# PERMEABILITY PLUGGING TESTER - P.P.T.
# OFI Part No. 171-84

***4000 psi (27,600 kPA) - 500°F (260°C)***
***Capacity***

## Preparation

The Permeability Plugging Tester is a modification of the standard 500 ml HPHT Filter press. It may be used in the field or in a laboratory environment. The instrument is useful for making filtration tests on plugging materials without the interference of particles settling on the filter medium during the heat up process. Typical differential pressures are much higher than those seen in standard HPHT testing, and the pressure cell is operated inverted with the filter medium and the back pressure receiver on top of the assembly. The cell is pressurized with hydraulic oil and a floating piston separates the oil from the test fluid within the cell. The P.P.T. is very useful in predicting how a drilling fluid can form a low permeable filter cake to seal off depleted, under pressured intervals and help prevent differential sticking.

The cell is furnished with a threaded cell inlet cap, a floating piston and a threaded scribed outlet cap for the ceramic filter disks. The outlet end of the cell has a 1/4" deeper recess than a standard cell to allow for the ceramic disk as a filter medium. The end cap used with the 1/4" disk has a scribed concentric pattern rather than the conventional screen. Filter paper or other thin filter medium may be used with this cap by using the spacer ring (Part No. 170-72) to fill the extra 1/4" space. Also, an extra thick end cap with a standard screen backup is furnished to use with thin filter media - paper or metal.

All of the end caps are designed to accept the standard valve stem. The inlet or bottom valve stem is fitted with a quick-connect for the connection to the hydraulic pressure manifold. The standard hydraulic pressure manifolds are equipped with a 4000 psi (27,600 kPA) relief valve. The outlet or upper valve stem assembly consists of a dual valve stem with a ball valve in the middle, which facilitates the opening and closing of the outlet flow. Power consumption for the P.P.T. heating jacket is 800 watts.

The 100 ml back-pressure receiver is mounted on top of the heating jacket and upside down, when compared to the normal HPHT filter press configuration. It attaches to the cell outlet valve stem and is secured with the no. 171-22 retainer pin. The fittings on the receiver are reversed with the pressure inlet on the small end (the upper end). A flare fitting may be provided if it is desired to use the low pressure side of a dual manifold on a nitrogen bottle instead of the standard $CO_2$ cartridges.

## Equipment - 4000 psi Capacity P.P.T.

| | |
|---|---|
| #153-14 | Cylinder, Graduated 50 ml x 1 ml, glass |
| #170-04 | $CO_2$ Pressuring Assembly, Complete, for Receiver |
| #170-35 | Wrench, Combination, 1/4 inch |
| #171-00 | Heating Jacket & Stand, HTHP, 115 volt, 800 Watt |
| #171-10 | Back Pressure Receiver, 100 ml |
| #171-22 | Retainer Pin, for Receiver |
| #NS | Hose, 5000 lb, 1/8" x 3' |
| #NS | Gauge, 5000 lb, 2 1/2", 1/4" NPT |
| #171-91 | *Manifold Assembly, Hydraulics Inlet |
| #171-94 | *Cell Rest Plunger Assembly |
| #171-96 | Pump, Hand, Hydraulic, Single Speed |
| #171-96-1 | Hydraulic Oil, for Hydraulic Pump, 32 oz |
| #171-96-2 | Hydraulic Oil, for Hydraulic Pump, gallon |
| | **Cell Assembly, No 171-85:** |
| #170-19 | Filter Paper, 2 1/2", 100/pkg |
| #170-53 | Ceramic Filter Disk, 10 darcy/35 micron (10 each) |
| #NS | Cell Cap, Threaded, Scribed, for Ceramic Disk (Outlet) |
| #170-72 | Spacer, 1/4" stainless steel, for Filter Paper usage |
| #NS | Cell Cap, Scribed, “thicker”, for Filter Paper usage |
| #NS | Cell Body, threaded, 500 ml, 4000 psi, Double Capped |
| #NS | Cell Cap, threaded, with Screen, 4000 psi (Inlet) |
| #171-93 | Piston, for Cell |
| #171-95 | T-Handle, for Piston |
| | **O-Rings:** |
| #170-13 | O-Ring for Cell |
| #170-17 | O-Ring for Valve Stem, Viton® |
| #170-77 | O-Ring, for stainless steel Spacer |
| #171-99 | O-Ring for Piston |
| | **Valves:** |
| #170-32 | Valve, Needle, 1/8" NPT, for Receiver Outlet |
| #171-90-08 | Valve Stem PPT, Cell Hydraulics Entry |
| #171-90-09 | Valve Stem PPT, Cell Filtrate Outlet |
| #171-90-10 | Valve Stem PPT, Receiver Entry |
| #NS | Relief Valve, Safety, 4000 psi, Inlet Manifold |
| #171-97 | Valve, 1/8", for Cell Outlet |
| #171-98 | Valve, Ball, for Inlet Pressure Line |

# Before starting a test, close all valves — ensure that all regulators are rotated fully counter clockwise.

## Preheating the Heating Jacket and Ceramic Disk Preparation

1. Connect the heating well to 110 or 220 volts AC as specified on the nameplate. Power requirement is 800 watts. Turn the thermostat to about mid-scale to begin heating and place a metal dial thermometer in the thermometer well.

2. The pilot light will turn on when the heating well is at the temperature at which the thermostat is set. The temperature should read 10° (6° C) above the desired test temperature. If the temperature obtained with the initial thermostat setting is not the desired test temperature, re-adjust the thermostat until the setting will maintain the desired test temperature.

3. Check the hydraulic pump and ensure it has plenty of hydraulic oil.

4. Prior to use, the ceramic disk should be soaked for at least 10 minutes in freshwater based fluids, brine for saltwater based fluids, diesel for oil based fluids and a synthetic base for synthetic based fluids. Disks should never be reused except for return permeability studies. Below is a listing of ceramic disks stocked.

| | |
|---|---|
| #170-55 | Ceramic Filter Disk, 400 milli-darcy, 3 micron, 2 1/2" x 1/4" |
| #170-53-2 | Ceramic Filter Disk, 750 milli-darcy, 5 micron, 2 1/2" x 1/4" |
| #170-53-3 | Ceramic Filter Disk, 2 darcy, 10 micron, 2 1/2" x 1/4" |
| #170-51 | Ceramic Filter Disk, 5 darcy, 20 micron, 2 1/2" x 1/4" |
| #170-53 | Ceramic Filter Disk, 10 darcy, 35 micron, 2 1/2" x 1/4" |
| #170-53-1 | Ceramic Filter Disk, 20 darcy, 60 micron, 2 1/2" x 1/4" |
| #170-53-4 | Ceramic Filter Disk, 100 darcy, 90 micron, 2 1/2" x 1/4" |

## Loading the Filtration Cell

1. Open the cell and check all o-rings, replacing any that appear worn or damaged. New o-rings are normally required after each test above 300° F (149°C). Apply a thin coating of silicone grease around the o-rings used on the piston, valve stems and cell caps. Also apply a thin coating of Never-Seez™ (a trademark of Bostik) Stopcock Grease to the threads on the cell caps.

2. Position the cell upright with the inlet or shallow recess facing upwards. Check the o-ring recess to make sure it is clean, and carefully insert an o-ring (No 170-13) inside the cell recess and cell caps. Obtain the inlet cell cap that has “IN” scribed on the outside, and using the Yoke, carefully screw the cell cap into the cell body.

3. Push in the red knob located just below the thermostat control on the heating jacket. This moves the stop plunger into position to support the cell while it is being filled with fluid and facilitates installing the outlet cell cap. Invert the cell and place it inside the heating jacket with the inlet cap facing downward and then begin preheating the cell.

4. Screw the T-handle into the piston and place inside the cell, working it up and down to ensure free movement. Position the piston with the T-handle so that it is a couple of inches from the inlet end of the cell.

5. Install and tighten the inlet valve stem/hydraulic quick connect fitting. Turn the inlet valve stem clockwise ½ (180°) of a complete turn. Connect the hydraulic pump pressurizing hose with the ¾" (2.0 cm) ball valve and quick-connect fitting to the inlet valve stem assembly. Open the ¼" (3/4 cm) and turn the pressure release knob on the hydraulic pump clockwise to close the pressure release valve. Stroke the hydraulic pump 30 to 40 times to add approximately 1 ½" (3.81 cm) of hydraulic fluid volume into the cell inlet. This is best determined by observing the T-bar wrench handle and noting when it has moved upward 1 ½" (3.81 cm). Close the ¼" (0.64 cm) ball valve on the inlet valve assembly and remove the T-handle from the piston and cell.

6. Add approximately 320 mls of fluid to the cell, being careful not to pour any fluid on the o-ring recess. The fluid to be tested should be mixed for approximately 10 minutes prior to testing. The fluid level inside the cell should be flush with the bottom of the cell o-ring recess. Install the rubber o-ring (Part No. 170-13) in the cell recess and place the prepared ceramic disk of the desired permeability on top of the o-ring.

7. Install the end cap with the scribed flow lines in the surface on the outlet end. Coating the o-ring with a thin coat of high temperature silicone grease will help. Be sure the cap is screwed all the way into the cell body.

8. Using a 3 ml syringe with needle, fill the outlet valve with base fluid (water or oil) which will enhance accuracy of the test. The total dead space volume from the filter media to the backpressure receiver should be filled with the base fluid prior to the test. This will insure that the initial volume of filtrate passing through the filtering media will displace an equal volume of filtrate at the receiver end. In some configurations the dead space can exceed 1 -2 mls, so erroneous filtrate volumes will result if this dead space is not filled.

9. Install and tighten the stem outlet valve assembly (closed position) with the 1/8" (0.32 cm) ball valve into the outlet cell cap on top of the cell. Hold the outlet valve assembly with one hand and pull the stop on the heating jacket out of the way to lower the cell fully inside the heating jacket. Rotate the cell until it locks in place over the alignment pin in the bottom of the heating jacket.

10. Tighten the outlet valve stem clockwise in the outlet cap until it stops (closed position) and then turn the stem ½ (180°) of a complete turn counter-clockwise (open position). Turn the lever of the 1/8" (0.32 cm) ball valve to the 90° or closed position. Place a metal dial thermometer (Part No. 154-20) in the top of the cell in the small hole. Place the back pressure receiver onto the top of the valve assembly while being careful to not rotate the valve assembly. Lock the receiver in place by installing the retainer pin, being sure that the pin is ALL the way in. The 1/8 inch (0.32 cm) outlet drain valve on the receiver should be in the closed position.

11. Install the $CO_2$ pressure assembly onto the valve stem connected to the top of the back pressure receiver and ensure the retainer pin is ALL the way in. Turn the T-handle on the air regulator counter-clockwise until approximately 6 threads are exposed. Puncture the $CO_2$ bulb and apply the appropriate amount of back pressure to the receiver for the desired test temperature. Refer to the following table for the recommended minimum back pressure to be applied.

**Recommended Minimum Back Pressure**

| ***Test Temperature*** | | ***Vapor Pressure*** | | ***Minimum Back Pressure*** | |
|---|---|---|---|---|---|
| **°F** | **°C** | **psi** | **kPa** | **psi** | **kPa** |
| 212 | 100 | 14.7 | 101 | 100 | 690 |
| 250 | 121 | 30 | 207 | 100 | 690 |
| 300 | 149 | 67 | 462 | 100 | 690 |
| 350 | 177 | 135 | 932 | 160 | 1104 |
| 400 | 204 | 247 | 1704 | 275 | 1898 |
| 450 | 232 | 422 | 2912 | 450 | 3105 |
| 500 | 260 | 680 | 4692 | 700 | 4830 |

12. Open the inlet ball valve 1/4 turn (0.64 cm) on the hydraulic manifold and apply the same amount of pressure to the fluid inside the cell. *Caution: When the closed cell is heating in the jacket the pressure in the cell will rise rapidly due to the thermal expansion of the sample and the hydraulic fluid. The pump is used to allow release of hydraulic oil to prevent over-pressurization.* Maintain the pressure on the fluid until the desired temperature is stabilized, as indicated by the thermometer. Use the hydraulic pumps pressure release valve to regulate and maintain the pressure. The heating time of the sample should never exceed one hour.

***NOTE: When working with heated pressurized vessels, always wear protective safety glasses.***

**If excessive pressure is used, there are four main areas of stress on the cell:**

*1.* End cap bending – may be observed either by eye or by measurement.
***2.*** End cap compression – may be observed by deformed or bent threads.
***3.*** Cylinder shear – Elevated areas along the ends of the cell bodies.
***4.*** Cylinder stress - Cell bodies that indicate signs of stress cracking or severe pitting.

## Test Procedure

1. Once the required cell temperature is reached, close the valve on the hydraulic pump, and open the 1/8" (0.32 cm) ball valve on the outlet side of the cell. Operate the pump to increase the pressure in the cell to the desired test pressure to initiate filtration. Using the pump, maintain the desired differential pressure in the cell. **The differential pressure is the cell pressure less the amount of back pressure.**

***DO NOT EXCEED 4000 PSI AS THE PRIMARY OR INLET PRESSURE***

2. Set the timer for the desired test times. Filtrate should be collected at 7.5 and 30 minute intervals at the minimum. Samples at other intervals may be taken. Collect and record the total amount of filtrate and/or mud for 30 minutes maintaining the selected differential pressure and test temperature within ±5°F (±3°C). Fluid loss is calculated as the spurt loss plus 2 times the corresponding fluid recovered during the 30 minute test. The spurt loss is the amount of mud or filtrate recovered from the back pressure receiver immediately after the differential pressure is applied, until the immediate flow of fluid through the filter stops and the receiver blows dry. Collect the liquid until the receiver blows dry, and record the initial amount collected as the spurt loss. This spurt loss value may be useful in some applications and should always be recorded in the mud report.

3. During filtration collection, the pressure on the cell will tend to decrease, so it will be necessary to apply additional hydraulic pressure to maintain a constant pressure. If the back pressure rises during the test, cautiously reduce the pressure by opening the drain valve on the receiver and drawing off some of the filtrate into the graduated cylinder. The filtrate will be at or near the test temperature and slowly opening the drain valve will minimize any spattering of the fluid and any potential contact with hands and fingers. Bleed only the amount of filtrate and/or mud required to reduce the back pressure to its initial setting.

4. After the 30 minute time period, close the outlet valve stem by tuning it ½ of a complete turn clockwise, or until it is tight. Open the receiver drain valve and allow it to blow dry to remove any filtrate and/or mud from the receiver. Record the total amount of liquid recovered, INCLUDING the spurt loss.

5. Release the pressure on the hydraulic pump by opening or turning the release valve on the pump counter-clockwise at least four complete turns until the pressure gauge on the hydraulic pump manifold reads 0 psi.

6. Close the ¼" (0.64 cm) inlet and 1/9" (0.32 cm) outlet ball valves and remove the hydraulic quick-connect from the pump to the cell. Bleed off the back pressure and remove the back pressure assembly from the valve stem. Allow the cell to cool or remove it from the heating jacket and cool it off with cold water. ***The temperature of the sample in the cell must be reduced to less than 100°F (46.5°C) before the cell can be safely opened***. Hold the cell so the inlet valve is **not** pointing to yourself or others and slowly open the outlet valve stem by turning it 1 complete turn counter-clockwise. Slowly open the 1/8" (0.32 cm) outlet ball valve to release pressure on the cell. Note that the filter cake may block the release of pressure on the outlet side.

7. Turn the cell upside down or lay it on its side, and using the spanner wrench, remove the outlet cell cap with the outlet end down. If the cap is difficult to unscrew, the may be pressure trapped inside the cell or the valve stem may be plugged. Try slowly turning the outlet valve stem ½ more times counter-clockwise and notice if any fluid spurts out. If it does, work the outlet valve stem back and forth to release any trapped pressure. It may be necessary to completely remove the obstruction with a small drill bit, wire or straightened paper clip, etc. into the valve stem. Make sure the opening is pointed away from the operator and others when inserting the wire. Once pressure has been removed, remove the outlet valve stem and inspect to make sure it is not plugged by blowing air into the valve.

8. Recover the ceramic disk and very lightly wash the filter cake with the type of base fluid used in the mud (fresh water, brine, diesel, synthetic, etc.) Measure the filter cake to the nearest 1/32 inch (0.8 mm). If the ceramic disk does not readily come out of the cell with the flow of fluid, lay the cell on its side and over a sink. Install the hydraulic connector onto the inlet valve stem and open the stem by turning it 2 turns counter-clockwise. Open the ¼" (0.64 cm) ball valve and close the pressure relief valve on the hydraulic pump. Stroke the pump handle 4 to 7 times until the piston pushes the fluid from the cell along with the ceramic disk. Do not try to pry or shake the ceramic disk from the cell as it may cause the disk to break.

9. To recover the hydraulic fluid. screw the T-bar wrench into the piston inside the cell. Open the inlet valve stem and the pressure release valve on the hydraulic pump 4 complete turns. Manually push the piston to the bottom of the cell. Close the pressure release valve on the hydraulic pump and close the ¼" ball valve. Remove the hydraulic pump manifold from the inlet valve stem and remove the piston from the cell using the T-handle.

10. Completely disassemble the cell and clean and dry the entire apparatus. Inspect and replace if necessary all o-rings.

    NOTE:
    If brine fluids are used, it is recommended to clean out the outlet valve stem assembly with freshwater and blow them dry with air before re-using.

## Data Reporting:

1. The filtrate volume collected should be corrected to a filter area of 7.1 $in^2$ (4580 $mm^2$) so the amount collected will have to be doubled.

2. The spurt loss is defined as the amount of mud and/or filtrate recovered from the collector immediately after the differential pressure is applied until the flow of fluid through the permeable disc stops and gas from the receiver blows out freely. The presence of whole mud in the spurt indicates that there was not an immediate seal of the mud when it passed through the filter. In most cases, the goal is to eliminate or minimize the amount of whole mud in the spurt and in the 30 minute test.

3. Measure the filter cake thickness to the nearest 1/32 inch (0.8 mm). Although cake descriptions are subjective, such notations such as hard, soft, tough, rubbery, firm, etc. may convey important information of cake quality.

## *Calculations:*

The total PPT fluid loss is calculated as follows:

$$\textbf{\textit{P.P.T. Value, ml = 2 x (*ml fluid recovered in 30 minutes)}}$$

***** *This includes the spurt loss amount.*

$$\textbf{\textit{Constant filtration rate}} = \frac{\textbf{\textit{30 min. filtrate, ml - 7.5 min. filtrate, ml}}}{\textbf{\textit{2.739}}}$$

## Remarks:

> Caution: **HPHT Filter Press cells that utilize set screws to fasten the cell cap should <u>NEVER</u> be pressurized above 2000 psi, even temporarily, and this applies to cells of all manufacturers. There are many older cells in use that are stamped "2500", but these also are not safe at pressures exceeding 2000 psi. Also note that unheated pressurized cells will experience drastic pressure increases as temperature is increased within the confined cell.**

1. For safe operation of the Hydraulic Pump Pressurization system, make sure the pressure has been released and the gauge on the pump reads zero before:
   A. Attempting to disconnect the pressure hose from the cell at the quick coupler.
   B. Attempting to remove the cell from the heating jacket.
   C. Reallocating or moving the P.P.T. in the laboratory.
   D. Refilling the hydraulic pump
   E. Performing any maintenance including tightening leaking fittings on the pump, hydraulic fittings or cell assembly.

2. When refilling or repairing the hydraulic system make sure any spilled oil is cleaned. Oil on the floor is very slippery and can cause falls and injury. Oil spills on the bench can accumulate and become a fire hazard.

3. Always use either Nitrogen or Carbon Dioxide to pressurize the back pressure receiver. Never connect it to compressed air, Oxygen or other non-recommended gas. If Nitrogen is used it must be supplied in an approved nitrogen gas cylinder and it must be secured to meet safety standards. $CO_2$ is normally supplied in small bulbs, which contain about 900 psi, and are normally used for field operations. Do not allow these bulbs to be heated or exposed to fire as they can explode if overheated.

4. When pressurizing the back pressure receiver always open the supply pressure first, and then adjust the regulator. When de-pressurizing, shut off the supply pressure first, then bleed the system of pressure and then back out the regulator T-screw.

5. The practice of removing the cell and cooling it under water is a very dangerous procedure and extreme care should be used to avoid severe burns if touched or accidentally dropped. Steam generated when the hot cell contacts water can also cause severe burns.

6. Make sure the electrical source is fused and grounded. Verify the power cord on the heating jacket is in good condition and has the proper ground connection.

7. Electrical problems in the wiring or the heaters may not be obvious by looking at the equipment. A malfunction is suspected if the unit starts blowing fuses or tripping breakers, the heating time seems too long or the thermostat control does not repeat. These are indications an electrical repair job may be required. Always disconnect the power cables before attempting any repair.

8. The filtration cell assembly is a pressure vessel and these safety precautions should be followed:
   A. Cell bodies that show signs of stress cracking, severe pitting or have damaged threads must not be used.
   B. Cell caps showing evidence of damaged or deformed threads must not be used.

**It is strongly recommended the instruction manual be attached to the apparatus and read completely prior to the initial operation by anyone unfamiliar with the equipment**

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