



High Pressure Gas Lift Equipment Design and Validation Testing

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High Pressure Gas Lift Equipment Design and Validation Testing

Challenges and requirements

Summary of well conditions

- 30,000 psi reservoir pressure @ ~ 30,000' MD
- 300 F+ reservoir temperature
- 4,000' water depth
- Gas Lift injection point ~18,000'
- Gas Injection Pressure 10,000 psi
- Gas Injection Rate 12.5 Mmscf/d
- Single injection point / 8 wells, Well Completions starting 2018

Gas Lift Equipment required for this project:

- 5.5" Dual Barrier Side Pocket Mandrel – Tested per API 19 G1 & client Validation Requirement
- 1.5" Barrier Gas Lift Valves
- 1.5" Shear Valve
- Kick Over Tools
- Specialised HPHT Latches
- Running tools
- Pulling tools



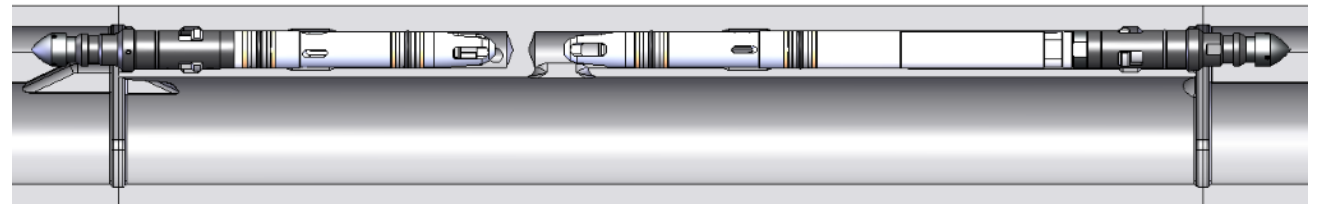
High Pressure Side Pocket Mandrel

5.5" Dual barrier SPM

- Two retrievable valves in series
- Requires two different Kick Over Tools for intervention
- Manufactured in Incoloy 945

Validation:

- Working pressure of 17,000psi
- Extensive strain gauge testing for FEA validation and CFD work
- Full API 19G1 KOT performed @ 45 degrees on wireline
- Additional KOT on E-Line and stroker validation testing in the workshop and in a downhole test well.



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SafeLift-XT & ShearLift-XT-A Barrier valves

1.5" Barrier Isolation valve and Shear Orifice valve

- Validated to Client Validation Requirement which exceeds current most extreme industry standards
- Manufactured in Incoloy 945

Validation

- 17,000 psi Working Pressure
- Injection rate of 12.5mmscf/d
- Comprehensive nonmetallic seal testing
- High pressure annulus shear 5,700psi
- Shear device pressure cycle testing
- CFD and valve flow performance testing



Client validation test – Gas Lift Valves

0	3 Valves must past the test with no interface between steps.
1	Mechanical function tests; Spring-activated darts/closure mechanism testing & Pressure differential opening test
2	Backflow integrity test with water at ambient temperature; Low/High pressure water test @ ambient temperature
3	Backflow integrity test with water at elevated temperature Low/High pressure water test @ 300°F
4	Backflow integrity test with gas at ambient temperature; Low/High pressure gas test @ ambient
5	Backflow integrity test with gas at elevated temperature Low/High pressure gas test @ 300°F
6	Erosion testing 2000 bbl @1.5 bbl/min
7	Repeat Step 1-5
8	Backflow Integrity Test with Gas; 10,000psi test @ ambient temperature.
9	Step Test; 85 flow rate steps from 0.177mmscfd to 12.5mmscfd in increasing steps of 0.177mmscfd. Hold 5 minutes at each step. (Approx. 14.2 hours of flow)
10	Cycle Test; 100 flow cycles, 1 minute at max flow, slowly reduce flow to zero. requires 15 minutes to reduce flow from max to zero. (Approx. 25 hours of flow)
11	Long Duration Flow Test; 24 hours at maximum flow of 12.5mmscfd
12	Backflow Integrity Test with Gas; 10,000psi test @ ambient temperature.
13	Enforced Chatter Test: Flow at highest rate in which chattering observed for 4 hours. 4-hour test time.
14	Backflow Integrity Test with Gas; 10,000psi test @ ambient temperature.
15	Repeat Step 1-5
Hydro	Any detectable leaks will be considered failure of the test.
Gas	For the low and high pressure tests, no more than 20 cm³ (0.1 SCFD) leakage over the 10-minute hold period after stabilization. In addition, any leakage rate (bubble rate) shall be measured and shall not increase during the 10-minute hold period.

Kick Over Tools and accessories

Two KOTs required

- Specific KOT for each valve pocket
- Designed for high intervention success
- Both are API19 G3 monogrammed
- Optimised for use together with stoker in very deep wells
- Detailed operating procedure for each

KOT accessories:

- High Pressure RM Latch (20,000psi)
- Double Jar Down pulling tool
- Running tool
- All accessories are API 19G3 monogrammed



Full System Downhole Validation

Objective

- To verify successful setting and pulling of valves to and from the Dual Barrier SPMs using both KOT types and 3rd party e-line and stroker tool.
- 26 intervention runs were successfully carried out to validate each combination of equipment



Conclusion

6 years of design, testing and validation produced the Highest Pressure Rated Gas Lift System in the world, meeting the customer requirements:

- 5.5” Dual Barrier Side Pocket Mandrel
- 1.5” Barrier Gas Lift Valves
- 1.5” Shear Valve
- Kick Over Tools
- Specialized HP Latches
- Running tools
- Pulling tools



- The first system was successfully installed and operating since Q3 2018.
- Further 5 systems have been successfully installed and continue to operate.
- This initial project has enabled PTC to design and supply more robust products across our gas lift equipment portfolio to better serve the gas lift equipment market