



Dependable Products From People You Trust



Differential Sticking Tester

Part No. 150-50

Instruction Manual

Updated 1/15/2014

Ver. 2.1

OFI Testing Equipment, Inc.

11302 Steeplecrest Dr. · Houston, Texas · 77065 · U.S.A.

Tele: 832.320.7300 · Fax: 713.880.9886 · www.ofite.com

©Copyright OFITE 2013

Table of Contents

Intro	2
Description	2
Components	3
Safety	5
Test Procedure	6
<i>Timed Filtration</i>	6
<i>Fixed Cake Thickness</i>	11
Disassembly	12
Theory	13
<i>Example</i>	15
<i>Worksheet</i>	16
Maintenance	17
Diagrams	18
<i>Full Unit</i>	18
<i>Cell Assembly</i>	19

Intro

The OFITE Differential Sticking Tester measures the “Stuck Pipe Tendency Coefficient” of drilling fluids, and also determines how effective lubricants or treatments might be with any given drilling fluid. This coefficient takes into account both the friction, or “stickiness”, of the filter cake, as well as the amount of cake building that must occur in order to freeze or stick the pipe in the hole. The coefficient is determined by running a Timed Filtration test. By measuring the area of cake building during a test, the “Bulk Sticking Coefficient” is obtained and read directly at the conclusion of the test. How likely a given fluid will be to produce a stuck pipe situation and how effective a given treatment may be, can be immediately determined on-site.

Description

The unit is normally pressurized by a CO₂ pressuring assembly, but any nitrogen source will also work. If nitrogen is used, the tester apparatus must be fitted with a suitable nitrogen regulator, gauges, valves, and high-pressure hoses. The standard test uses 477.5 PSI (3,291 kPa) applied to a 200-mL stainless steel vessel. The unit includes both a flat-faced plate and a plate of 12½" (31.75 cm) spherical radius, which simulates the pipe inside the casing or collars in the borehole. For samples that adhere more to the plate than to the filter paper, stainless steel micro-corrugation disks are provided. For convenience a stainless steel carrying case is available as an optional item.

Components

#130-10-52	Jam Nut, 3/8-24, Qty: 2
#142-56	O-ring
#150-52	Neoprene Gasket
#150-53	Plastic Gasket
#150-54	Torque Wrench
#150-55	Spanner Wrench
#150-56	Test Cell O-ring
#150-57	5/16" Socket with 3/8" Drive
#150-58	Torque Plate; Flat Bottom
#150-59	Torque Plate; Spherical
#153-16	Glass Graduated Cylinder; 25 mL × 3/10 mL
#170-04	CO₂ Pressurization Unit:
#143-02-10	CO ₂ Puncture Head Assembly
#143-03	Barrel for CO ₂ Cartridge
#170-08	Regulator
#170-20	Manifold Block
#170-32	1/8" × 1/8" NPT Male Needle Valve
#171-22	Retainer Pin
#171-34	1500-PSI Gauge; 2"; 1/4" NPT Bottom
#170-13	Test Cell O-ring; Buna N
#170-15	Base
#170-16	Valve Stem; Qty: 2
#170-17	Valve Stem O-ring; Qty: 10
#170-19	2 1/2" (6.35 cm) Filter Paper; Specially Hardened for Filter Presses
#170-35	6" Adjustable Wrench
#170-44	1/2" Rubber Foot; Qty: 4
#171-79	1/4" Hex Wrench

Optional:

Yoke for Fixed Cake Thickness Test - Special Order Only

#150-50-SP Spare Parts for #150-50:

- #142-56 O-ring; Qty: 12
- #143-02-13 O-ring for Puncture Pin Holder Assembly; CO₂ Cartridge; Qty: 6
- #143-02-14 O-ring for Puncture Pin Holder Assembly; Qty: 4
- #143-05 EZ Puncture CO₂ Bulbs; 8-Gram; UN #1013; Package of 10; Qty: 30
- #143-06 Safety Bleeder Valve
- #143-07 Regulator Repair Kit for #143-00
- #143-22 Gasket for Puncturing Pin; Qty: 12
- #150-51 Locking Mesh Disc; Qty: 10
- #150-52 Neoprene Gasket; Qty: 10
- #150-53 Plastic Gasket; Qty: 8
- #153-16 Glass Graduated Cylinder; 25 mL × $\frac{3}{10}$ mL; Qty: 2
- #170-13 Test Cell O-ring; Buna N; Qty: 4
- #170-16 Valve Stem; Qty: 2
- #170-17 Valve Stem O-ring; Qty: 20
- #170-19 2½" (6.35 cm) Filter Paper; Specially Hardened for Filter Presses; Qty: 5
- #170-23 60-Mesh Screen; Qty: 8
- #171-22 Retainer Pin; Qty: 2
- #171-79 ¼" Hex Wrench

Safety

Nitrogen must be supplied in an approved Nitrogen Gas Cylinder and secured to meet safety standards. Do not use nitrous oxide cartridges as pressure sources.

Due to the high pressures involved in this test, extreme care must be exercised at all times. All safety precautions must be met, especially in the cell breakdown procedure after the filtration procedure has been completed.

Never transport CO₂ bulbs or cartridges by airplane without proper packaging. Cabin depressurization could cause them to explode.

Before pressuring, always check to be sure the regulator is in a closed position by ensuring the T-screw is backed out and free turning. Insert and puncture the CO₂ cartridge by turning the barrel only a quarter turn past the actual puncture point. Adjust the regulator to the desired pressure with the regulator T-screw. With the Differential Sticking Tester, never exceed 500 PSI (3,450 kPa). When depressurizing, shut off the pressure supply, then bleed off the system of pressure with the valve, and finally back out the regulator T-screw.

Test Procedure

Timed Filtration

The Differential Sticking Tester is capable of performing two different tests. Both of these tests determine the Stuck Tendency Coefficient and the Bulk Sticking Coefficient. The Timed Filtration test uses a pre-determined sticking time. The Fixed Cake Thickness test uses an optional yoke assembly to determine the amount of time required to create a cake of specified thickness. The general procedure for assembling and operating the instrument is basically the same for either test.

Two torque plates are provided with the unit. The spherical torque plate (#150-59) has a very slight curve on the bottom. The radius of the curve is 12.5" (31.75 cm) and simulates a 25" (63.5 cm) diameter drill casing or collar. The flat torque plate (#150-58) is completely flat across the surface. The difference between the two is sometimes difficult to see. To distinguish between the two, place them next to each other on a flat surface. The spherical torque plate will rock slightly, while the flat torque plate will sit firmly.

1. Make sure the unit is clean and dry before beginning a test.
2. Open the test cell. Remove the inner cap by turning the cell over and removing the two allen screws with the supplied wrench.
3. Inspect the o-ring on the bottom of the inner cap. Replace it if it shows signs of wear or damage.

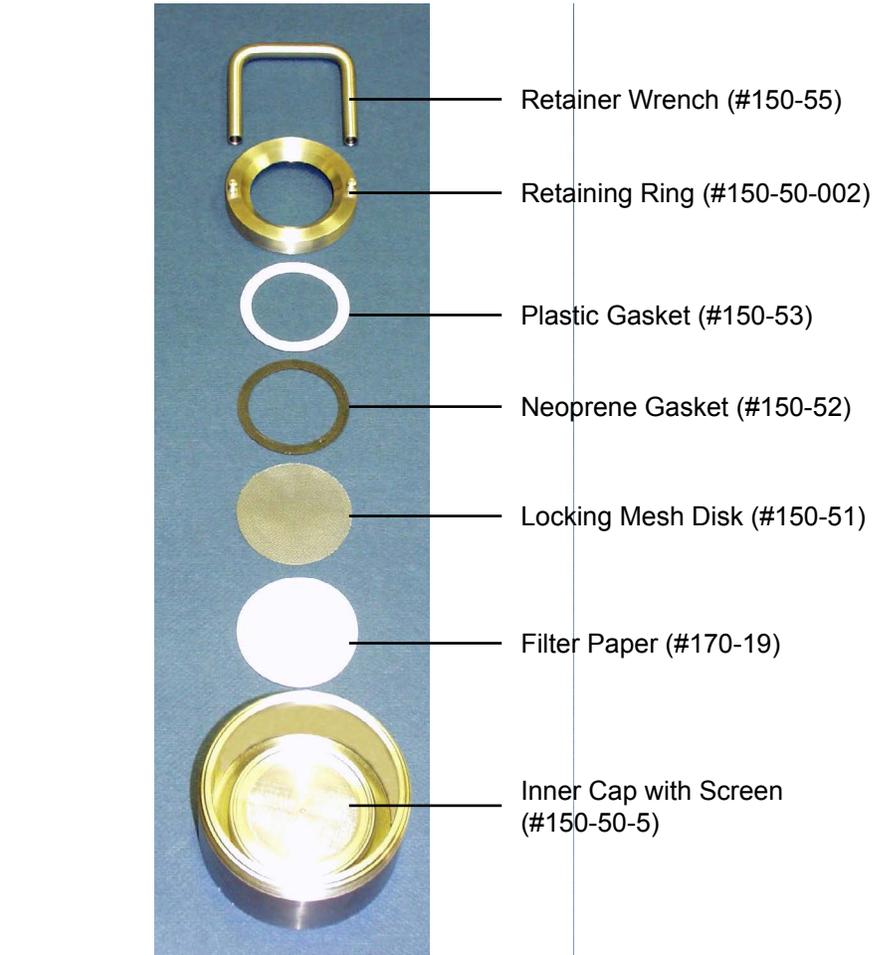




Tip

4. Place a sheet of filter paper on top of the screen on the inner cap. On top of the filter paper, place the rubber gasket, then the plastic ring.

The locking mesh disk can be used to lock the filter cake to the paper so that it does not stick to the torque plate face and break loose from the filter paper. If you choose to use the locking mesh disk, place it on top of the filter paper, beneath the rubber gasket.



5. Screw the retaining ring in place on top of the filter paper and gaskets. Be sure to keep the gaskets centered.
6. Place the inner cap back into the cell. Make sure the o-ring seats properly beneath the inner cap. Refer to the photos on page 8.
7. Turn the cell over and secure the inner cap with the two allen screws.
8. Tighten the retaining ring securely with the supplied retainer wrench.
9. Inspect the o-rings on the valve stems and replace any that show signs of wear or damage. Screw one of the valve stems into the hole in the base of the test cell and hand tighten.

10. Place the cell on the stand. Make sure the four holes in the base of the cell line up with the stand tips.
11. Fill the cell with sample fluid to the scribed line.
12. Insert the stem of the torque plate through the hole in the cell cap as far as possible. The face of the plate should be facing towards the inside of the cell. Be careful not to cut the o-ring.



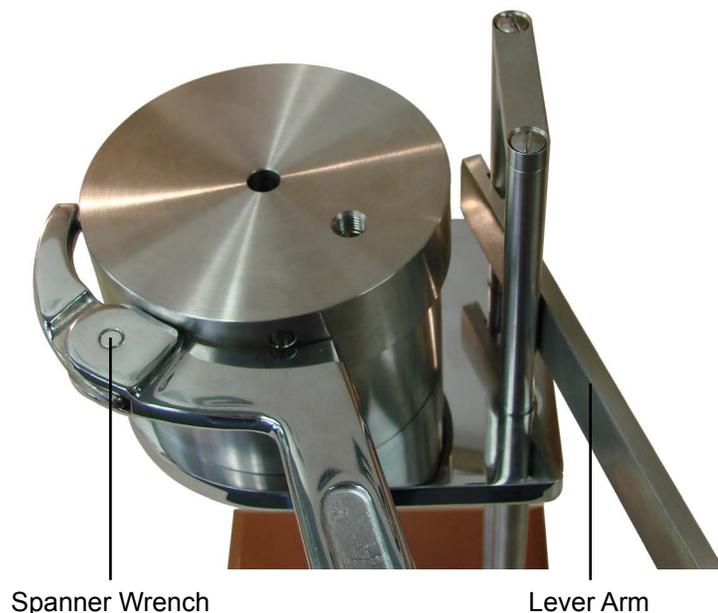
Torque Plate

13. Screw the cell cap onto the test cell body. Make sure the o-ring is properly seated in the groove in the cell cap.
14. Tighten the cell cap using the supplied spanner wrench. For additional leverage, place the lever arm horizontally between the two support legs.



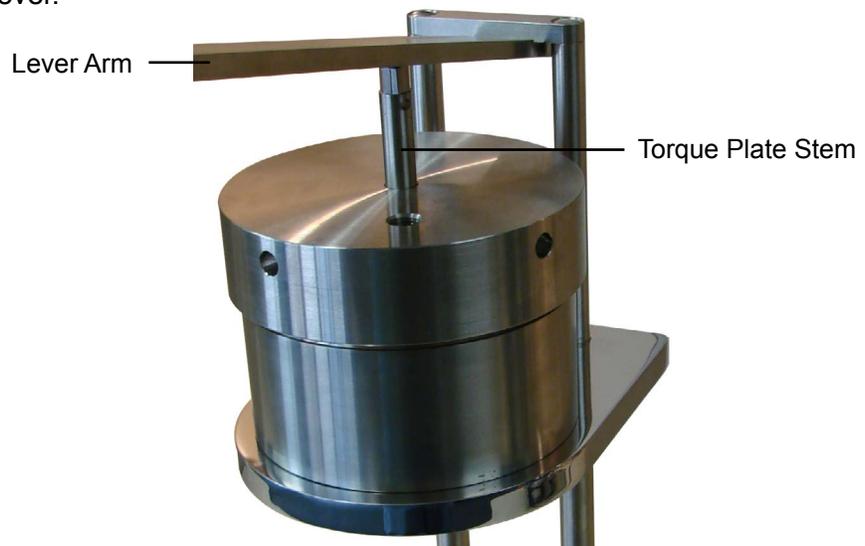
Tip

Once the cell cap is tightened, rotate the cell on the stand until the valve stem hole is oriented away from the stand supports. This will provide more space for the torque lever.



15. Screw the other valve stem into the hole in the cell cap and hand tighten.
16. Place the CO₂ assembly onto the top valve stem and secure it in place with the retaining pin.
17. Unscrew (counter-clockwise) the regulator T-screw until it turns freely.
18. Remove the barrel from the regulator. Place a CO₂ cartridge into the barrel and tighten the barrel to the puncture head until the cartridge punctures.
19. Tighten (clockwise) the regulator T-screw until the gauge reads 477.5 PSI (3,292 kPa).
20. Place the 25 mL graduated cylinder under the cell and open the lower valve stem by turning it counter-clockwise ¼ turn.
21. Make sure the torque plate is up as far as possible by turning and pulling it upward.
22. Open the top valve stem ¼ turn to initiate filtration. Record the time of the start of the test.
23. Continue filtration for 10 minutes, or until the desired filtrate volume is collected.

If the yoke option is being used, filter until the desired cake thickness is reached (usually ½" / 1.6 mm). Refer to page 11 for details.
24. Align the groove in the lever under the column top cross support and press the torque plate down into the cell. Continue to hold the torque plate all the way down against the screen until the pressure equalizes sufficiently to allow the plate to stick. This usually takes about two minutes and will require 50 to 80 pounds (23 to 36 kg) of force on the end of the lever.





25. Record the filtrate volume.
26. Allow the torque plate to stick in the down position for 10 minutes.
27. Remove the lever and attach the socket to the torque wrench. Place the torque wrench and socket on the hex top of the torque plate stem. Wedge the lever between the columns above the cell platform so it can be used as a counter-torque lever.

If the filter paper tears when the torque plate is rotated, cell pressure will be lost through the valve stem. A standard HTHP Filter Press back pressure receiver may be substituted for the graduated cylinder while the torque readings are being taken. A length of rubber or tygon tubing can also be attached to the valve stem with the outlet end attached to a closed container.

28. Measure the torque by rotating the torque plate in either direction with the torque wrench. Observe the dial reading.
29. Repeat the torque measurements three to six times, allowing 30 seconds between each check. Record each reading.
30. Calculate the average torque reading and record the plate sticking time.

Test Procedure

Fixed Cake Thickness

To determine the time required to develop a fixed cake thickness, a modification of the Timed Filtration test may be used. This test determines the Bulk Sticking Coefficient (K_{sc}). Both torque plates can be used for this test. If you use the spherical torque plate, you must allow enough time after the plate sticks for the cake to build before the $r = 1$ " condition exists. To run this test, an accessory yoke mechanism must be used. This yoke attaches onto the cell cap and is used to set the torque plate at a given distance from the filter surface. This distance will be the desired cake thickness and is usually $\frac{3}{32}$ " (1.6 mm).

1. Assemble the cell as described in the Timed Filtration test procedure on page 6, steps 1 through 21.
2. Install the yoke assembly onto the cell cap by fitting the two setscrews on the sides of the yoke into the holes in the side of the cell cap. Tighten these screws by hand.
3. Fit the stem of the T-screw over the stem of the torque plate. Align the hole in the T-screw stem with the hole in the torque plate stem. Insert the retaining pin through the hole to secure the assembly in place.
4. Turn the T-screw down until the torque plate touches the filter paper (or the locking mesh). Now turn the T-screw back until the torque plate face is the desired distance from the filter paper. One turn of the T-screw raises the torque plate $\frac{1}{32}$ " (.8 mm).
5. Open the top valve stem and record the time as the start of the test.
6. Allow the cell to filter until the plate becomes stuck. You will know the plate is stuck when you hear an audible click. This indicates that the locking pin is bound in place because the plates are sticking. The sticking time will vary according to the cake-building properties of the sample.
7. If you are using the flat torque plate, take the torque readings as described in steps 27 - 30 on page 10 immediately after the plate is stuck.
8. If you are using the spherical torque plate, the time required for additional cake to build will have to be determined by trial and error. The filter cake must build up to, but not around, the edge of the plate. After waiting, take the torque readings.
9. As an alternative method, you can set a finite time for the test. At the end of the time period, measure the stuck cake area on the spherical torque plate. If the radius is equal to 1", record the average edge height for use in the calculations later.

Disassembly

1. Turn the regulator T-handle counter-clockwise until the pressure gauge reads 0. Once the T-handle turns freely, open the bleeder valve.
2. Unscrew the barrel on the CO₂ assembly and remove the empty cartridge.
3. Remove the torque wrench and socket from the test cell.
4. Remove the CO₂ pressure assembly from the top valve stem.
5. Slowly open the valve stem to relieve any remaining pressure inside the test cell.
6. If you used the yoke, unscrew the locking pins and remove it from the cell cap.
7. Remove the cell cap. If the torque plate remains in the cell cap, carefully push it through the lid by the stem.
8. Empty the test cell.
9. Gently wash the sample from the edge of the torque plate.
10. Note the diameter of the depression from the torque plate. If this diameter is less than 2 inches or if any cake is adhering to the edge of the torque plate, estimate the edge height of the cake from the filter paper.



If the cake is stuck to the torque plate rather than to the filter paper, then the test is invalid. Repeat the test using the locking mesh.

11. Using the retainer wrench, unscrew the retaining ring. Remove the slip ring and gasket. Remove the locking mesh, filter paper, and filter cake. Examine the filter cake as desired and note any observations.
12. Remove the cell from the stage and thoroughly clean all parts. Polish any surface where corrosion is noted.
13. Check all o-rings for damage or wear and replace as needed. Lubricate all o-rings with grease.

Theory

Bulk Sticking Coefficient (K_{sc}) Derivation:

The Bulk Sticking Coefficient (K_{sc}) is the ratio of the force necessary to initiate sliding of the plate (F_s) to the normal force on the plate (F_n).

Where:

- T_u = Average of readings from Torque Wrench (inch-pounds)
- r = Radius of Plate (inches)
- h = Height above flat surface of cake around the edge of the plate (inches)
- P = Cell Pressure (PSI), differential (inlet to outlet)
- F_s = Sliding force
- F_n = Normal force on plate
- K_{sc} = Bulk Sticking Coefficient
- K_{st} = Stuck Tendency Coefficient

a. The Sliding Force (F_s):

The Sliding Force (F_s) is a function of the measured torque (T_u). This equation should only be used when the radius is 1 and edge effects are not being considered.

$$F_s = 1.5 \times T_u$$

b. The normal force (F_n):

The Normal Force (F_n) is determined by multiplying the area by the differential pressure. This assumes that a pressure of 477.5 PSI was used during the test.

$$F_n = 1,500 \times r^2$$

If you are considering edge effects:

$$F_n = 1500 \times (1 + 4/3h)$$

c. The Bulk Sticking Coefficient (K_{sc})

The Bulk Sticking Coefficient (K_{sc}) is calculated by dividing the Sliding Force (F_s) by the Normal Force (F_n): $K_{sc} = F_s / F_n$

Ignoring Edge Effects:

$$= 1.5 T_u / \pi Pr^3$$

For a standard pressure of 477.5 PSI (3,292 kPa):

$$K_{sc} = 1.5 T_u / 1,500 r^3 = .001 \times T_u / r^3$$

And for $r = 1$ ":

$$K_{sc} = .001 \times T_u$$

Taking into account Edge Effects:

$$K_{sc} = F_s / F_n = (1.5 T_u / r) / (\pi Pr^2 + 4/3\pi rhP)$$

$$= (1.5T_u) / [\pi Pr^2 \times (r + 4/3h)]$$

For a standard pressure of 477.5 PSI (3,292 kPa) and $r = 1$ ":

$$K_{sc} = (1.5 \times T_u) / [1,500 \times (1 + 4/3h)]$$

$$K_{sc} = (.001 \times T_u) / (1 + 1.33h)$$

The Stuck Tendency Coefficient (K_{st}) is equal to the Bulk Sticking Coefficient (K_{sc}) multiplied by the variable stuck area.

$$K_{st} = K_{sc} \times (\text{Variable Stuck Area}) = T_u$$

K_{st} is not valid for the flat plate because the stuck area is either 0 or 3.14 in² ($r = 1$) and not a variable.



Note

Theory

Example

The drilling fluid sample is mixed and then loaded into the cell and pressurized at 477.5 PSI (3292 kPa) for 10 minutes. The torque plate is seated using the lever and held for two minutes. Eight additional minutes are then allowed to pass. The breaking torque is then measured in four breaks at 30 seconds apart:

- 36 inch pounds (41.47 kg-cm)
- 39 inch pounds (44.93 kg-cm)
- 40 inch pounds (46.08 kg-cm)
- 41 inch pounds (47.23 kgt-cm)

The drilling fluid sample has an average 0.039 Stuck Tendency Coefficient. The pressure is then removed and the cell is carefully opened, leaving the torque plate set in the filter cake. The torque plate and cake are washed and the torque plate is turned (not lifted) loose. The diameter of the imprint of the torque plate impression (smoothed dome area) is measured at 1.57" (3.95 cm) diameter, which gives a radius of 0.785" (1.98 cm).

Therefore, (using inch dimensions):

$$K_{sc} = (.001 \times 39.3) / (.785)^3 = 0.081$$

Theory

Worksheet

1. Using the spherical torque plate and inch dimensions:

$$K_{st} = \frac{(\text{Average Torque Wrench Reading}) \times (\text{Pressure}) \times (.001)}{477.5}$$
$$= \frac{(\quad) \times (\quad) \times (.001)}{477.5} =$$

For a standard pressure of 477.5 PSI (3,292 kPa):

$$K_{st} = (\text{Average Torque Wrench Reading}) \times .001$$
$$= (\quad) \times (.001) =$$

2. Using the spherical torque plate and 477.5 PSI (3,292 kPa) and inch dimensions:

- a. For cake with less than 1" stuck radius:

$$K_{sc} = \frac{(\text{Average Torque Wrench Reading}) \times (.001)}{(\text{Measured Stuck Cake Radius})^3}$$
$$= \frac{(\quad) \times (.001)}{(\quad)^3} =$$

- b. Using either the spherical or flat torque plate and 477.5 PSI (3,292 kPa) and inch dimensions:

For cake with 1" radius, edge effects considered and a pressure 477.5 PSI (3,292 kPa):

$$K_{sc} = \frac{(\text{Average Torque Wrench Reading}) \times (.001)}{1 + 1.33 (\text{Cake Height on Edges})}$$
$$= \frac{(\quad) \times (.001)}{(1 + 1.33 (\quad))} =$$

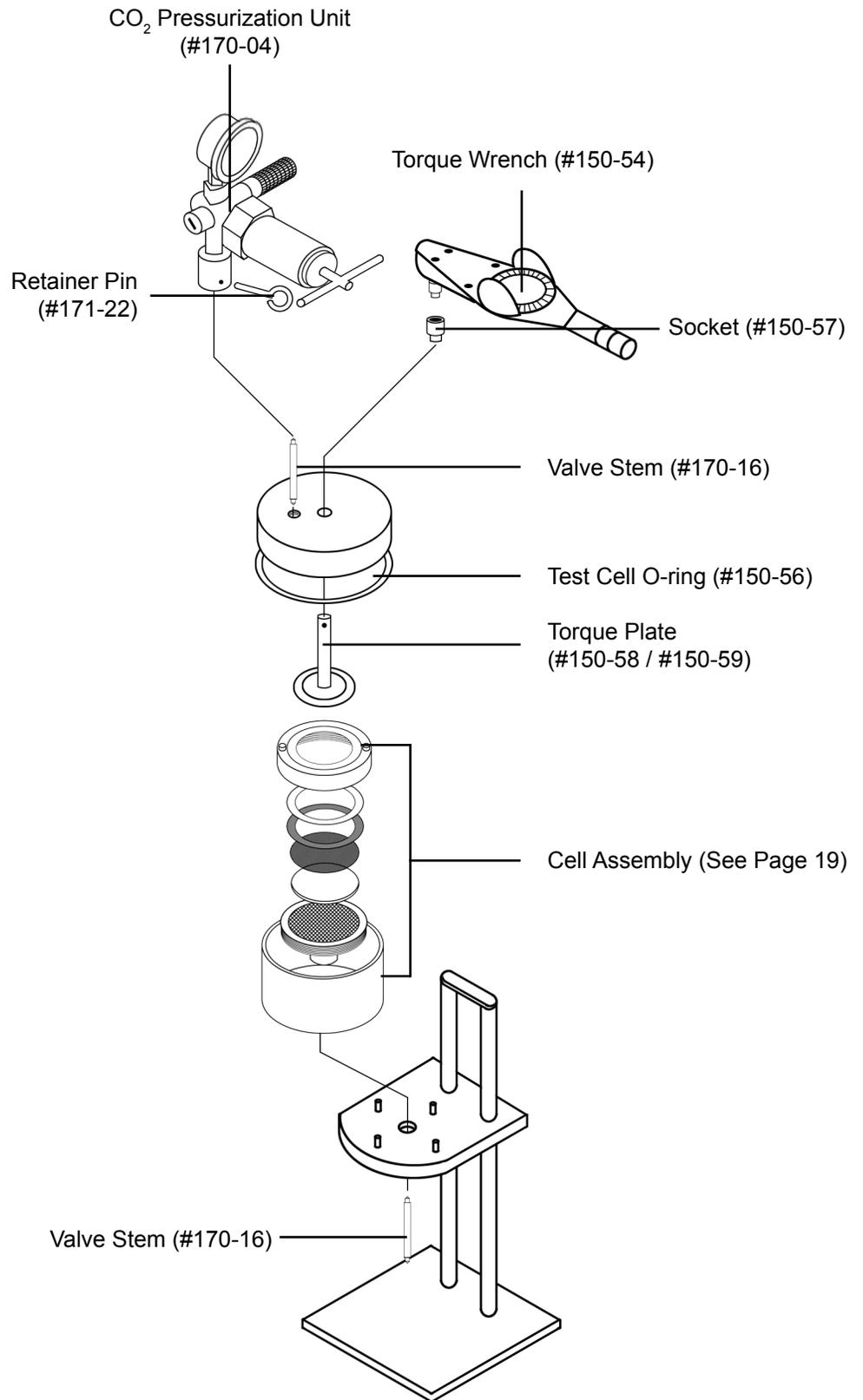
3. For tests using the yoke attachment, the cake thickness before sticking should be recorded, and the data in 1, 2a and 2b above apply.

Maintenance

1. Disassemble the test cell after each test and thoroughly clean and dry all surfaces.
2. Check all o-rings and o-ring grooves for signs of wear or damage. Replace any damaged o-ring and lubricate all o-rings before they are installed.
3. Wash and dry the support screen and the locking mesh disk (If used).
4. Wipe any spilled fluid or other debris from the stand. Some materials may damage the finish of these parts if allowed to remain for a long period of time.
5. Sample fluids can cause corrosion in the test cell and cap. The standard cell is made of 303 stainless steel, however other materials, which are more corrosive resistant, are available. Periodically inspect the inside of the cell for evidence of corrosion. Light corrosion may be removed using 329 or finer wet or dry sand paper. Deeper corrosion pitting may be removed by sand blasting the area of the corrosion. If severe corrosion is evident, the cell should be replaced.
6. A metal-to-metal pressure tight seal is made between the valve stem and its seat. Leaks can occur if either the valve stem or the seat is damaged. The conical point of the valve stem should be inspected for damage by removing the stem from the cap or cell body and replacing the stem if the point is damaged. If the point is in good condition, the seat in the cell or cap may be rough. A $\frac{5}{16}$ " drill bit can be used to re-surface the seat, or a special resurfacing tool may be ordered from OFI Testing Equipment. Valve stems should also be inspected for possible plugging of the passages by dried fluid samples. A small drill or wire may be used to insure that both the cross-bore and the main passage openings are clear.

Diagrams

Full Unit



Diagrams

Cell Assembly

