

E.P. (Extreme Pressure) & LUBRICITY TESTER

OFI Part No. 111-00

The OFI combination EP and Lubricity Tester is a high-quality instrument used to measure the lubricating quality of drilling fluids, provide data to evaluate the type and quantity of lubricating additives that may be required and predict wear rates of mechanical parts in known fluid systems. Frictional resistance to rotation of the drill string is called torque and frictional resistance to hoisting and lowering the drill string is called drag. Many different materials have been used as mud additives in order to improve lubricity. Examples are Bentonite, graphite, asphalt, diesel and crude oil, fine mica and finely ground nut hulls, to name a few examples. The lubricity or surface-to-surface drag of a drilling fluid is a property of special importance in drilling directional wells. Friction between the drill string and the borehole is expected when drilling a hole off-vertical.

The lubricity test which is the more common of the two, measures fluid resistance (lubricating character) between two hardened steel moving surfaces at a hundred pounds of force. This translates into a 5,000 to 10,000 psi pressure on intermediate fluid. A steel block is pressed against a rotating steel ring and load in inch-pounds is read directly from the dial on the torque arm. The EP test is performed by applying a measured force with a torque arm to a torque-sensitive, rotating bearing cup. This operation produces an indication of the film strength of the fluid being tested.:

$$\text{Coefficient of Friction} = F/W$$

Where:

F - denotes the frictional force required to slide the block and ring surfaces across each other at a given rate and is measured by the number of amperes required to turn the test ring at a prescribed number of revolutions per minute..

W - is the load or force with which the test block is pressed against the test ring through the torque arm.

Lubricity Test

1. Clean the test ring and the test block with ACETONE, and rinse thoroughly with Deionized water. Before starting the test, all parts of the machine in the sample area must be clean. These include the stainless steel cup, the exposed portion of the bushing, the cup retainer nut, block holder and lower part of the shaft. Do not touch metal contact areas with bare hands.
2. Place the lubricity test ring on the main shaft and using the wrench secure with the test ring retainer nut. Make sure the ring seats squarely on the taper of the shaft. Avoid touching the outside of the test ring, as contamination will cause incorrect tests results.
3. Carefully place the test block in the block holder with the concave side facing out, and align with the test ring.
4. Turn on the power and let the machine run for approximately 15 minutes. Rotate the speed control knob until the indicator registers 60 RPM.
5. After the 15 minutes, adjust the torque zero adjustment knob until the torque registers zero. Run the unit approximately 5 minutes longer and adjust again if required.
6. Fill the stainless steel sample cup with deionized water and place on the lowered cup stand. Raise the cup stand until the ring is submerged and secure in place with the thumb screw.
7. Position the torque arm so that it fits inside the concave portion of the torque arm clamp. Turn the torque adjust handle clockwise until 150 inch-pounds of torque have been applied to the test block. ***Never apply torque to the test ring unless it is submerged in fluid.*** If necessary readjust the rotational speed to 60 rpm.
8. Let the machine run for 5 minutes and then check the torque reading. The torque reading should be between 33 and 36 and the reading should be stable to ± 2 . The Coefficient of Friction (F/W) is the torque meter reading divided by 100 (150 inch-pounds @ 1 1/2 inches producing 100 psi). The Coefficient of Friction value for Deionized water should be 34 at 60 rpm, and 150-inch pounds force, if all of the ring-block metallurgical structures were the same. Since they are not all the same, a correction factor of 34 reading is used. If the Coefficient of Friction value for water is in this range, proceed to step 9. If the instrument is not in this range, see the “Standardizing the Test Block” section below.
9. CLEAN UP. Rotate the torque adjustment handle counterclockwise until the torque registers zero. Lower the cup stand and discard the fluid. Wipe any remaining fluid from the sample cup, block, block holder and test ring. Do not touch any metal contact areas with bare hands.
10. Mix the sample fluid for at least 10 minutes. After ensuring the instrument is clean from any previous test, pour the desired test fluid into the stainless steel cup. Place on the cup stand and raise until all metal surfaces, i.e. the block holder and test ring, are fully immersed in the fluid. Secure in place with the thumb screw.
11. Turn the speed control knob until the indicator registers 60 rpm. Adjust the torque zero adjustment knob until the torque registers zero. Run approximately 5 minutes and adjust again if necessary.

12. Turn the torque adjustment handle clockwise until 150 inch-pounds of torque have been applied to the test block. Let the machine run for 3 to 5 minutes.
13. After the 3 to 5 minute run, record the torque reading, and release the torque on the arm.
14. Repeat steps 10 through 13 using the identical fluid, or a new sample with test lubricants added to the fluid.

$$\text{Mud Lubricity Coefficient} = \frac{\text{Meter Reading}}{100} \times \text{Correction Factor}$$

$$\text{Percent (\%) Torque Reduction at a given Load} = \frac{A_L - B_L}{A_L} \times 100$$

Where:

A_L = Torque reading of untreated mud under force equal to B_L

B_L = Torque reading of treated mud under force equal to A_L

15. Turn the power breaker off. Lower the cup stand and turn the torque arm clamp up and away. Swing the torque arm back to allow removal of the test block. Remove and thoroughly rinse the test block with deionized water. Remove the cup and discard the test fluid. Use ACETONE, Deionized water, and brush to clean the main shaft, socket head screw, block holder, adjustable offset bushing, test ring and cup retainer nut after removing it from the shaft.

Standardizing the Test Block:

If the Coefficient of Friction is not in this 33 to 36 range, the ring and block surfaces must be reconditioned or standardized. In order to standardize the block, a substantial portion (at least $\frac{1}{2}$) of its curved surface must be worn to a shiny condition with a minimum of groove lines throughout this polished area. The standardizing procedure is as follows;

- A. Check to ensure that all surfaces are clean and that the wear surface is in the middle of the curvature of the block.
- B. Carefully apply fine valve grinding compound by finger to the test ring. With the machine running at 100 to 200 rpm, apply 150 inch-pounds of force to the ring and block while immersed in Deionized water. Remove the torque after 5 minutes and re-apply grinding compound on the ring. This procedure should be repeated 3 to 4 times. Replace dirty Deionized water with clean Deionized when needed. Do not let Deionized water temperature become hot.
- C. Remove any compound grease with ACETONE and rinse thoroughly with Deionized water.
- D. Mix 2 tablespoons of Aluminum Oxide powder to a cupful of deionized water and submerge the ring and block into this mixture. At 700 to 1000 rpm, apply 50 inch-pounds of force between the ring and block, and let the instrument run for 5 minutes. Then reduce the torque to 25 inch-pounds and let run for another 5 minutes.
- E. Rotate the torque adjust handle counterclockwise until the torque registers zero. Examine the ring and block for a smoothly worn shiny condition with a minimum of scars. Lower the cup stand, discard the standardizing fluid and wipe any remaining fluid from the sample cup, block, block holder and test ring.
- F. As in steps 7 and 8 above, at 60 rpm, apply 150 inch-pounds to the ring and block, which has been submerged in water. After 5 minutes, the torque reading should be between 33 and 36 at a steady to ± 2 rpm.

G. Coarse grinding compound may be used instead of Fine grinding compound to remove deep scarring.

Extreme Pressure (EP) Test:

This test is a measure of the extreme pressure lubricating ability of a drilling fluid and additives.

Equipment:

#111-04	Test Block (cube), EP Test
#111-06	Test Ring, EP Test
No #	Wrench, for tightening 15/16" flare nut
No #	Magnifier, for measuring scar width to 0.005 inches

Preparation:

Before the test can be accurately run, the machine must be in proper adjustment. To test for proper adjustment, or to run a standard test, proceed through the following steps.

1. Clean the EP test ring (#111-06 with a raised narrow surface) and the EP test block (#111-04 cube with smooth surface) with ACETONE and thoroughly rinse with Deionized water. ALL parts of the machine must be clean before starting the test. These include the stainless steel sample cup, the exposed portion of the bushing, cup retainer nut, block holder and the lower portion of the shaft.
2. Install the test ring squarely onto the tapered portion of the shaft, and using the wrench, secure in place with the test ring retainer nut. Take care not to contaminate the outside of the test ring. Do not touch the ring with bare hands, as skin oil can cause inaccurate test results.
3. Place the EP test block in the block holder, again being careful not to touch the block with bare hands.
4. Turn the power switch to ON. Rotate the speed control knob clockwise or counterclockwise until the RPM indicator registers 1000 ± 100 RPM.
5. Rotate the torque zero adjustment knob clockwise or counterclockwise until the torque registers zero.
6. Do not apply a load yet. Run the machine at 1000 RPM for approximately 3 minutes, or until the torque zero reading appears to stabilize and ceases to drift appreciably. Reset the knob to zero if necessary.
7. Position the torque arm so that the arm fits inside the concave portion of the torque arm clamp. Do not apply a load yet.
8. Fill the stainless steel sample cup with the desired fluid to be tested and place the cup on the stand.

Loosen the thumb screw and raise the cup stand so that the test ring, test block and block holder are Completely immersed in the fluid. Tighten the thumb screw.

9. Rotate the torque adjust handle clockwise so that torque is increased at the rate of 5 inch-pounds per second (no more) until the torque meter indicator attains the desired torque reading, or until a SEIZURE occurs. If a seizure occurs, remove the load quickly. *Due to the extreme friction between the ring and the block, the fluid will get very hot and may reach the boiling point.*

Note: A seizure is defined as tearing and galling (scarring) of the metal to metal contact between the test ring and the test block surface. This represents a complete breakdown of the extreme pressure lubricating ability of the fluid or mud under the test conditions. A seizure is identified by a rapid, as opposed to a slow, rise in the torque reading. It may also appear as a sharp substantial increase in current which then drops back to normal. This type of seizure usually occurs at a relatively low torque reading or during tests of highly abrasive muds or muds containing a high solids content.. A seizure is also accompanied by an obvious change in the pitch (sound) of the machine, i.e., a rasping sound. After a seizure, the wear surface on the test block will be very large, and will appear rough and scarred.

10. Repeat steps 1 through 9 until a PASS is obtained. A pass is identified in one of two different ways.
 - A. A 5 minute run at a constant load during which the torque meter reading remains essentially constant, and the wear surface is small and polished.
 - B. A 5 minute run in which there is a moderate amount of torque meter deflection and the wear surface is moderate, and may either be polished or dull, depending upon the abrasiveness of the test fluid.
11. Remove the load by rotating the torque adjust handle counterclockwise until torque is completely released from the main shaft. When the torque registers zero, turn the power switch off. Lower the cup stand, turn the torque arm clamp up and away and swing the torque arm back to allow removal of the test block. Remove and clean the test block. With the aid of a magnifying glass, observe the scar left on the block by the test ring. A proper alignment of the test block in the holder will be indicated by the appearance of a rectangular scar on the test block. Conversely, and improper alignment will be indicated by the appearance of a triangular or trapezoidal shaped scar. If the alignment is proper, proceed with step 12. If the alignment is improper, the block holder and block must be repositioned as follows;

The block holder should always fit solidly against the shoulder at the bottom of the threads on the torque shaft bushing. If it ever becomes loose, remove the holder, clean and reinstall against the shoulder on the keyed shaft and tightened Allen cap screw. Realign the holder as in figures 2 and 3. Depending upon the shape of the triangle or trapezoid, adjust the block holder either up or downward. If the trapezoid appears larger on top than on the bottom, the holder must be adjusted downward. This is accomplished by loosening the bushing adjuster lock screw and running the torque arm-adjusting nut up the shaft until it is finger tight on the shoulder at the bottom of the shaft. While putting a 3/4" (1.9 cm) eccentric shaft wrench on the threaded shaft flats, simultaneously put the 1 1/4" (3.17 cm) torque adjust wrench on the torque arm adjusting nut. While

maintaining a ¾ (1.9 cm) wrench orientation, turn the nut counterclockwise until it is tight on the shoulder. With the nut tight, every 6 that the nut is turned counterclockwise will lower the bushing .001" (0.00254 cm). Tighten the socket head screw. If further adjustment is required, repeat the above procedure. If the trapezoid appears smaller on top than on the bottom (Figure 3, Example B), loosen the bushing adjuster lock screw and before running the adjusting nut up the shaft, tap the end of the shaft upwards about 1/16" (0.16 cm). Then follow the above instructions to bring the block holder down in increments of a few thousandths of an inch. After each adjustment, repeat the test until a rectangular scar (Figure 3, Example C) appears on the block.

12. Remove the sample and discard the test fluid. Clean the main shaft, block holder, adjusting offset bushing and cup retainer nut. Remove and discard the test ring. Clean a new test ring and install.

Measurements And Calculations:

- A. To measure the scar length on the block, use a magnifier calibrated to read 0.005 inch (0.0127 cm). An appropriate magnifier may be obtained at OFI. Before measuring, the test block should be wiped clean. The magnifier is placed at the center of the scar, parallel to the edges so that the average width of the scar can be obtained. The scar measurement is taken in hundredths of an inch. When a scar width is measured at 0.095 inch, for example, it should be referred to and recorded as 9.5 hundredths of an inch.
- B. To calculate the pressure on the block, begin by computing the total area of the scar on the block. This is found by multiplying the width of the scar in inches, by the length. (If measuring a trapezoidal scar, an average width must be used). The force acting on the scar area is found by dividing the torque meter reading at which a pass was obtained by the lever arm, by 1.5 (the travel distance of the arm). The pressure on the test block at the time the test was stopped is found by dividing the force by the scar area. This pressure is the film strength of the mud. In equation form it is written as follows:

$$P (\text{Film Strength, psi}) = 533 \times \frac{T}{W}$$

Where: P = Film Strength, psi
 T = Torque Meter Reading, pounds
 W = Scar width, hundredths of an inch

The nomograph in Figure 4 may be used to derive the film strength without calculation.

Reporting Test Results:

1. The lowest load (torque meter reading) in inch-pounds and the average torque in pounds at which the seizure occurred are recorded.

2. Record the following at the conclusion of a pass or if a 5-minute test does not produce a seizure.
 - a. Load (torque meter reading) in inch-pounds
 - b. Scar width in hundredths of an inch.
 - c. Film strength in psi.
 - d. Average current (torque meter reading in pounds divided by 10) in amps.

Preventative Maintenance of Equipment:

1. The roller bearings in the main shaft are greased with high-temperature bearing grease (Lubriplate No. 12601, etc.) via the zerk in the casting. These bearings should only require attention once a year, unless grease is found to be leaking from around the lower seal and running down the shaft into the sample. If leakage is found, the seal should be replaced with a double-lipped seal, like National Federal Mogul no. 471413. After the seal has been replaced, grease the roller bearing via the zerk fitting.
2. The upper main shaft ball bearing is sealed and will need replacement only when the shaft end-lay can be detected.
3. After each usage, ensure the lower end of the main shaft, test ring retainer nut, block holder, block, adjustment offset bushing threads, and adjusting nut, are all clean and dry. This will prevent rusting. If the machine is to be stored for a long time, coat the above areas with oil.
4. Be certain the control panel does not have fluid spilled upon it, since this can seep around electrical components and cause damage.
5. Remove the belt guard after extensive use and check the belt tension. Ensure sufficient tightness so that when the motor is stalled, the belt will not slip. Tension can be increased by loosening the motor mount bolts, sliding the motor towards the torque adjust handle and then retightening the mounting bolts. Replace the belt guard..

Independent Calibration Plot:

The unit may also be “scaled” using a “Prony Brake” apparatus, instead of the Deionized water procedure, to measure the standarization of 33 to 36. The lamicord “Prony Brake” assembly is available as an extra item through OFI Testing Equipment. A set of 50 to 1000 gram weights in 50-gram increments will also be required. Set the instrument on its right side, with the torque arm handle over the table edge. Attach the Prony Brake (with no weights hung from the notch) to the main shaft of the instrument. Rotate the shaft at 60 rpm and slowly tighten the screw in the Prony Brake slot until friction tension barely holds the brake suspended. Zero the torque meter. Hang 50 grams and tighten the screw until suspension is achieved. Repeat with weights in increasing increments of 50 grams up through 1300 grams. Reduce the weights back to zero and recheck torque zero. Construct a calibration plot. Note that 1000 grams produces about 38 ½pounds above brake alone (2 1/2 to 3 pounds) so that 1000 grams reads 41 to 41 ½pounds and 1300 grams produces about 50 pounds above the brake alone.

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