

# PetroQuip Engineering Design Specification Document

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**Tool Name:** 7” HPHT Locking Bridge Plug (LBP) and Landing Profile (LP)

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**Document Version:** 2

-Modified the casing weight from 32# to 38#

## **Application:**

Develop a Locking Bridge Plug (LBP) that isolates different internal sections (stages) of the casing by locating and sealing in a Landing Profile (LP) installed on and run with the casing. The LP can also be run as part of a full completion system with additional tools as needed (e.g. liner hanger, flow initiation toe sub). The system will be utilized in both the Cased and the Open-Hole applications.

## **Operations:**

### **Desired Method of Setting the LBP**

The LP should be threaded in the casing string. The LP will be positioned within the casing string and provide a location to land the LBP inside the well. The LP and the LBP should both be designed to work in cemented and un-cemented applications. Proposed running procedure below:

1. The LBP is Run In Hole (RIH) on pipe (threaded or coiled) with a Running Tool (RT). This can be referred to as a Bottom Hole Assembly (BHA).
2. Once the BHA is above the LP, 1000 psi is applied internally to the pipe, exposing No-Go Dogs on the RT.
3. The BHA is RIH until the No-Go Dogs stop against the shoulder inside the LP.
4. Increase internal pressure on then pipe to 3,000 psi, setting the LBP in the LP.
5. The BHA is then lifted to shear the RT from the LBP. This shear confirms that the LBP is set and the BHA is Pulled Out Of Hole (POOH).

### **Desired Method of Removing the LBP**

The LBP should be designed to be removed by a modified GS Pulling Tool (GS) on pipe or milled up with a mill or bit on pipe. Proposed Procedure Below:

#### **GS and Pipe**

1. RIH with a GS and pipe.
2. Set down against the fishing neck of the LBP, engaging the GS into the LBP.
3. Pull the BHA up hole. This should unlock and release the LBP.
4. POOH BHA.

#### **Mill and Pipe**

1. RIH with a 5-3/4” Mill or Roller Cone bit.
2. Set down against the LBP, then pick up 5 ft. Increase circulation
3. Start the rotation on the Mill or Bit
4. Set back down on the LBP with 6000 lbs of force
5. Mill up the LBP and circulate the pieces to the surface

**Specs: Landing Profile (LP)**

<b>CASING</b>	
Casing Size (in)	7
Casing Weight (lbs / ft)	38
Casing Drift (in)	5.795
<b>LANDING PROFILE (LP)</b>	
OD (in)	7.656
ID Seal Bore (in)	5.625
OAL (in)	<60
Pressure Rating Burst (psi)	10,000
Pressure Rating Collapse (psi)	10,000
Temperature Rating (°F)	450
Thread	TBD
Material	P-110
Coating	thermochemical quench-polish-quench (QPQ), nitriding process

**Specs: Locking Bridge Plug (LBP)**

<b>CASING</b>	
Casing Size (in)	7
Min Casing Weight (lbs / ft)	38
Casing Drift (in)	5.795
<b>LOCKING BRIDGE PLUG (LBP)</b>	
OD (in)	5.550 ?
ID (in)	>2.500
Temperature Rating	450°F
OAL (in)	>30
Tubing Pressure to set (psi)	<3000
Pressure Rating (psi) from above	7,500 min
Pressure Rating (psi) from below	0, checks from above
Material	Millable
ID isolation of the LBP	Flapper or ball
Thread	na
Rotationally locked	Yes
Selective Style Location	Expandable No-Go with 1000 psi pressure applied
Installation Method	Running Tool - <3000 psi applied
Shear Release once set	Doesn't release until LBP is fully set, then straight pull to overcome shear

## **Landing Profile (LP) Testing (component only):**

### **Pressure Test**

This test confirms the design specs of the LP for burst and collapse pressure ratings. The specs give it a pressure rating equal to 7" 32# casing. API typically applies a 20% safety factor to all ratings. The LP should be designed to be more burst and collapse resistant than the casing.

### **Burst Pressure Test**

1. Thread two bull plugs to each end of the LP.
2. Place the assembly (LP and Bull Plugs) in the test cell and fill with water through the control line to the data acquisition panel. Ensure all air pockets are removed.
3. Place an inductive heater on the OD of the fixture.
4. Apply 10,000 psi to the ID of the fixture for 5 minutes to ensure there are no leaks in the fittings of the control lines or threads before applying temperature. After 5 minutes, reduce the pressure to 1000 psi.
5. Turn on the inductive heater to 450°F to heat the fixture and water to the working temperature of the LP.
6. Maintain 1000 to 2000 psi while heating. Once the temperature has stabilized at 450°F the pressure will be increased to 10,000 psi for 30 minutes. A leak rate equal to or better than API 14L (1% loss over 15 minutes) is acceptable after stabilization.
7. Turn the heater off and reduce the pressure to 3000 psi. Once it is cooled reduce the pressure to 0 psi, remove the heating coils, then remove the LP from the Test Cell.
8. Perform a 100% inspection of the LP to ensure that no damage occurred during the pressure test.

### **Collapse Pressure Test**

1. Thread a bull plug to each end of the LP, and attach a control line to one bull plug providing access to the ID of the LP. Fill plugged LP with water, removing all air pockets.
2. Place the plugged LP assembly into a chamber with a burst rating of at least 12,000 psi. Place another control line to the chamber itself.
3. Secure test assembly into a Test Cell, and fill chamber with water, removing all air pockets.
4. Apply 500 psi to the ID of the LP and 10,500 psi to the ID of the chamber. This pressure is held for 5 minutes to ensure that there are no leaks.
5. After the ambient pressure test, reduce the pressure in the chamber to 3000 psi and leave the pressure on the ID of the LP at 500 psi.
6. Wrap the OD of the chamber with the inductive heater coils and increase the temp to 450°F. Bleed pressure off as the heat increases in both volumes, keeping the Chamber between 3000 and 5000 psi, and the LP between 500 and 1,500 psi.
7. Once temperature has stabilized at 450°F, apply 500 psi on the ID of the LP and 10,500 psi on the ID of the chamber for 30 minutes. A leak rate equal to or better than API 14L (1% loss over 15 minutes) is acceptable after stabilization.
7. **NOTE:** A leak is defined as an increase in the ID of the LP and a decrease in the ID of the Chamber.
8. Turn the heater off and reduce the pressure to 3,000 psi on the ID of the Chamber and leave the LP ID pressure at 500 psi. Once cooled, reduce both internal and external pressures to 0 psi, remove the heating coils, and remove the LP from the Test Cell.
9. Perform a 100% inspection of the LP to ensure that no damage occurred during the pressure test.

## Locking Bridge Plug (LBP) Testing:

### Function Test (ambient):

1. Place the tested Landing Profile (LP) in a vise.
2. Take the assembled LBP and Running Tool (RT), attach the RT to the LBP, (now referred to as a BHA). Attach BHA to hydraulic ram, and use ram to pass BHA through the LP from the top side of the LP to the bottom side of the LP.
3. Pull the Assembly back through the LP bottom to top, ensuring No-Go Dogs are at least six inches above No-Go Shoulder of LP.  
**NOTE:** The only engagement between the BHA and the LP is the seal stack sliding thru the polished bore of the LP.
4. Apply 1000 psi to the BHA, extending the No-Go Dogs. Push the BHA into the LP. The No-Go Dogs on the BHA will stop it from going any further into the LP. Apply 10,000 to 15,000 lbf against the No-Go Shoulder via hydraulic ram.
5. Apply 3000 psi down tubing to the BHA and set the lock in the LP.
6. Reduce setting pressure to 0 psi.
7. Utilizing the hydraulic ram, shear release the RT from the LBP to complete the setting sequence, and record the load required.
8. Remove RT from hydraulic ram, and attach GS Pulling Tool.
9. Remove the LBP with the GS. Record the force to retrieve the LBP from the LP.
10. Perform a 100% inspection to ensure no damage occurred during the test to the LBP, RT, or GS.

### Operation Test (temperature and pressure)

1. Set the LBP using the same procedure described above (Steps 1-7). The LP with installed LBP will be referred to as the Test Assembly.
2. Install Bull Plugs to each end of the Test Assembly.
3. Fill the Test Assembly with water by pumping from the bottom (the LBP flapper or ball will open automatically, allowing fluid to flow above the LBP).
4. Place the Test Assembly inside in the test cell and wrap it with the heating coils.
5. Place control lines to each bull plug, and attach lines to the data acquisition.
6. Apply 8,000 psi above the LBP, and 500 psi below the LBP. Wait for the pressure to stabilize. Hold differential for 30 minutes. Any pressure loss on the 8,000 psi and increase on the 500 psi will indicate a leak. A leak rate equal to or better than API 14L (1% loss over 15 minutes) is acceptable after stabilization.
7. Reduce pressure above and below the LBP to 1,000 psi.
8. Heat the test fixture to 450°F while maintaining a pressure of 1000 – 2000 psi to each side of the LBP.
9. Once the temperature is stabilized at 450°F, apply 8,000 psi above the LBP, and 500 psi below the LBP. Wait for the pressure and temperature to stabilize. Hold for 30 minutes. Any pressure loss on the 6,500 psi and increase on the 500 psi will indicate a leak. A leak rate of under 1% (60psi per API 14L) is acceptable over 15 minutes.
10. Reduce pressure above LBP to 3000 psi, and pressure below LBP to 500 psi. Remove heat and allow Test Assembly to cool. Once cooled, reduce all pressures to 0 psi and remove bull plugs from LP.
11. Retrieve the LBP with the GS. Record the force to pull the LBP from the LP.
12. Perform a 100% Inspection to ensure no damage occurred during the test to either the LBP, LP, or GS.

## **Locking Bridge Plug (LBP) Testing (Cont'd):**

### **Contingency Retrieval Test**

1. Repeat Operation Test (Steps 1-10).
2. Place the Test Assembly on a lathe with a Mill.
3. Document the time it takes to mill the LBP with a 5.75" bit.
4. Collect the debris and document the size particles.

### **Debris Test (ambient)**

1. Repeat Function Test (Steps 1-7) of the function test, except for adding 100 mesh sand to the water at a consistency of 3 lbs/gallon that is used to fill the assembly.
2. Remove the LBP with the Internal Spear Retrieving Tool. Record the force to pull the LBP from the LP.
3. Perform a 100% Inspection to ensure no damage was done during the test to either the LBP or the LP.