



PERFORMANCE BULLETIN

FOAM BALL TESTING THROUGH PBL® MULTIPLE ACTIVATION BYPASS SYSTEM

Challenge

A Major Operating Company in Norway wanted to qualify if 2 x 5" OD foam balls could be pumped down the 5" Drill Pipe and circulated out through the side ports of a 6-3/4" and 4-3/4" PBL circulating sub into the annulus. Various projects would benefit in their cementing program if this could be achieved, allowing the 5" Drill Pipe to be effectively cleaned of cement debris.

Solution

Equipment & BHA:

TFS Services AS supplied the following DSI Dual Ported PBL Multi-Activation Circulating Subs:

6-3/4" PBL with Serial # WES 675 SBP 577

Toolbox # B032

No. of cycles: 5

Activation ball size and type: 2" vinyl ball (1 no. per activation)

De-activation ball size and type: 1-3/8" steel balls (2 no. per de-activation)

Port size: 2 no. 1.235" diameter (Total TFA= 2.396 sq. inches)

De-activation shear pressure = 3200psi (221 bar)

4-3/4" PBL with Serial # WES 475 BP 266

Toolbox # A009

No. of cycles: 5

Activation ball size and type: 1-1/2" vinyl ball (1 no. per activation)

De-activation ball size and type: 1-3/8" steel balls (2 no. per de-activation)

Port size: 2 no. 1.225" diameter (Total TFA= 2.358 sq. inches)

De-activation shear pressure = 3000psi (207 bar)

All 5" OD Foam balls were provided by a third-party service company.

Fluid Used: Fresh Water

6-3/4" PBL Circulating Sub Bottom Hole Assembly

7" OD Bullnose with 1 no. 19/32" centre nozzle (TFA = 0.277 sq. inches). Length approx. 0.75m. 4-1/2" IF Box up.

5" OD Pup Joint. Length approx. 5m. 4-1/2" IF Pin x Box.

6-3/4" OD PBL Circ Sub. Length approx. 3m. 4-1/2" IF Pin x Box.

Float collar # 1: ID = 2.2". Length = approx. 0.5m. 4-1/2" IF Pin x Box.

Float collar # 2: ID = 2.2". Length = approx. 0.5m. 4-1/2" IF Pin x Box.

5" OD Drill Pipe (1 joint): Length = approx. 10m. 4-1/2" IF Pin x Box.

5" OD Side Entry Sub: Length = approx. 3m.

Bottom FOSV: Length = approx. 0.5m.

Top FOSV: Length = approx. 0.5m.

5" OD Pup Joint. Length = approx. 5m



Test conducted at X-Rig Test facility, Algård, Norway



6.3/4" & 4.3/4" DSI PBL Bypass Systems were used in the tests

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4-3/4" PBL Circulating Sub Bottom Hole Assembly

7" OD Bullnose with 1 no. 19/32" centre nozzle (TFA = 0.277 sq. inches). Length = approx. 0.75m. 4-1/2" IF Box up.

5" OD Pup Joint. Length approx. 5m. 4-1/2" IF Pin x Box.

XO with 4-1/2" IF Box x 3-1/2" IF Pin. Length = approx. 0.5m

4-3/4" OD PBL Circ Sub. Length approx. 3m. 3-1/2" IF Pin x Box.

XO with 3-1/2" IF Box x 4-1/2" IF Pin. Length = approx. 0.5m

Float collar # 1: ID = 2.56". Length = approx. 0.5m. 4-1/2" IF Pin x Box.

Float collar # 2: ID = 2.56". Length = approx. 0.5m. 4-1/2" IF Pin x Box.

5" OD Drill Pipe (1 joint): Length = approx. 10m. 4-1/2" IF Pin x Box.

5" OD Side Entry Sub: Length = approx. 3m.

Bottom FOSV: Length = approx. 0.5m.

Top FOSV: Length = approx. 0.5m.

5" OD Pup Joint. Length = approx. 5m.

Execution

Procedure and Results:

6-3/4" PBL Circulating Sub Testing

The BHA was made up as described above and RIH. Circulation was established through the side entry sub. Pumps were brought up slowly to balance the system, bringing the fluid up to temperature and ensuring all air was expelled from flow lines etc., before beginning the tests.

PBL Sub Activation:

Once at 700 lpm, a SPP reading was noted of 55-57 bar. This would be used as a base line reading to confirm if the PBL sub is either activated or deactivated.

Pumps were stopped and a 2" vinyl activation ball was placed in the lower FOSV. Pumping was resumed via the side entry sub at 700 lpm (57 bar). The lower FOSV was opened and the 2" activation ball was pumped down to the PBL Circ sub ball seat. The PBL sub opened and this was confirmed by the SPP reducing to 8 bar, indicating that 100% of the fluid was now passing through the 2 x side ports in the PBL sub.

Foam Ball Displacement Through the PBL Sub Ports:

Pumps were stopped and the pup joint lower connection was broken and 2 x 5" OD foam balls were pushed inside the pin end of the pup. The pup joint was made up again. The system 'pop-off' valve was set to 180 bar to ensure the PBL sub did not de-activate if the foam balls plugged the side ports (The PBL sub de-activation shear pressure was 221 bar).

The low torque valve was set to allow the flow to be diverted through the top drive rather than the side entry sub. The two FOSV's were set into the open position and the flow rate brought up to 705 lpm (6.5 bar – the SPP being slightly lower through the top drive compared to same flow rate through side entry sub which was expected).

The two foam balls successfully passed directly through the ports of the PBL sub without incident. The SPP briefly increased to 48 bar as the foam balls went through the ports. Flow rate was then increased to 1000 lpm (13 bar) for approx. 1 – 2 minutes to ensure any remaining debris from the foam balls was cleared.

The flow rate was reduced to 700 lpm with a SPP of 6.5 bar, which was the same pressure as before the foam balls were pumped through. The foam balls were



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found in pieces in the settling tank confirming they had successfully passed through the ports of the PBL sub.

PBL Sub De-activation:

Pumps were stopped, the pup joint lower connection was broken and 2 x 1-3/8" steel deactivation balls were placed in the top FOSV. The pup joint was made up again and the top FOSV opened to allow the steel de-activation balls to drop into bottom FOSV. The top FOSV was then closed. The system 'pop-off' valve was re-set to 280 bar to allow for the PBL de-activation shear pressure of 221 bar to be obtained.

The low Torque valve was then set to allow the flow to be diverted through the side entry sub. The flow rate was brought up to 700 lpm giving a SPP of 7-8 bar indicating the tool was in open position.

Flow rate was increased to 1500 lpm (20 bar) and the bottom FOSV opened allowing the 2 x 1-3/8" steel de-activation balls to be pumped down to the PBL sub. Pressure increased rapidly to approx. 220 bar as balls landed in the PBL sub ports. The 2" vinyl activation ball sheared through ball seat without issue and the PBL sub deactivated. This was confirmed by bringing the flow rate back to 700 lpm, resulting in a SPP of 56 bar which was remarkably close to the base line reading taken at the beginning of 57 bar.

The above procedure was successfully repeated 3 more times with similar results. Each time the 2 x 5" foam balls passed through the ports of the PBL sub without any issue and were located in the settling tank. On each occasion the PBL sub also de-activated without any problems. In order to save time and since the previous 3 activation and de-activation cycles were successful, it was decided by the Company representative on the 4th and final cycle not to de-activate the PBL.

Table 1.0 - Results for 6-3/4" PBL Circulating Sub

Cycle No.	Pre-Activation		Post-Activation		SPP as foam balls pass Circ. sub ports		Post De-activation	
	(PBL Closed)		(PBL Open)				(PBL Closed)	
	Flow (lpm)	SPP (bar)	Flow (lpm)	SPP (bar)	Flow (lpm)	SPP (bar)	Flow (lpm)	SPP (bar)
1	710	57	710	8	707	48	700	56
2	700	56	700	8	705	52	700	56
3	700	56	700	8	700	18	700	56
4	700	56	700	8	790	18	N/A	N/A

4-3/4" PBL Circulating Sub Testing

The BHA was made up as described, with circulation established through the side entry sub. Pumps were brought up slowly to balance the system, bringing the fluid up to temperature and ensuring all air was expelled from flow lines etc., before beginning the tests.

PBL Sub Activation

Once at 700 lpm, a SPP reading was noted at 56 bar. This would be used as a base line reading to confirm the PBL sub is either activated or deactivated.

Pumps were then stopped and a 1-1/2" vinyl activation ball was placed in the lower FOSV. Pumping resumed via the side entry sub at 700 lpm (56 bar). The lower FOSV was opened and the 1-1/2" activation ball was pumped down to the PBL sub ball seat. The PBL sub opened and this was confirmed by the SPP reducing to 8-9 bar, indicating that 100% of the fluid was now passing through the 2 x side ports of the PBL sub.



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Foam Ball Displacement Through the PBL Sub Ports:

Pumps were stopped, the pup joint lower connection was broken and 2 x 5" foam balls were pushed inside the pin end of the pup. The pup joint was made up again. The system 'pop-off' valve was set to 170 bar to ensure PBL sub did not deactivate if foam balls plugged the side ports of the PBL sub (the PBL sub de-activation shear pressure was 207 bar).

The low torque valve was then set to allow the flow to be diverted through the top drive rather than the side entry sub. The two FOSV's were set into the open position and the flow rate brought up to 700 lpm (6 - 7 bar – the SPP being slightly lower through the top drive compared to same flow rate through side entry sub which was expected).

The two foam balls successfully passed directly through the ports of the PBL sub without incident. The SPP briefly increased to 33 bar as the foam balls went through the ports. The flow rate was increased to 1000 lpm for approx. 1 – 2 minutes to ensure any remaining debris from the foam balls was cleared from inside the PBL sub.

The flow rate was reduced to 700 lpm with a SPP of 8 bar, which was the same as before the foam balls were pumped through. The foam balls were found in pieces in the settling tank confirming they had successfully passed through the ports of the PBL sub.

PBL Sub De-activation:

Pumps were stopped, the pup joint lower connection was broken and 2 x 1-3/8" steel de-activation balls were placed in the top FOSV. The pup joint was made up again and the top FOSV opened to allow the steel de-activation balls to drop into bottom FOSV. The top FOSV was then closed. The system 'pop-off' valve was re-set to 250 bar to allow for the PBL sub de-activation pressure of 207 bar to be obtained.

The low Torque valve was set to allow the flow to be diverted through the side entry sub. The flow rate was brought up to 700 lpm giving a SPP of 8 bar indicating tool was in open position.

Flow rate was increased to 1100 lpm (16 bar) and the bottom FOSV opened, allowing the 2 x 1-3/8" steel de-activation balls to be pumped down to the PBL sub. Pressure increased rapidly to approx. 210 bar as balls landed in the PBL sub ports. The 1-1/2" vinyl activation ball sheared through ball seat without any issues and the PBL sub de-activated. This was confirmed by bringing the flow rate back to 700 lpm, resulting in a SPP of 56 bar which was the same as the base line reading taken at the beginning of 57 bar.

The above procedure, including tool activation and de-activation, was successfully repeated 3 more times with similar results. Each time the 2 x 5" foam balls passed through the ports of the PBL sub without any problem and were found located in the settling tank.

Table 2.0 - Results for 4-3/4" PBL Circulating Sub

Cycle No.	Pre-Activation		Post-Activation		SPP as foam balls pass Circ. sub ports		Post De-activation	
	(PBL Closed)		(PBL Open)				(PBL Closed)	
	Flow	SPP	Flow	SPP	Flow	SPP	Flow	SPP
	(lpm)	(bar)	(lpm)	(bar)	(lpm)	(bar)	(lpm)	(bar)
1	700	56	700	8	700	33	700	56
2	700	56	700	8	700	38	700	56
3	700	56	700	8	700	56	700	56
4	700	56	700	8	790	58	700	56



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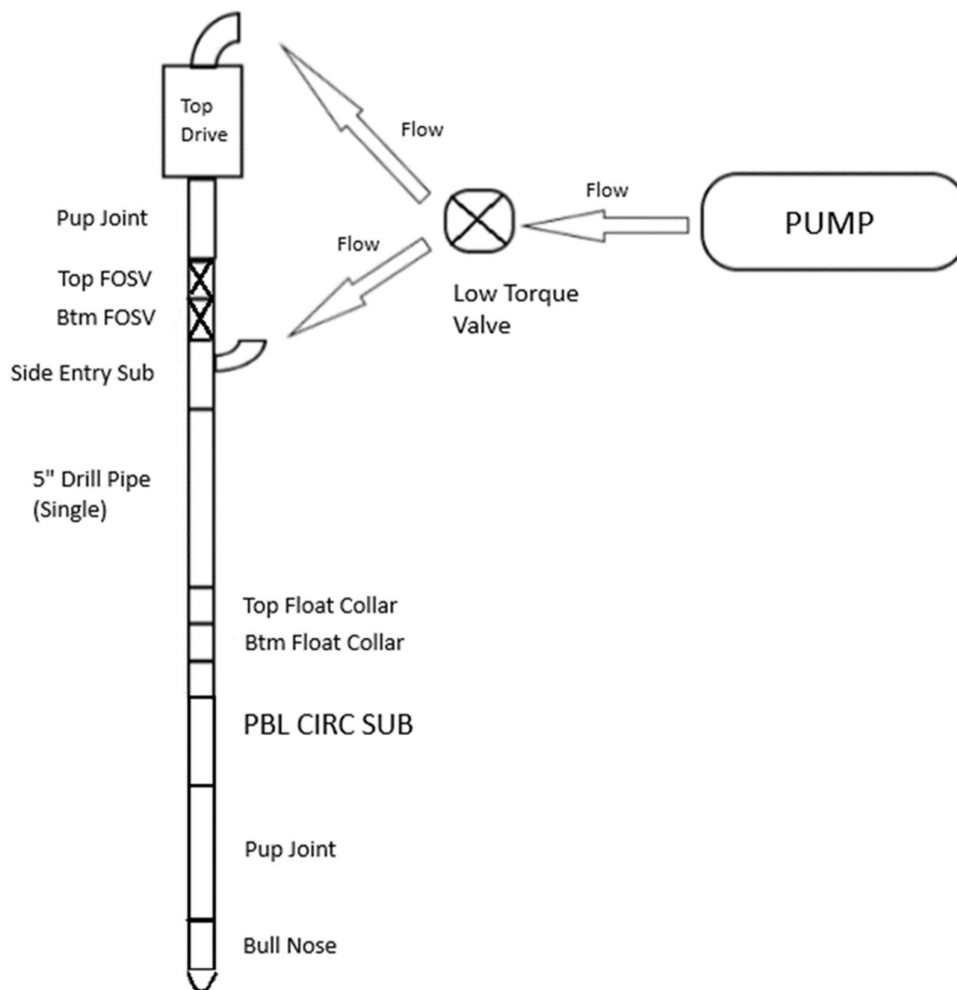
Conclusion & Recommendation

The testing conclusively demonstrated that both the 6-3/4" and 4-3/4" PBL multi-activation circulating subs will successfully allow for 5" foam balls to pass through the side ports without any issue. Each size of tool recorded a 100% success rate, including the passage of 2 x 5" foam balls and successful activation and de-activation of the PBL sub on each cycle.

We observed a variance in the increased SPP which was recorded as the foam balls passed through the PBL sub ports. This may have been due to the fact that the foam balls were supplied in two separate batches, with the densities of each ball appearing to vary. Foam balls are known to be supplied in hard, medium, and soft compounds.



Photographs & Schematics



Schematic 1. Test Layout



Pic 1. PBL Circulating Sub and Tool Box



Pic 2. X-Rig Test facility in Ålgård, Norway



Pic 3. 5" Foam balls used for testing



Pic 4. 5" foam ball after passing through PBL ports