and 1,200 cycles. Each phase contains computer-to-stand control parameters (load, speed, etc.) Short sequence procedure parameters are dynamic coefficients of friction vs cycle, dynamic/static coefficients of friction vs load and speed, energy. The energy pass/fail criteria are based on rotational speed at which engagement of disk and reaction plate results in specified percent change in dynamic coefficient compared to average dynamic coefficient of previous phase. The friction retention procedure concerns itself with static and dynamic coefficients of friction vs cycle.

### Procedure parts evaluated

The measurement of plates for wear is evaluated.

### **Friction Properties (cont'd)**

#### **Pass/fail criteria**

The pass/fail criteria are as follows:

- Maximum plate wear for sequences respectively in ascending order: 0.03, 0.04, 0.07, 0.07, 0.07, 0.04.
- The computer generates limits for coefficients of friction by multiplying reference fluid run data by limit factors and these factors and above listed wear criteria are given in the Caterpillar TO-4 transmission and drive train fluid requirements manual. Factors vary at the 3000-, 8000-, and 25,000-cycle points. Factors also differ when two- and three-run averaging techniques are used in testing a fluid. The two- or three-run averaging option may be used when a procedure result is questionable or very close to the limit in order to ascertain pass/fail status of a fluid.

#### **Biodegradable applications**

Two special sequences and a brake paper material are also used in testing fluids for conformance to Caterpillar's BF-1 specification. This specification relates to biodegradable fluids.

### **Other procedures include:**

#### **Vickers Pump Wear Procedure**

##### **Specifications**

This procedure covers ASTM D 2882.

##### **Objective**

The objective is to determine fluid anti-wear characteristics.

##### **Procedure fixture**

Performance of this procedure requires an electric motor-driven Vickers 104-C pump. A pressure regulator is used to control pump pressure.

##### **Procedure parameters**

The fluid is tested for 100 hours at 2000 psi and either 150°F or 175°F, depending on fluid viscosity.

##### **Procedure capacity**

Three procedure stands are available.

## **Specialized Automatic Transmission Fluid Evaluations**

In addition to standardized ATF evaluations, Southwest Research Institute offers service in the areas of specialized laboratory and field evaluations. Specialized testing could be in the form of bench rigs, engine-transmission-dynamometer stands, or vehicle procedures. Vehicles can be instrumented for pressures, speeds, and torques. Testing can involve fluid shift quality or durability evaluations.

Both domestic and foreign front-wheel or rear-wheel drive vehicles can be utilized. Testing may be carried out using the local roadways or the on-site procedure track. The track may be utilized as a single oval or dual straightaway, permitting several different evaluations to be conducted concurrently.