INTRODUCTION

Since the late 1980's, Caterpillar Inc. has recommended that our customers use oils which meet the TO-4 specification to lubricate power shift transmissions, final drives and axles. The fluids which met that specification provided good oxidation stability, foam and rust control and cleanliness. They were specially blended to protect gears and bearings satisfactorily. They also were required to develop friction coefficients high enough to allow efficient engagement of clutches and brakes, with subsequent secure maintenance of pack engagement under both static and dynamic conditions.

Caterpillar machines are under continual change to meet customer needs. Significant improvement in final drives and axles has increased durability and productivity, but also has increased the workload on gears and bearings. Lubricants designed specifically for their improved protection are critical for satisfactory life and performance.

Caterpillar Inc. has introduced new requirements, "Caterpillar FD-1," for lubricants which provide improved gear and bearing life in final drives and axles. Oils (Final Drive and Axle Oil, or FDAO), which meet these requirements, are not required to develop friction coefficients for clutch and brake packs; rather, they only serve to protect gears and bearings from various modes of failure. Because of that narrower focus, lubricants which satisfy the new requirements must meet more stringent demands for the protection of gears and bearings than do those which pass the TO-4 specification. Caterpillar Inc. still accepts the TO-4 oils as suitable for final drive and axle compartments, under the temperature and machine limitations imposed by Caterpillar publication SEBU6250. However, the Company now recommends FDAO as the preferred oil in most compartments of those types. Generally, FDAOs are not recommended for use in compartments which contain friction materials. Specific exceptions might be identified for certain machines in the future.

This document contains all of the performance requirements that a finished lubricant must meet before it can legitimately be marketed as meeting the Caterpillar Inc. FD-1 requirements.

Caterpillar Inc. will not monitor or approve any fluid marketed under the FD-1 designation. Each supplier is responsible for the performance of its own product and the associated liabilities.

Fluids Engineering
501 S.W. Jefferson Avenue
Caterpillar Inc.
Peoria, IL 61630-2172

OBJECTIVE:

The requirements described herein are intended to communicate the minimum performance requirements for a lubricant that is intended for use in Caterpillar equipment wherever FD-1 fluids are recommended. The primary use of these fluids will be final drives, differentials, and axles.

GENERAL DESCRIPTION:

The Caterpillar FD-1 requirements are divided into eight principle areas: Physical and Chemical Properties, Elastomer Compatibility, Oxidation Stability, Viscometrics, Elastohydrodynamic Film Thickness, Rolling Element Bearing Fatigue, Wear and Gear Scuffing. All FD-1 oils must comply with the viscometric and elastohydrodynamic (EHD) properties described in Sections 4 and 5, respectively. Unless otherwise specified in the individual sections which follow, the SAE 60 grade can be used to qualify all the viscosity grades of the same formulation for all other performance requirements.

TEST EQUIPMENT REQUIRED:

The following list of equipment is for your convenience. It does not include all of the equipment that is needed, but does include those items which might not be common laboratory equipment:

- FZG Gear Oil Test Machine with 100 RPM capability
- Instrument capable of measuring elastomer elongation in 10% increments, such as Instron Model No. 2610-001 Incremental Extensometer or equivalent
- Scott Testers Aluminum Block Aging Oven Model LG or equivalent
- ASTM D412 Die C
- ASTM D412 Silicon Rubber tensile slabs
- Turbohydramatic THM-4L60 transmission
- Caterpillar Test Parts: 1E2827 elastomer test slabs
- Reference Test Oils: Caterpillar Catalogue Numbers (CT) 5021, 5026, 5062, 5063 and 5588
- KRL Shear
- Rolling Contact/ Bearing Fatigue Test rig
- WAM 4 (Wedeven Associates, Inc.)
- D8N Four-Square Test Rig

.

SUMMARY AND TABLE OF CONTENTS:

The following information is a summary that defines a fluid which meets the performance requirements for Caterpillar FD-1 Final Drive and Axle Oil. Information regarding the appropriate test methods and the applicable limits for each can be found in the referenced section.

RUST CONTROL

1.0 SCOPE:

This test method will be used to determine the corrosion protection offered by lubricating oil to a finished ferrous surface under dynamic humidity conditions.

2.0 TEST METHOD:

International Harvester Engineering Materials Specification, Test Method BT-9, June 1966, with modifications.

3.0 TEST EQUIPMENT:

- 500mL Erhlenmeyer Flask, Wide Mouth
- 25mL Erhlenmeyer Flask
- Modified No. 10 Rubber Stopper
- Bath capable of maintaining a temperature of 32± 0.6°C (90± 1°F)
- Water Jacket
- Drill or Lathe Rated At 2500 Revolutions Per Minute
- Bath, Controlled at 27± 0.6°C (80± 1°F) with Pump Capable of Circulating Solution through Water Jacket
- Test Specimen: The test specimen is made from a 9/16 inch (14mm) outside diameter cold drawn bar of C1018 steel and finished to an 11 maximum microinch (0.279 micron) arithmetical average. The finished part from vendor must be free from scratches and rust and must be protected for storage by coating with MIL-C-1507b fluid. The supplier for test specimens is Centerless Grinding Co., 2330 17th Street, Franklin Park, Illinois 60131.
- Toluene – ACS
- Methanol – ACS
- Metal Polishing Cloth – Grade A – 320 (25 mm [1”] Side), Carborundum Grit 320

4.0 TEST PROCEDURE:

Use three separate rods for each oil. The rod specimens shall be given a preliminary cleaning by immersion in a hot 50/50 mixture of toluene and methanol to remove rustproof coating.

Chuck the test specimen in a lathe or drill (fixed position) and run at 2500 revolutions per minute. Use a 356 x 25 mm (14 x 1 inch) strip of the abrasive cloth and pass slowly from the chuck end to the specimen tip. Pull the abrasive cloth slowly from one end to the other in opposition to the rod rotation to provide a fresh surface on the paper while progressing down the specimen. The pass should take approximately 20 seconds. Make three passes using a new strip of abrasive cloth each time. Final overall specimen finish shall range from 9 to 14 microinches arithmetical average, except for chucking area. CAUTION: DO NOT USE CHUCKING AREA AS TEST PORTION. Rinse rods with toluene and wipe clean with toluene-soaked Kimwipe. Rinse again with toluene followed by dipping in clean toluene at 57 °C (135°F) for 15 seconds. Remove an adhering drop at bottom of rod with a clean piece of Kimwipe after each dipping. Allow to air dry, then immediately immerse the 152 mm (6 inch) test section of the specimen 6 times per minute for 1 min in a 250 mL graduated cylinder containing 200 mL of the fluid to be tested.

After the last dip, place the test section of the rod in a plastic beaker (on a nonskid surface) containing approximately 25 mm (1 inch) of test fluid. Push the pre-drilled rubber stopper down the rod until a 76 mm (3 inch) section protrudes. Hang the rod vertically by the exposed 76 mm (3 inch) section and allow the test fluid to drain for 30 min. Next, place the rod vertically in a 500 mL flask containing 100mL of distilled water and a 25 mL flask containing 15 mL of distilled water. Place the 25 mL flask so that the test fluid from the rod cannot enter this flask .

Immerse the assembly to the bottom of the stopper in the bath maintained at 32°C (90°F). Place a water jacket over the exposed 76 mm (3 inches) of rod and circulate water controlled at 27°C (80°F), maintaining a 5°C (9°F) differential.

CAUTION: CARE SHOULD BE TAKEN THROUGHOUT THE TEST THAT THE TEST ROD IS NOT TOUCHED WITH BARE HANDS. PLASTIC GLOVES SHOULD BE WORN AT ALL TIMES WHEN HANDLING THE ROD.

5.0 ACCEPTANCE LIMITS:

Minimum time to failure is 150 h. The specimen shall be examined for appearance of corrosion spots every 25 h. Failure is defined as six or more spots per any linear inch (as viewed without magnification). The first 9.5 mm (0.375 inch) below the contact line of stopper with rod shall be disregarded. Two specimen failures in less than 150 h shall be considered a failure.

COPPER CORROSION

1.0 SCOPE:

This test method will be used to evaluate the corrosiveness of lubricating oils to copper.

2.0 METHOD:

ASTM D130
IP 154

3.0 CONDITIONS:

Oil Temperature:	150°C
Time Of Immersion:	3 h

4.0 ACCEPTANCE LIMITS:

A rating of 1b (slight tarnish) is allowed.
A rating of 1c or worse constitutes a failure.

FLUID COMPATIBILITY

1.0 SCOPE:

This test method will be used to evaluate the compatibility of different lubricating oil additive formulations with one another.

2.0 METHOD:

The test oil is mixed, in separate tests, with CT5021 and CCT5588 reference oils. It is then heated, cooled, and centrifuged to determine residue.

3.0 TEST EQUIPMENT:

100 mL centrifuge tubes
6000-g high-speed centrifuge

4.0 PROCEDURE:

Pour a 50 mL sample of the candidate oil and 50 mL of one of the reference oils (CT5021 or CT5588) into a 100 mL centrifuge tube. Shake well and heat to 204°C. Cool to room temperature. Centrifuge for 30 min @ 6000g. The tube containing the test sample and the selected oil shall be examined for precipitation of insoluble residue and separated components. Repeat with the remaining oil (CT5021 or CT5588).

5.0 ACCEPTANCE LIMITS:

No sedimentation or precipitation is allowed with either of the reference oils.

HOMOGENEITY

1.0 SCOPE:

This test method will be used to evaluate the compatibility of the additive with its base stock.

2.0 METHOD:

The test oil is held at -32°C for 24 h, warmed to room temperature, and centrifuged. The absence of sedimentation or separation of insoluble material indicates that the oil and additive are homogeneous.

3.0 TEST EQUIPMENT:

High-speed centrifuge capable of producing 6000 g.

4.0 TEST PROCEDURE:

A 100 mL sample of the candidate oil is put in a 100 mL centrifuge tube. The sample is stoppered and held at -32°C for 24 h. Allow the sample to reach room temperature and then centrifuge for 30 min at 6000 g. The tube containing the test sample shall be examined for sedimentation or separation of insoluble material.

5.0 ACCEPTANCE LIMITS:

No sedimentation or precipitation is allowed.

FOAMING

1.0 SCOPE:

This test method will be used to determine the foaming characteristics of lubricating oils at specified temperatures. Means of empirically rating the foaming tendency and the stability of the foam are described.

2.0 TEST METHOD:

ASTM D892

3.0 TEST PROCEDURE:

ASTM D892 or IP 146 standard test method will be used to evaluate the foaming characteristics of lubricating oils with the following modifications: It will be divided into two parts. The first part uses the standard ASTM D892 and the second part uses ASTM D892 with (0.1%) water added to simulate water accumulating in drive train applications

PART I. The standard ASTM D892 or IP 146 foam method without water added

PART II. Foaming Of Lubricating Oils with Added Water (0.1%)

This procedure measures the effect of a small amount of water on the foaming of lubricating oils. Water is mixed with the oil to be used and measured by the above methods.

PROCEDURE: Mix 500 mL of the oil to be tested with 0.5 mL of distilled water in a blender for 5 min at low speed (1000 RPM) and then for 1 min at high speed (1300 RPM). Allow any foam to dissipate before determining the foam by all three sequences of test method.

4.0 ACCEPTANCE LIMITS:

	WITHOUT ADDED WATER	WITH 0.1% WATER
SEQUENCE I	25/0	25/0
SEQUENCE II	50/0	50/0
SEQUENCE III	25/0	25/0

FLASH AND FIRE POINTS

1.0 SCOPE:

This test method will be used to evaluate the flash and fire points of lubricating oils by Cleveland Open Cup.

2.0 METHOD:

ASTM D92
IP 36/84

3.0 ACCEPTANCE LIMIT:

FLASH POINT	220°C or legal limit, whichever is greater.
FIRE POINT	220°C or legal limit, whichever is greater.

ELASTOMER COMPATIBILITY

1.0 SCOPE:

This test method will be used to evaluate the compatibility of Final Drive and Axle Oil with elastomeric seal materials.

2.0 TEST METHODS:

Per General Motors Specification GM6417M Appendix B, except as noted below:

Exceptions:

2.1 Testing of B2.10 Elastomer compounds is not required.

2.2 Testing of Caterpillar Specification 1E2827 is required.

2.3 Testing of Caterpillar Specification 1E2827 in ASTM #1 oil is not required

2.4 Report the change in tensile strength and the change in elongation for Caterpillar specification 1E2827 in addition to the volume change and Durometer A change.

2.5 Any test details not covered in GM 6417M Appendix B, will be per ASTM D471.

3.0 ACCEPTANCE CRITERIA:

Per General Motors Specification GM6417M Appendix B, except as noted below.

Exceptions:

3.1 Acceptance criteria for Caterpillar Specification 1E2827 Compound as follows:

3.1.1 Volume Change, %: 0 to +30

3.1.2 Durometer A Change, Points: 0 to –20

3.1.3 T ensile Strength Change, %: 0 to –30

3.1.4 Elongation Change, %: -20 to +30

OXIDATION STABILITY

1.0 SCOPE:

This test method (L60-1) will be used to evaluate the thermal oxidation stability of lubricating oils.

2.0 TEST METHOD:

ASTM D5704; 100-hour test

3.0 TEST PROCEDURE:

ASTM D5704 Standard Test Method will be used to evaluate the thermal and oxidative stability of lubricants in Caterpillar final drives, differentials, and axles.

4.0 ACCEPTANCE LIMITS:

Percent Viscosity Increase	50%
Percent by weight of pentane insoluble	3%
Percent by weight of toluene insoluble	2%
Carbon/varnish rating	7.5 MIN
Sludge Rating	9.4 MIN

VISCOSITY

1.0 SCOPE

This test method will be used to evaluate the ability of a lubricant to provide acceptable viscometric properties in cold and hot ambient conditions when used in final drives and axles.

2.0 TEST METHODS:

The SAE J300 viscosity classification system is the basis of our recommendation. In addition to SAE J300 requirements, Low Temperature and High Temperature/High Shear requirements will be specified for all recommended viscosity grades. Caterpillar does not recommend oils that contain viscosity improvers in this application.

3.0 VISCOSITY TABLE:

Grade	ASTM D2983 (latest) Maximum Temperature For Brookfield Viscosity of 150,000 cP (°C)	ASTM D4684 (latest) Low-Temperature Pumpability (MRV TP-1) Maximum Temperature (°C) for 30,000 cP	ASTM D4683 (or equivalent) High Temperature/High Shear Viscosity at 150°C (10^6 s^{-1})
SAE 50	-15	-5	4.5
SAE 60	-10	+10	5.7

4.0 POUR POINT:

SAE 50 Max. -24 °C

SAE 60 Max. -15 °C

ELASTOHYDRODYNAMIC (EHD) FILM THICKNESS

1.0 SCOPE:

This test method will be used to evaluate the elastohydrodynamic (EHD) film thickness generation capability of the oil.

2.0 TEST METHOD:

The test will be EHD Film-Forming Capability Test on the WAM4 test machine at Wedeven Associates, Inc. The following test conditions will apply:

Ball	13/16 inch diameter M50 steel (Grade 5), Ra<1 □in.
Disc	5-inch dia. x 0.625 inch, Pyrex 7740 with optical coatings
Max. Hertz Stress	0.69 Gpa (86,000 psi), 10 lb. Load
Entraining Velocity	Variable, defined as half the sum of surface velocities
Sliding Velocity	Near zero, tests are run with disc driving the ball
Nominal Temperatures	70°C, 100°C, and 130°C

3.0 TEST PROCEDURE:

The candidate is run in sequence with a reference fluid supplied by Caterpillar to Wedeven Associates, Inc.

4.0 REFERENCE FLUIDS:

Two reference fluids are available. CT5588 reference oil must be used with SAE 50 grade candidates. CT5621 must be used with SAE Grade 60 candidates.

5.0 CONTACT:

For more information regarding testing and procedure, contact:

Wedeven Associates, Inc.
5072 West Chester Pike
Edgemont, PA 19028
Phone: 610-356-7161
FAX: 610-325-0687

6.0 ACCEPTANCE CRITERIA:

The acceptance criteria shall be that the EHD film thickness of the candidate at an entraining velocity of 2 m/s must be equal to or greater than that of the reference fluid at each of the following temperatures: 70°C, 100°C, and 130°C. At each temperature, the candidate must meet the acceptance criterion on the first test or as an arithmetic average of up to three tests.

GEAR WEAR – FZG TEST METHOD

1.0 SCOPE:

This test method will be used to screen the ability of a lubricant to provide acceptable gear antiwear performance in final drives, differentials and axles.

2.0 TEST METHOD:

ASTM D4998

3.0 TEST PROCEDURE:

ASTM D4998 Standard Test Method will be used to evaluate the antiwear performance of lubricants when used in conjunction with gear applications in Caterpillar final drives, differentials and axles.

4.0 ACCEPTANCE LIMITS:

A maximum weight loss of 35 mg indicates candidate oil is viable for passing the D8N test method on the next page.

GEAR WEAR – D8N TEST METHOD

1.0 SCOPE:

This test method will be used to evaluate the ability of a lubricant to provide acceptable thin-film wear.

2.0 TEST METHOD:

The candidate lubricant is subjected to an adhesive wear resistance test for gears in a full-scale D8N Final Drive Four-Square arrangement. The testing methods are accelerated to obtain representative results with minimum testing time.

3.0 TEST EQUIPMENT:

D8N Four-Square testing rig

4.0 TEST PROCEDURE:

The Caterpillar D8N-1 procedure outlines the wear resistance test that is internally controlled and available upon request. Testing must be done with the lowest viscosity oil specified in Section 4 (currently SAE J300 grade 50).

5.0 ACCEPTANCE LIMITS:

The candidate lubricant must protect the test gears from displaying any signs of adhesive wear on the tooth profile. Gears tested with candidate oils must exhibit involute profile wear equal to or less than for gears tested with reference oil of the same SAE viscosity grade as the candidate oil. CT5026 is the SAE50 reference oil. Some minor micropitting may be present.

ROLLING ELEMENT BEARING

ACKNOWLEDGEMENT:

Caterpillar acknowledges the considerable assistance provided by The Timken Company during the development of the test methods for rolling contact fatigue performance of lubricants.

1.0 SCOPE:

This test method will be used to evaluate the ability of a lubricant to provide acceptable bearing rolling contact fatigue life under a controlled (laboratory) set of operating conditions.

2.0 TEST METHOD:

Full-scale bearing testing that generates line contact with as large a contact ellipse as possible without edge stress is required. It is desirable to generate as much stressed material volume as possible. The Caterpillar Roller Bearing Test Machine is one means of approval, and the procedure used with that machine is described below. Other sources of full-scale bearing testing exist. A known one is The Timken Company. Others likely will develop. As they do, their identities will be made available by Caterpillar Inc. on request.

3.0 TEST PROCEDURE:

Bearings rollers are to be in true (zero slip) rolling contact without edge stress. Test bearings are loaded to generate 300 to 400 KSI contact stress. Each contact surface should have a surface finish of 5 to 10 microinch, preferably honed, although other surface finishes would be acceptable. All test bearings must be from the same steel lot and processed together to reduce specimen variation. Lubrication test temperature (200 to 250 degrees F), component speed, and lubrication viscosity need to be adjusted to achieve .8 to 1.5 lambda ratio. The candidate lubricant fatigue life must be compared to the fatigue life of Reference Oil CT5026, which is SAE viscosity grade 50. Viscosity of the candidate oil must be equal to that of CT5026 within 0.5 cSt at 100 C.

At least six first-in-four tests (24 bearings, 6 failures) or the equivalent must be run. Additional data sets can be run to reduce the confidence range on either lubricant.

4.0 ANALYSIS OF TEST DATA:

4.1 Analysis software:
Weibull++ Version 6.0 from
ReliaSoft Corporation
ReliaSoft Plaza
115 South Sherwood Village Drive
Tucson, AZ 85710 USA
(See website http://www.reliasoft.com/)

4.2 Analysis procedures to be used within Weibull++:
2-Parameter Weibull
Analysis Method = RR on Y
Confidence Bounds = Fisher Matrix
Ranking Method = Median

4.3 Methodology:
- 4.3.1 Enter both failure and suspension data into Weibull++.
- 4.3.2 Use the Quick Calculation Pad to find the Mean Life of both reference and candidate oils.
- 4.3.3 Calculate the Mean Life Ratio (MLR):
  MLR = Mean Life of candidate oil/Mean Life of reference oil.
- 4.3.4 Find the confidence in a significant difference between the candidate and reference oils by adjusting the contour plots of confidence for each oil until they just touch.

4.4 For a complete example of data analysis, see Appendix I.

5.0 ACCEPTANCE LIMITS:

5.1 Mean Life Ratio must be a minimum of 2.0
5.2 Confidence level at which contour plots just touch must be 75% or greater.

6.0 ALTERNATIVE TEST POSSIBILITIES:

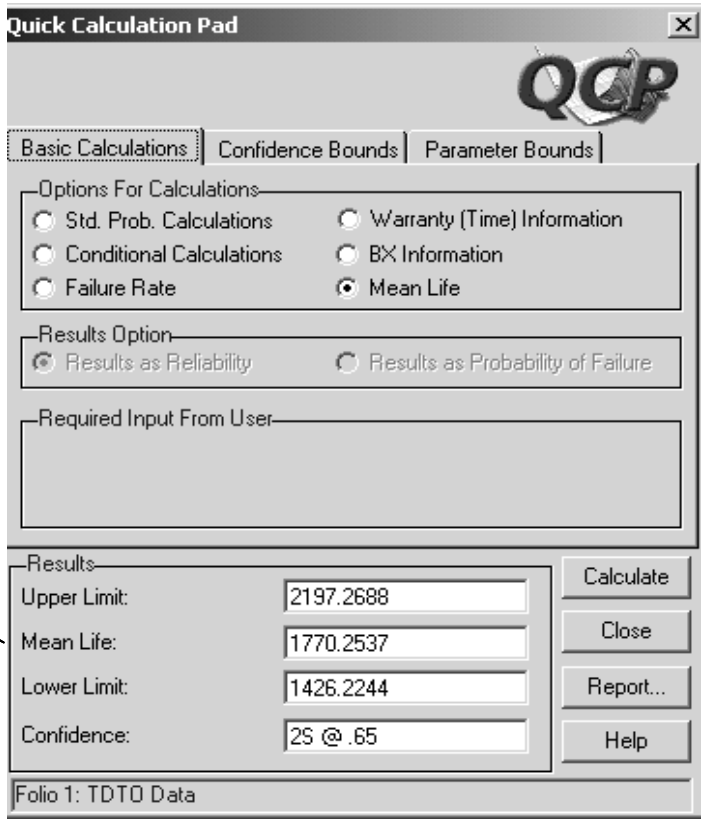
Caterpillar Inc. can envision the possibility of viable tests other than those which employ full-scale bearings. Tests of that nature might become approved for the evaluation of rolling contact fatigue performance, subject to the examination by Caterpillar Inc., of the methods, hardware and data analysis procedures.

D-GS	Number in State	State F or S	State End Time	Subset ID
1	1	F	621	Baseline Oil
2	3	S	621	Baseline Oil
3	1	F	679	Baseline Oil
4	3	S	679	Baseline Oil
5	1	F	714	Baseline Oil
6	3	S	714	Baseline Oil
7	1	F	1192	Baseline Oil
8	3	S	1192	Baseline Oil
9	1	F	1263	Baseline Oil
10	3	S	1263	Baseline Oil
11	1	F	1598	Baseline Oil
12	3	S	1598	Baseline Oil
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				

Baseline Oil | Candidate Oil | Multiple Plot 2 | Plot of Baseline Oil | Plot of Candidate Oil | Multiple Plot 1

Weibull | Normal
Lognormal | Exponential
More >>>
Parameters/Type
1 | 2 | 3
Mixed | Comp. FM
Beta 2.5140
Eta 1994.9084
Rho 0.9256
Lk Value -52.2555
RRY | SRM
FM | MED
CHKD
F=6/S=18

Mean Life of Baseline Oil



D-GS	Number in State	State F or S	State End Time	Subset ID
1	4	S	346	Candidate Oil
2	1	F	1342	Candidate Oil
3	3	S	1342	Candidate Oil
4	1	F	1387	Candidate Oil
5	3	S	1387	Candidate Oil
6	1	F	1823	Candidate Oil
7	3	S	1823	Candidate Oil
8	4	S	2519	Candidate Oil
9	1	F	3021	Candidate Oil
10	3	S	3021	Candidate Oil
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				

Baseline Oil | Candidate Oil | Multiple Plot 2 | Plot of Baseline Oil | Plot of Candidate Oil | Multiple Plot 1

Weibull | Normal | Lognormal | Exponential | More >>>

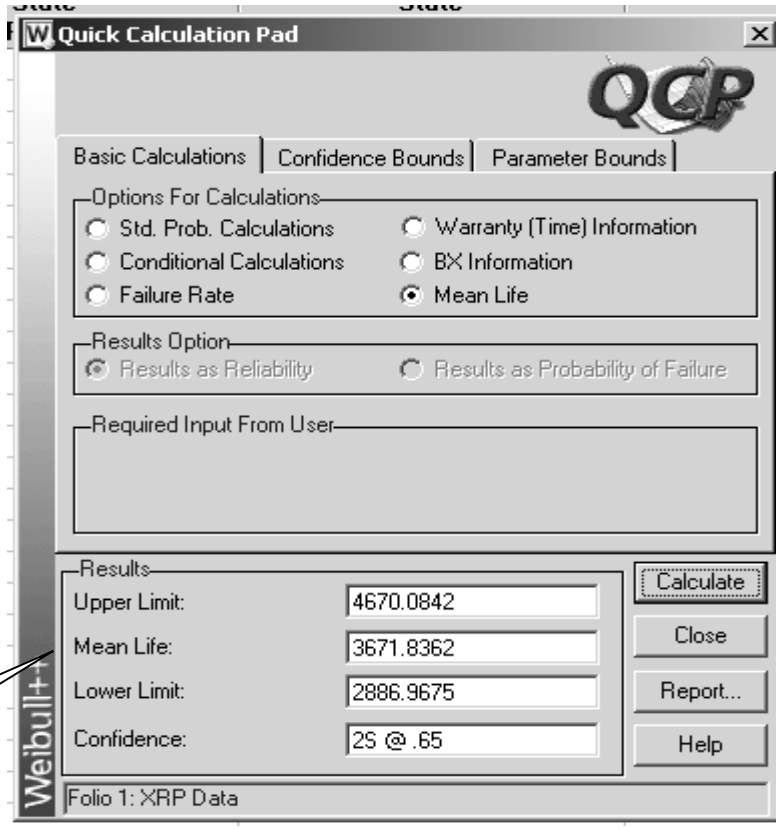
Parameters/Type: 1 | 2 | 3 | Mixed | Comp. FM

Beta 2.4591
Eta 4139.9847
Rho 0.9115
Lk Value -38.6959

RRY | SRM | FM | MED | CHKD | F=4/S=20

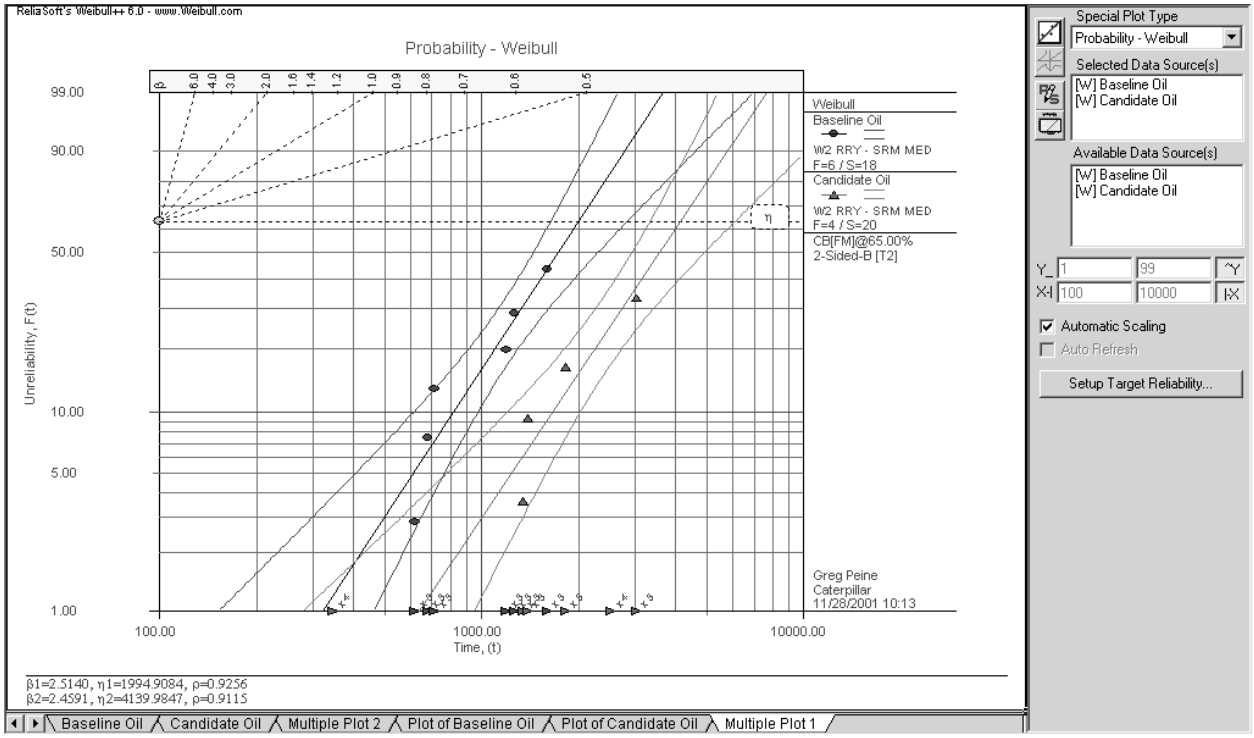
Mean Life Ratio (MLR)

MLR = 3671.8 / 1770.3
= 2.073

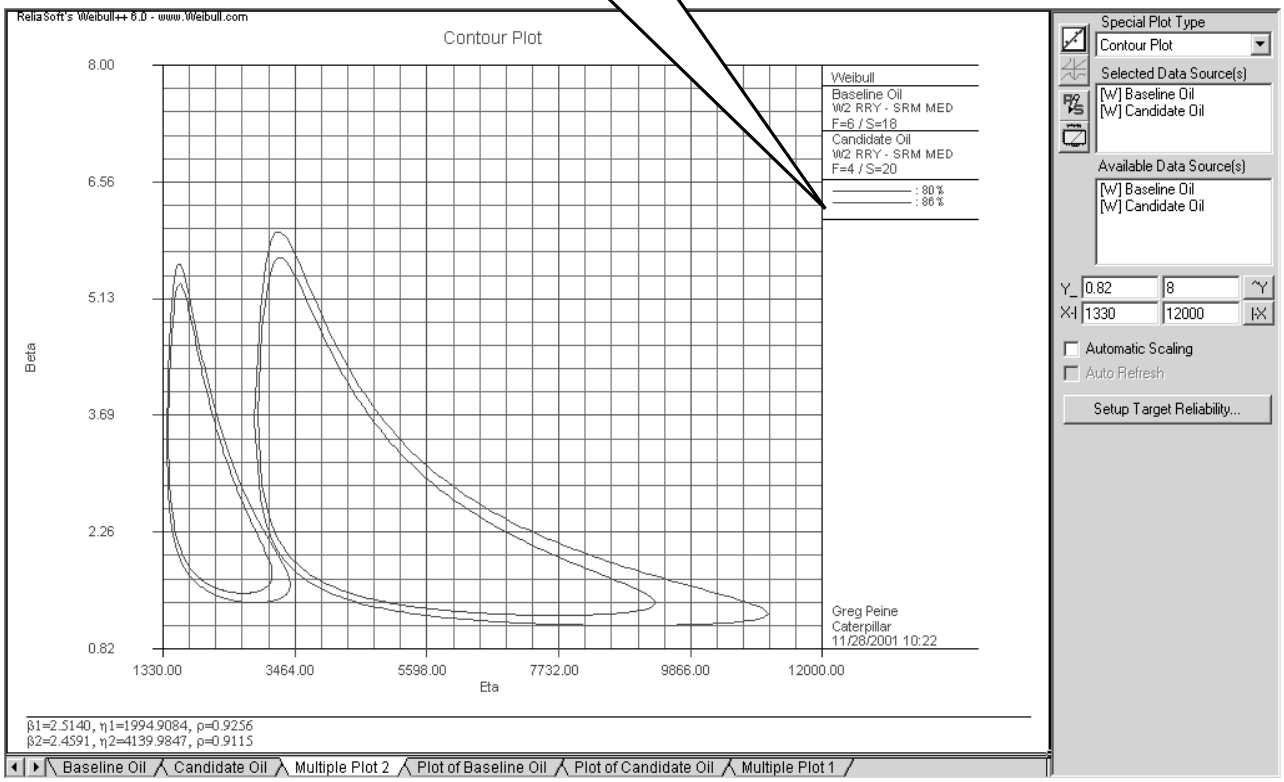


Mean Life of Candidate Oil

CONTACT FATIGUE LIFE	DATE	CHG NO	SECTION
	21 Dec 2001	0	7



At 86% confidence, contours just touch



CONTACT FATIGUE LIFE	DATE 21 Dec 2001	CHG NO 0	SECTION 7

GEAR PITTING (FZG)

1.0 SCOPE:

This test method will be used to evaluate the ability of a lubricant to provide acceptable gear contact fatigue life.

2.0 TEST METHOD:

The candidate lubricant is subject to a pitting resistance test. The testing methods are accelerated to obtain results with minimal testing time.

3.0 TEST EQUIPMENT:

FZG testing rig.

4.0 TEST PROCEDURE:

Caterpillar document FZG-1 details the gear pitting resistance test procedure and is available upon request. The test operates in the diplube mode and uses gears available from Caterpillar. SAE viscosity grade 50 candidate oil must be used. Viscosity of the candidate oil must be equal to that of the CT5026 reference oil within 0.5 cSt at 100°C.

5.0 ACCEPTANCE LIMITS:

The Candidate Oil must achieve a 3-run average gear pitting life greater than the 3-run average found for CT5026 Reference Oil.

GEAR SCUFFING

1.0 SCOPE:

This test method will be used to evaluate the scuffing load capacity of oil used to lubricate hardened steel gears.

2.0 TEST METHOD:

ASTM D5182

3.0 TEST PROCEDURE:

ASTM D5182 test method will be used to evaluate the gear scuffing load capacity of lubricants when used in conjunction with gear applications in Caterpillar final drives, axles, or wherever FD-1 oils are specified for service fill.

4.0 ACCEPTANCE LIMITS:

The candidate oil must achieve at least a 12-stage fail.