Rigless Retrofit Thru-Tubing Jet Pump Straddle System Installation increases production by ~250 % in a mature well in the UK North Sea

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PRESENTATION AGENDA

1 INTRODUCTION

2 BACKGROUND

3 PROPOSED SOLUTION

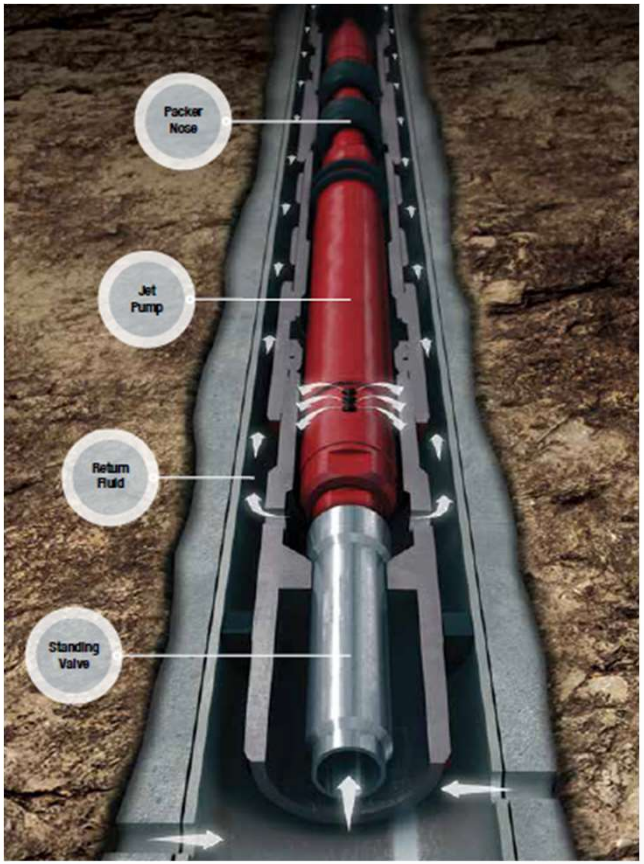
4 SYSTEM COMPONENTS

5 EQUIPMENT RIG UP

6 JET PUMP STRADDLE INSTALLATION PROCEDURE

7 HIGHLIGHTS & CONCLUSION

8 QUESTIONS



ICoTA Intervention & Coiled Tubing Association

SPE International Aberdeen Section

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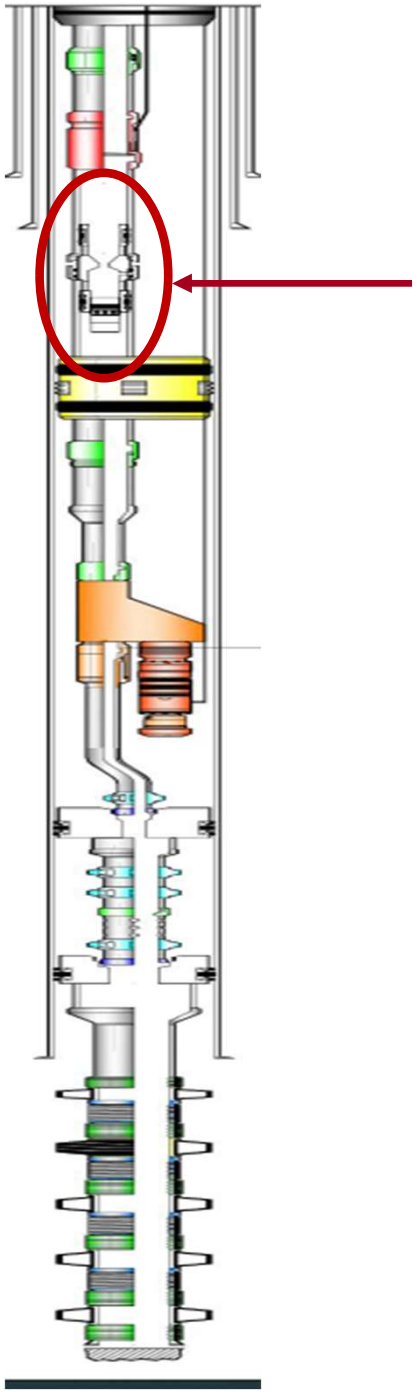
BACKGROUND



An oil producing well on a mature asset operated by a leading energy company in the North Sea had seen steady production decline over several years.

Several artificial lift technologies were evaluated to determine the best fit for this well, given the operating parameters and available lift systems.

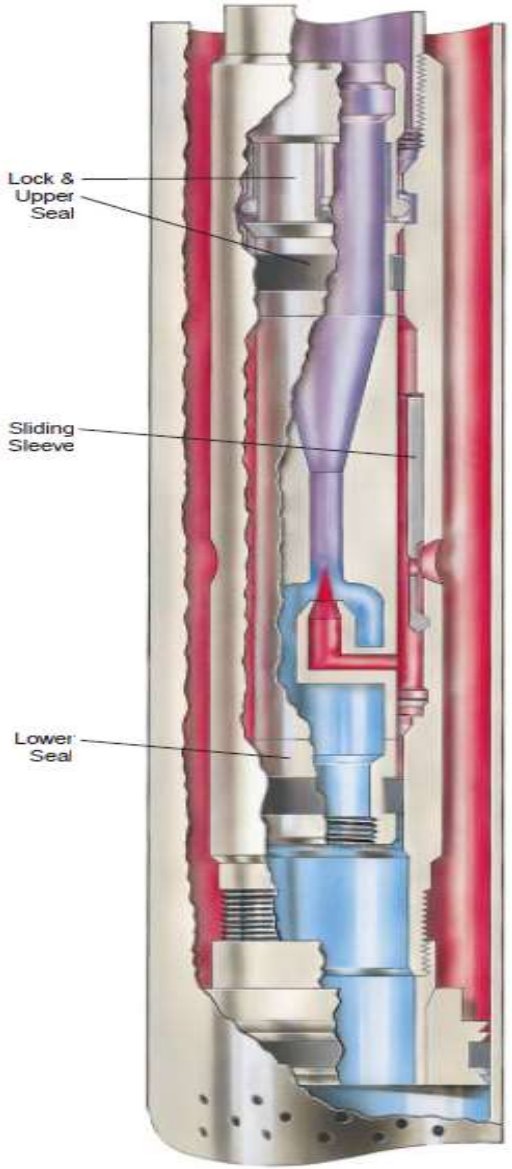
JEMS software modelling predicted that with the installation of a Thru-Tubing Retrofit Jet Pump System, production could be increased by approximately 250%,

Surface Systems were already in place on this platform to supply High Pressure Power Fluid to the “A” annulus to deliver power to the Retrofit Jet Pump System.

The Jet Pump Straddle assembly was set across an SSD which had been previously opened to deliver power fluid via the “A” annulus to drive the Jet Pump and produce the well using the existing completion.

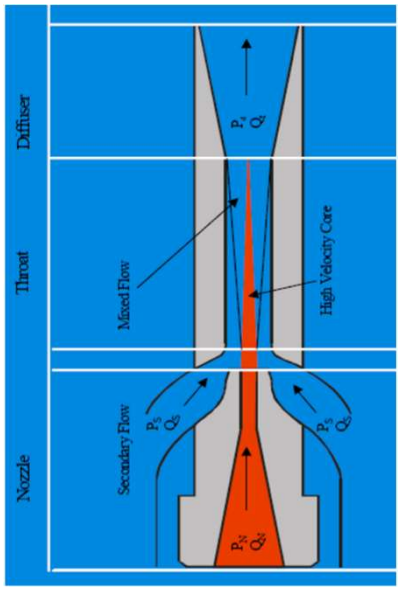
For additional well control purposes, the Jet Pump assembly also incorporated an inline Downhole Safety Valve between the Jet Pump and the lower WidePak Packer.

JET PUMP PRINCIPLE



SLIDING SLEEVE

- In a jet-pump lifting system, the pump is run downhole with no need for a rig, in this case, all components were installed using Slickline.
- At surface, the power-fluid is injected into the ”A” annulus and enters the production tubing through an open SSD in the completion string, in this example, power fluid was already available on the platform.
- The fluid travels through the jet pump to the nozzle, which reduces the fluid pressure using the Venturi effect, this draws reservoir fluid into the pump throat, where the fluids combine.
- The mixture then transfers to the pump diffuser, where pressure is increased pump diffuser, where pressure is increased to raise the fluids to the surface.



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JET PUMP MODELLING EXAMPLE

Jet Pump Evaluation and Modelling Software (JEMS™)

JEMS software can customize your jet pumps to optimize performance and maximize your returns for specific applications.

Weatherford engineers can simulate anticipated downhole conditions and performance ranges for every possible scenario.

The software also determines the precise nozzle and throat sizes to deliver the most efficient, cost-effective jet-lift system for your well

Case 1				
Surface Power Fluid Injection Pressure	1700	psig		Run ID: 090237-11
Surface Power Fluid Injection Rate Available	2000	bbl/d		Oilmaster 11B Jet Pump Performance Summary
				Injection Pressure = 1700. psig
N/T Combo:	11B			Production Rate = 1536. STB/d
				Injection Rate = 1674. bpd
				Horsepower to Jet Pump = 56. hp
				Pump Intake Pressure = 1912. psig
				Discharge Pressure = 2594. psig
				Cavitation Rate = 2774. STB/d
Case 2				
Surface Power Fluid Injection Pressure	1700	psig		Run ID: 090759-12
Surface Power Fluid Injection Rate Available	3000	bbl/d		Oilmaster 13B Jet Pump Performance Summary
				Injection Pressure = 1700. psig
N/T Combo:	13B			Production Rate = 1825. STB/d
				Injection Rate = 2790. bpd
				Horsepower to Jet Pump = 93. hp
				Pump Intake Pressure = 1768. psig
				Discharge Pressure = 2613. psig
				Cavitation Rate = 4324. STB/d

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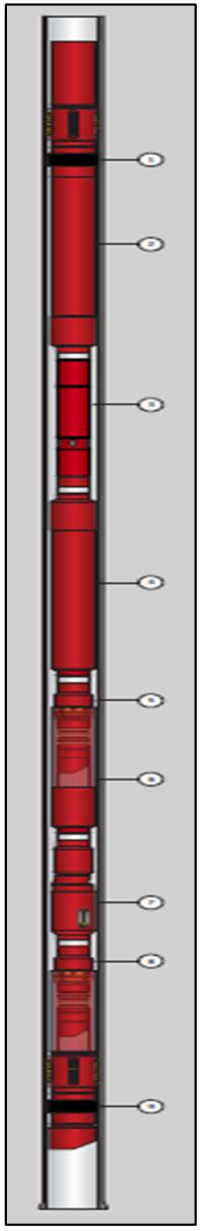
PROPOSED JET PUMP STRADDLE ASSEMBLY



By combining existing Weatherford Jet Pump, Retrievable WidePak™ Packer technology and with collaboration with DTI Products for an inline Downhole Safety Valve, a complete solution was designed for this application.

The installation of the Jet Pump assembly was carried out Rigless with use of Slickline as the conveyance to deploy the system into the well keeping cost and carbon footprint to a minimum during the installation.

Item	Description
1	Upper WidePak™ Packer
2	Extension
3	Weatherford OilMaster® Jet Pump
4	Extension
5	SO Tie- Back Seal Assembly
6	Extension
7	DTI – Slimline ESP Safety Valve
8	Extension
9	WidePak™ - Anchor Seal
10	Lower WidePak™ Packer
11	Wireline Entry Guide

Equipment Specification

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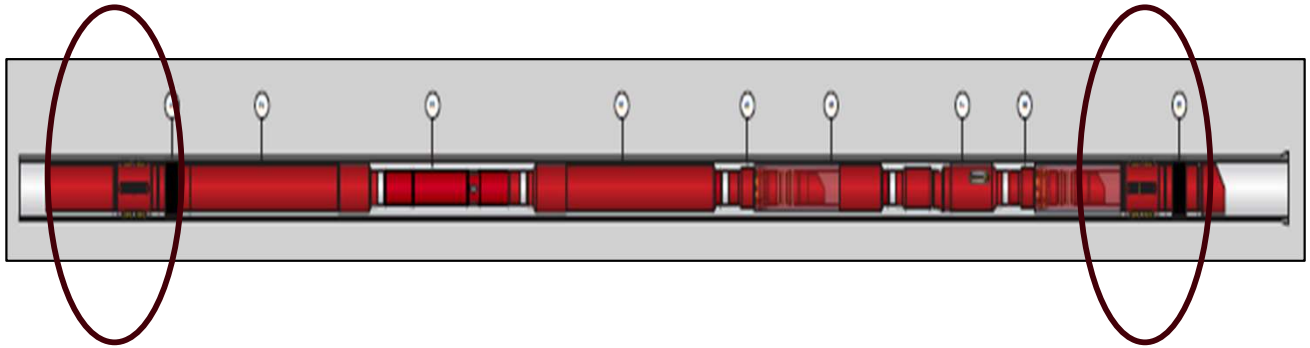
WEATHERFORD WIDEPAK™ PACKER

Applications

- Jet Pump Installation
- Water Shut-off
- Tubing Patch
- Gas Lift Installation
- Screen Hang-off
- Velocity String
- Deep Gas Lift

Specifications

- ❑ V0/V3 Rated to 5000 psi @ 325F
- ❑ Patented atmospheric booster system
- ❑ Fully Retrievable
- ❑ Designed to pass most common nipples
- ❑ Large thru-bore mandrel
- ❑ Multiple conveyance methods
- ❑ Low straight pull release



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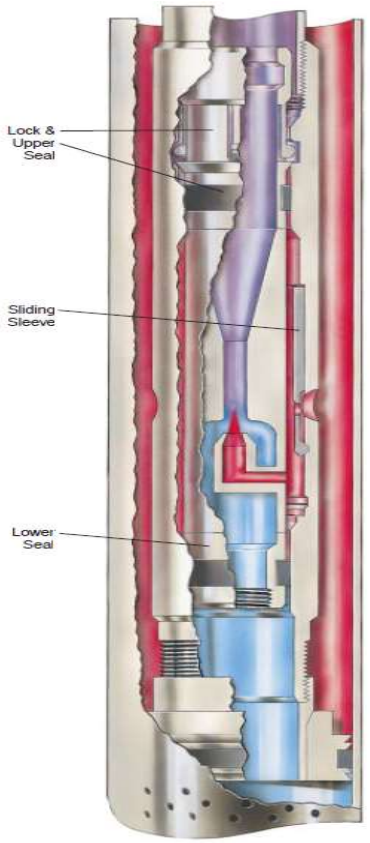
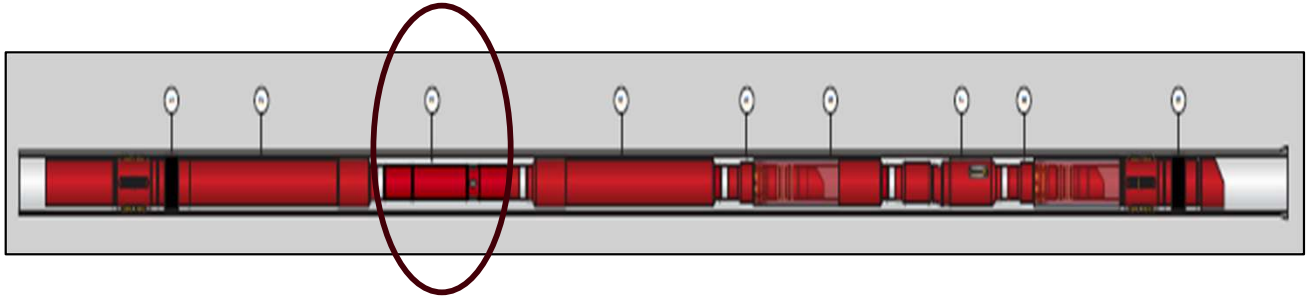
WEATHERFORD OILMASTER JET PUMP

	Typical Range	Maximum
Operating Depth	1000 - 3000 m TVD	6000 m TVD
Operating Volume	50 - 500 m3/day	4000 m3/day
Operating Temperature	30 - 120 C	260 C
Wellbore deviation	0-20deg hole angle	0-90deg hole angle (> 24deg / 30m DLS)
Corrosion Handling	Excellent	
Gas Handling	Good	
Solids Handling	Good	
Fluid Gravity	+/- 8° API	
Servicing	Hydraulic or Wireline	
Prime Mover Type	Multi-cylinder or electric	
Offshore Aplication	Excellent	
System Efficiency	10% to 30%	



SLIDING SLEEVE



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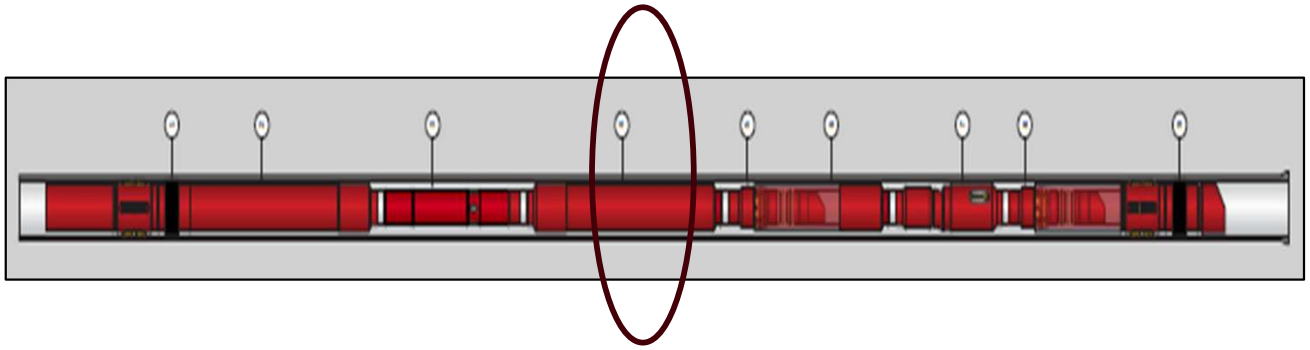
WEATHERFORD SO TIE-BACK

Applications

- Jet Pump Installation in conjunction with an RS Anchor Seal Singer to connect tubulars downhole.
- Water Shut-off
- Tubing Patch
- Gas Lift Installation

Specifications

- ❑ V0/V3 Rated to 5000 psi @ 325F
- ❑ Large bore provides enhance flow area for increased production.
- ❑ Low latch force for engagement enable slickline conveyance.



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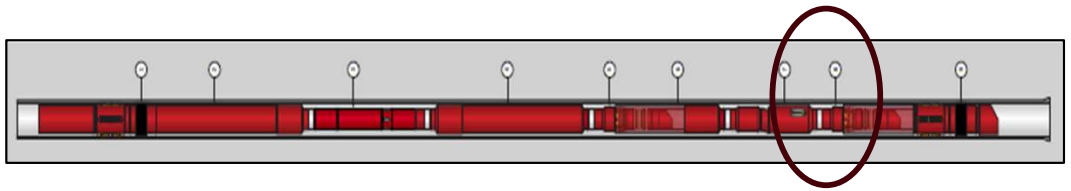
DTI SLIM PUMP SAFETY VALVE

- DTI had developed a Slim Pump Safety Valve (SPSV) specifically for use with Cable Deployed ESP's for applications where an in-line safety valve was required, and the existing safety valves had been compromised.
  - The SPSV is an API 14A qualified valve that is set at the pump depth and activated by pump switch on and off.
  - The completion was therefore simplified by not having a requirement for the use of existing or additional control lines or nipple profiles.
- The operating company asked DTI if they could develop a variant of the SPSV to operate with a Jet Pump.
- By deploying the Jet Pump in an inverse format, it would suit the way the SPSV functions.
  - The SPSV could be activated by sensing the power fluid pressure when the pump was switched on and the safety valve would then automatically open.
- Some modifications were required to adjust the Safety Valve to work in conjunction with the expected fluid power ratings.
- The modified design and its compatibility with the jet pump was validated through an SIT with the following objectives successfully met.
  - Ensure reliable SPSV operation and re-closure with Jet Pump.
  - Ensure that the safety valve does not impact the operation/out put of the Jet Pump.
  - Ensure that the safety valve hold pressure after flow loop operation.



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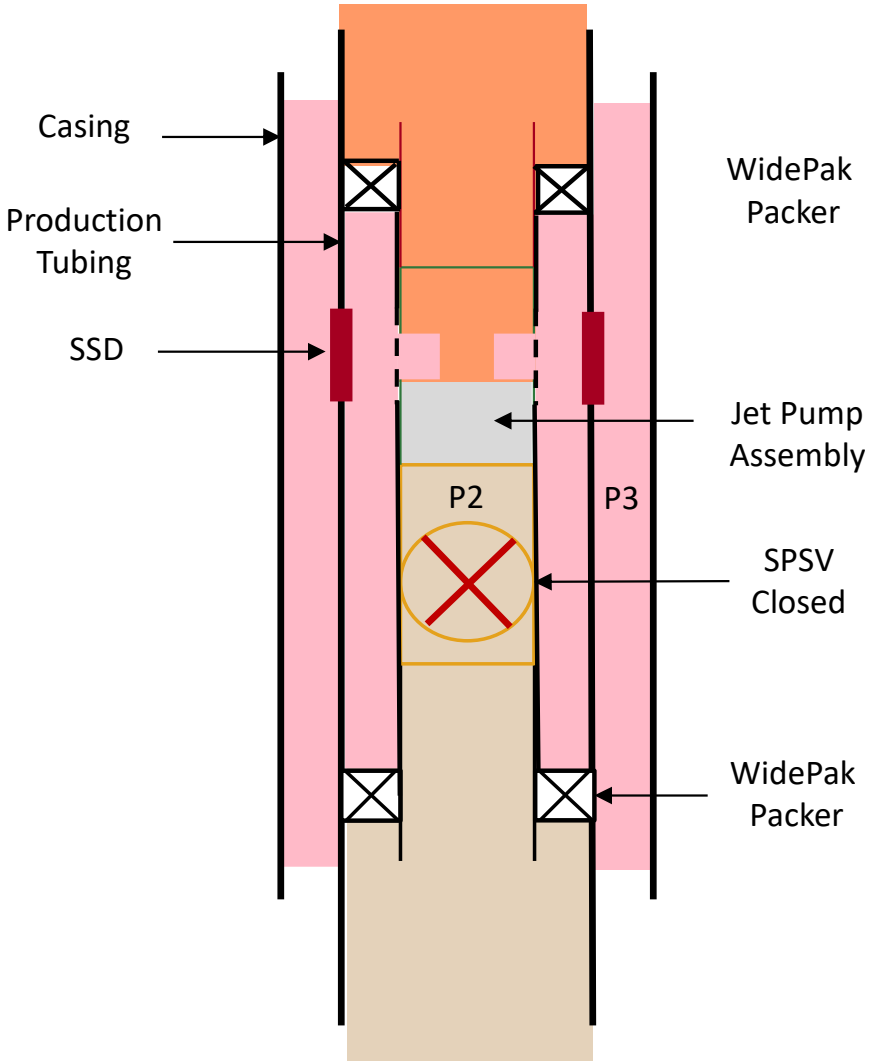
DTI SLIM PUMP SAFETY VALVE (SPSV) OPERATING PRINCIPAL



Jet Pump and SPSV installation

SPSV Operation (Shut In)

Power fluid for the Jet Pump is pumped down the "A" annulus (P3)

When power fluid injection is stopped, the pressure in the "A" annulus (P3) and the wellbore (P2) equalize and the SPSV closes to isolate the reservoir.

The pressure differential between the power fluid (P3) and the wellbore pressure (P2) pilot pressure to open the SPSV

(SPSV operating envelope = 240 – 1,400 Psi Psi)

Comingled Produced Fluid

Reservoir Production

Jet Pump Power Fluid

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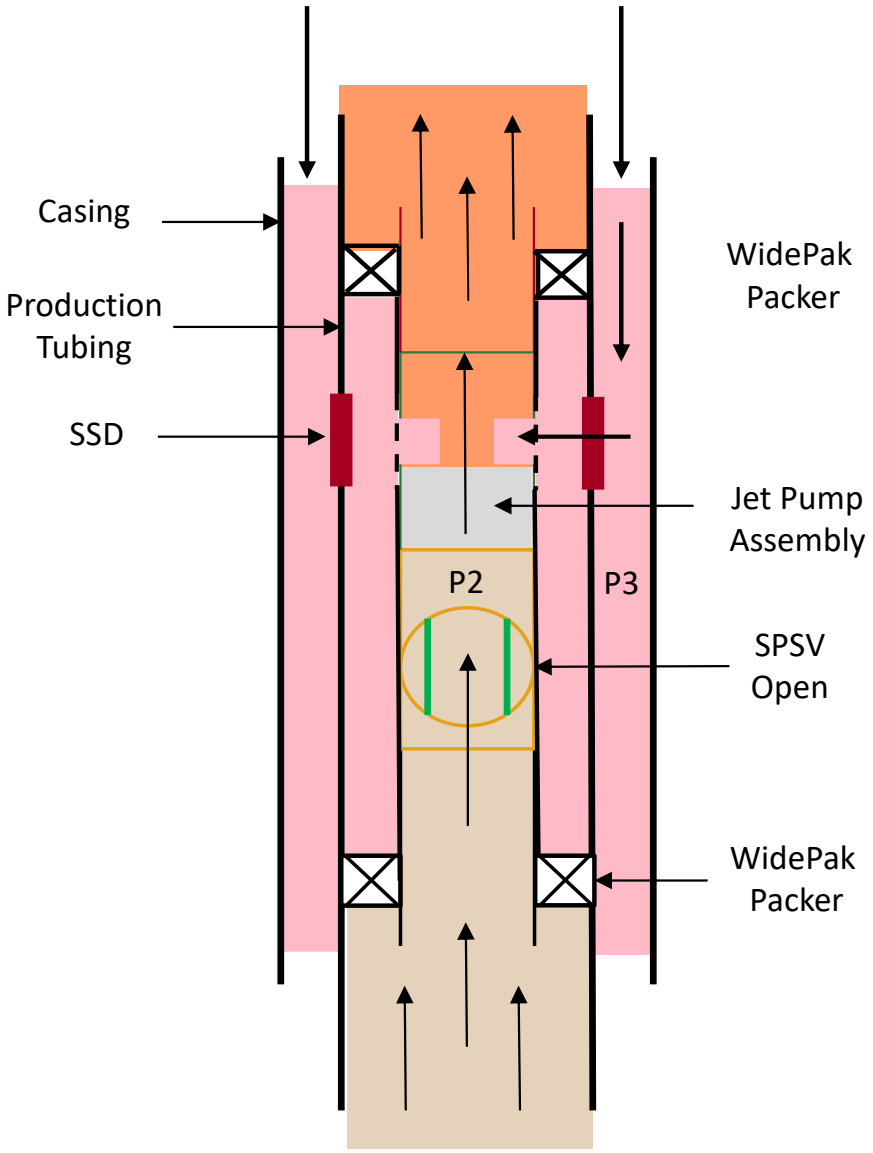
DTI SLIM PUMP SAFETY VALVE (SPSV) OPERATING PRINCIPAL



Jet Pump and SPSV installation

SPSV Operation (Flowing)

Power fluid for the Jet Pump is pumped down the "A" annulus (P3)

The pressure differential between the power fluid (P3) and the wellbore pressure (P2) pilot pressure to open the SPSV

(SPSV operating envelope = 240 – 1,400 Psi Psi)

When power fluid injection is stopped, the pressure in the "A" annulus (P3) and the wellbore (P2) equalize and the SPSV closes to isolate the reservoir.

Comingled Produced Fluid

Reservoir Production

Jet Pump Power Fluid

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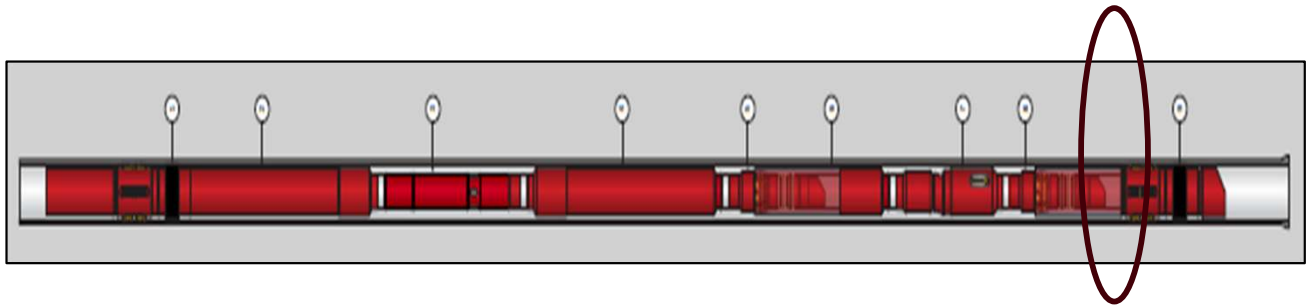
WIDEPAK™ ANCHOR SEAL / SO TIE BACK

Applications

- Jet Pump Installation
- Water Shut-off
- Tubing Patch
- Gas Lift Installation

Specifications

- 5000-psi ISO 14310 V0 tested
- Straight pull release with adjustable shear value - 2400 – 12000-lbs
- Shear value adjustable on location prior to RIH
- Positive indication of latching via overpull
- Bi-Directional HNBR V chevron seals



EQUIPMENT RIG UP & INSTALLTION PROCERURE

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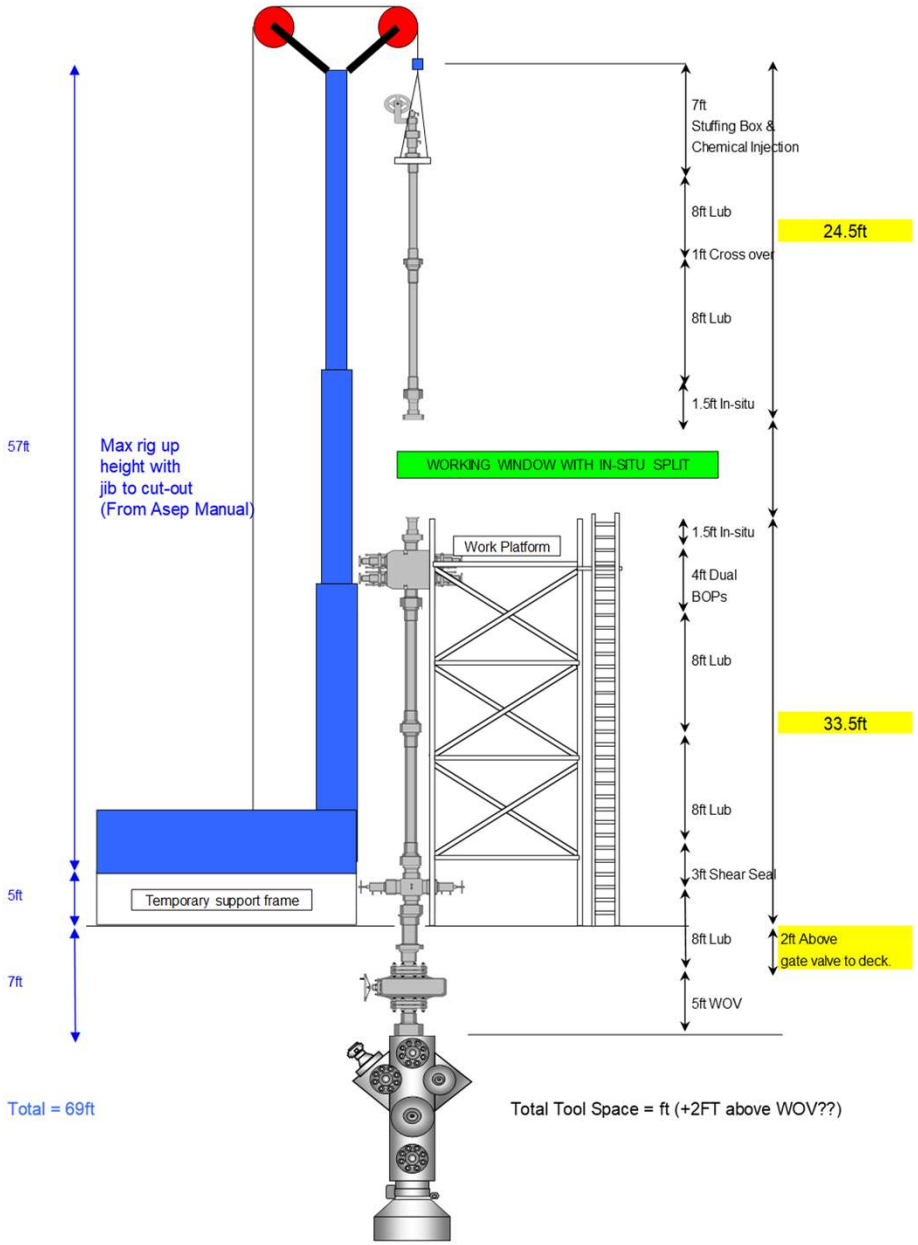
EQUIPMENT RIG UP & PRE-WORK



Prior to the Jet Pump Straddle Installation, upfront evaluation work was carried out in the well to ensure suitability for the longevity of the system. The sequence of runs was as follows:

- Drift Run incorporating memory PT Gauge
- Memory MFCT (Multi-Finger Caliper Tool) to check the completion to the Tubing Hanger
- Memory Corrosion Log to log completion to Tubing Hanger
- Open SSD to allow for power fluid to enter tubing from “A” Annulus

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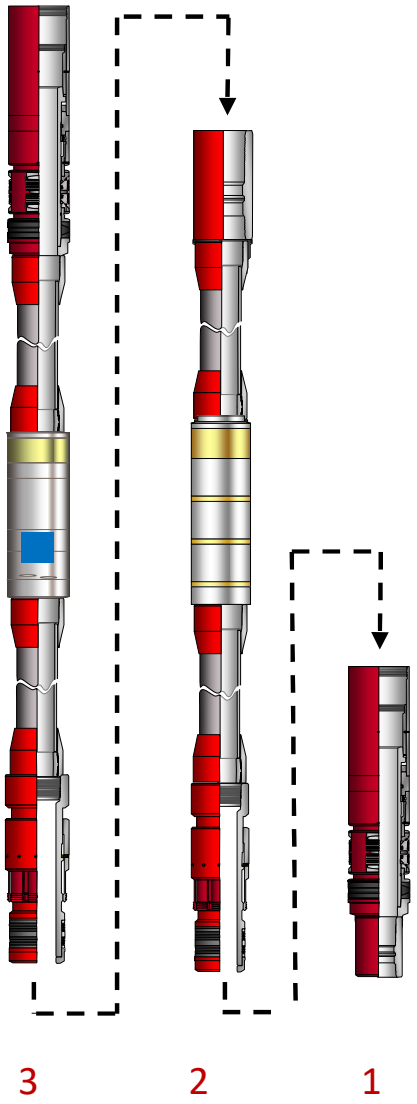
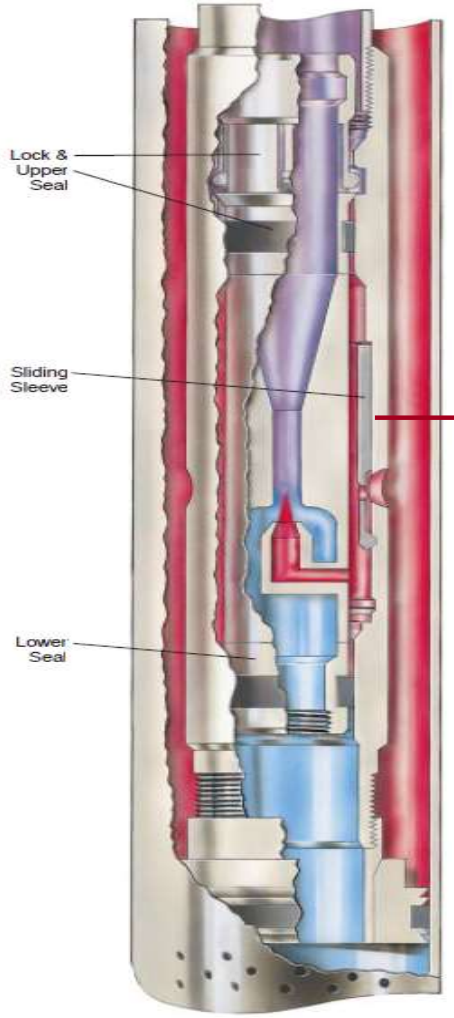
JET PUMP INSTALLATION PROCEDURE



When the up-front work had been completed, installation of the Jet-Pump Assembly was carried out in 3 runs as per below:

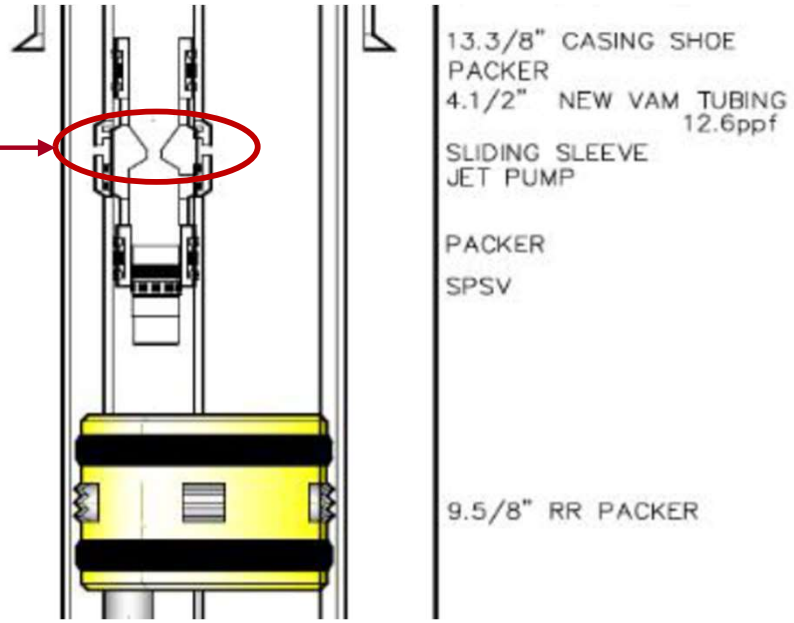
1. Set Lower Weatherford WidePak™ Packer - memory setting tool.
   - WidePak™ Packer – Wireline Entry Guide
2. Set intermediate straddle section – Standard GS running tool.
   - SO Tie Back Female – Extension - DTi Pragma Insert Safety Valve – Extension WidePak™ Anchor Seal
3. Set Upper WidePak™ Packer - memory setting tool.
   - WidePak ™Packer – Extension - OilMaster® Jet Pump Assembly - Extension - SO Tie Back Male

JET PUMP SPACE OUT



SLIDING SLEEVE

The Lower WidePak™ Packer was spaced out in order that when the complete straddle assembly was in position, the intake of the jet pump assembly was directly opposite the open SSD allowing easy movement of power fluid into the Jet Pump Assembly



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Highlights & Conclusion

Highlights

- The system was installed successfully in an efficient and safe manner with no accidents, incidents or environmental impact.
- A number of engineering challengers were overcome during the planning and execution of the operation
  - The setting value of the Slimline Pump Safety Valve (SPSV) operating pressure had been adjusted prior to the SIT, however following the SIT, the operating pressure of the SPSV was further adjusted to provide a larger operating "window". This alone, demonstrates the importance of performing SIT's pre-job to ensure that systems are fully compatible and function correctly prior to being mobilised offshore.
  - Extension Subs were included in the Jet Pump Assembly to ensure that the intake of the Jet Pump was in line with the open SSD post installation.
- Production was increased by 250% following system installation as predicted by the JEMS™ modelling software.
- Further projects are being evaluated as a result of the success of the Jet Pump Straddle System installation.

Add value to Underperforming Assets

Conclusion

The above is the result of a collaborative effort by all parties from the onset of the project, throughout the planning, testing and execution phase. This demonstrated the benefits of early engagement with all parties and working closely together throughout any campaign.

* Under development

RESULT

INCREASED UPTIME
REDUCED COSTS
INCREASED PRODUCTION

THANKS