P&A Success with New Technologies Designed for Annulus Remediation in Challenging Subsea HPHT Well

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Well History – Pre 2018 P&A

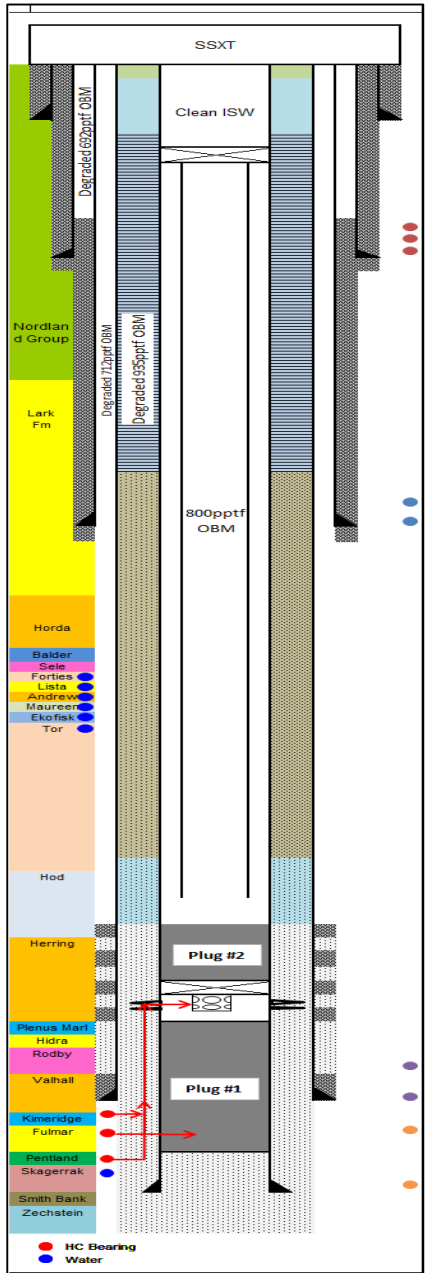
- HPHT Appraisal Well (vertical) drilled in 1985 and suspended.
- Returned to well in 2015 > unable to complete abandonment due to live 7” annulus

Well Status Pre 2018 P&A:

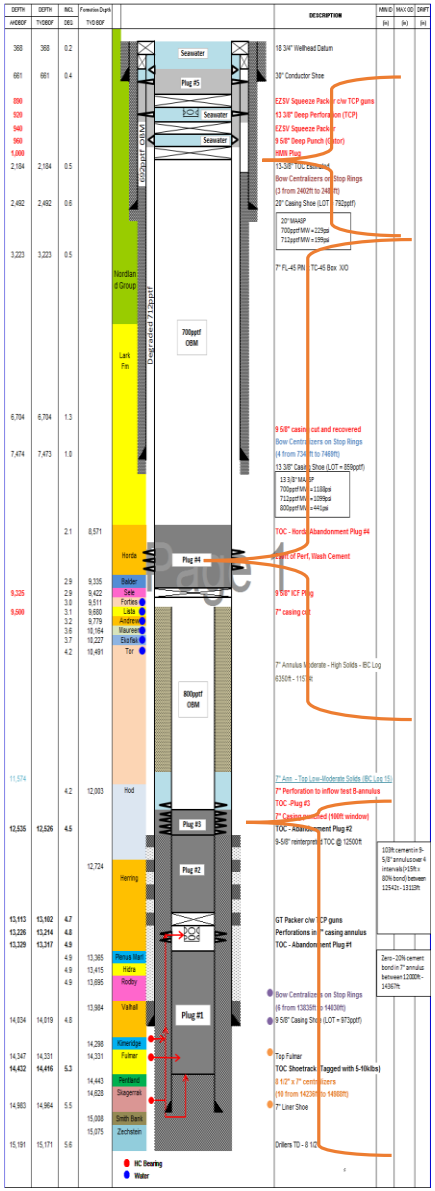
- Suspended with kill string on DLT packer
- 15.4ppg Oil Based Mud
- 7” casing had flush connections (FL-4S)

Reservoir Data:

- Fulmar reservoir pressure of 13,000psi & 332degF



Abandonment Isolation Strategy



Environmental Barrier

- Perforate, Circulate, Cement for 9 5/8 x 13 3/8” x 20”

Intermediate Horda Abandonment barrier

- 9000ft
- Set inside 9 5/8” casing
- Squeezing shale or PWC

7” Annulus Deep Barrier

- 12,500ft
- Set inside 7” casing (flush joint)

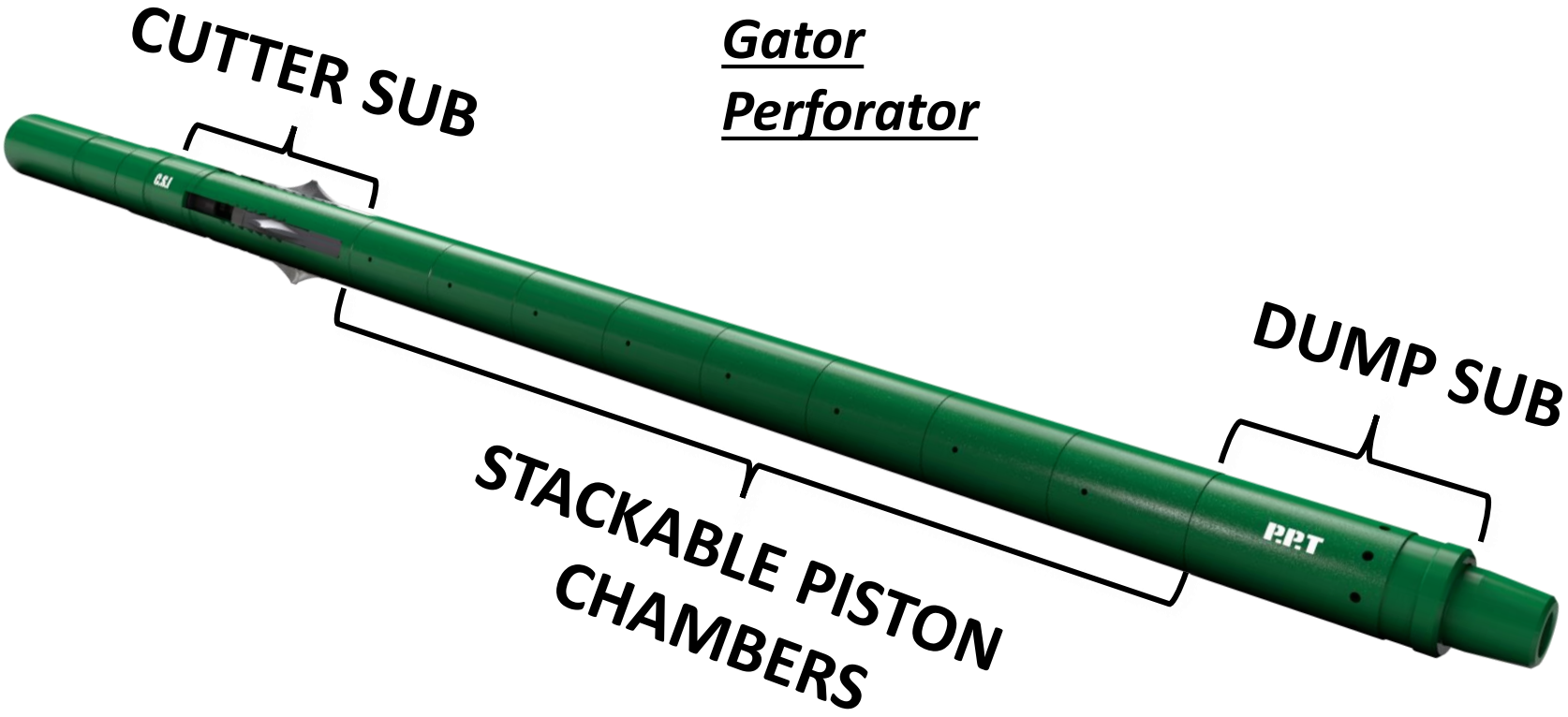
Technology Review

Challenge:

- Must perforate or cut 7” – 38# P110 flush joint casing under HPHT conditions
- Maintaining the integrity of the 9-5/8” intermediate string.

Solution:

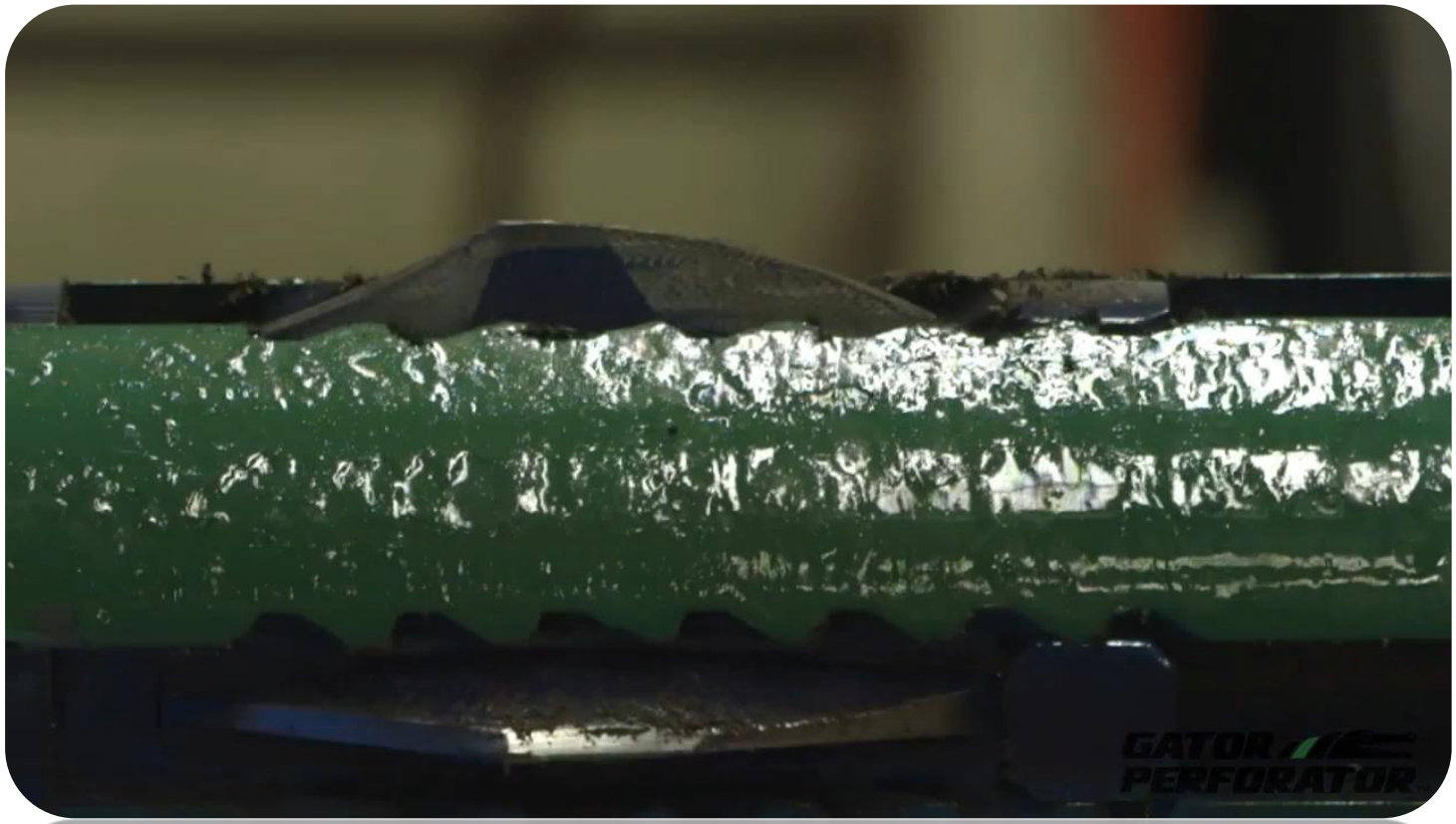
- Hydro-mechanical casing cutter (Lee Gator Perforator) was selected.



Technology Review

Hydro-Mechanical Casing Cutter:

- Provide access to the B-Annulus without the risk of compromising the intermediate casing string.
- Allows for full and effective clean of A-Annulus.
- Centralization of the 7” casing if laying on the low side.



Technology Redesign

Challenge:

- No tool that would fit in the current casing size under the extreme HPHT.
- A Heavy Wall Gator System was designed for this particular well.
- The new tool was designed with the following parameters:
  - HPHT well conditions
  - Heavy wall perforating performance >> Able to cut casing and produce 2.7 X more output force.
  - New materials were selected and a custom tool was built.

Gator Tool		570 HD	570 HD	570 HWG	570 HWG + re-hardened blades
Test		1	2	3	4
Date		August 2017	Oct 2017	Jan 2018	June 2019
Pistons		12	12 + 4 thick walled – all high grade	14 + 4 thick walled – all high grade	14 + 4 thick walled – all high grade
Tool Body/Blade Material Upgrades		Standard grade steel	Pistons upgraded to higher grade steel	Pistons/tool body higher grade steel Blade/travel block machined as one part	Pistons/tool body higher grade steel Blades -re-treated the for a hardness of 55-58 HRC (originally 52HRC).
Max Allowable Pressure (psi)		3300	3600 (4000)	4500 (5000)	4500 (5000)
Max tool output force (lbs)		440,000lbs	780,000lbs	1,200,000lbs	1,200,000lbs
Testing	7" 38# P110	14cuts made - failure of pistons closest to tool	10 cuts made successfully	18 cuts made successfully – Blades wore out prematurely	50 cuts made successfully
	7" eccentric inside 9 5/8"		Barite filled annulus – 5cuts Barite/5% cement – 1 partial cut, 2nd cut tool body/blade failure at 3590psi	Cement filled annulus - successful limit test of tool taken to limit of 4500psi, no breach of 7" casing	

Technology Testing & Verification

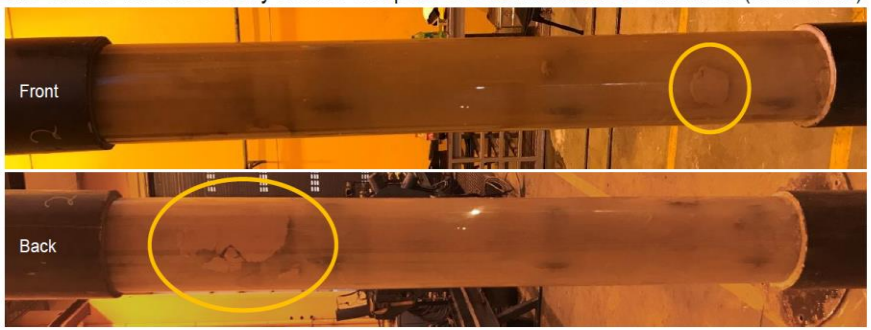
Shop Testing in Canada and UK:

- Gator Testing and Tool Validation carried out in Canada .
  - Tool function tested
  - Test targets cut
  - Multiple cycles for tool validation

- HydraHemera Testing and Tool Validation carried out in Norway .
  - Three test fixtures manufactured for casing cut at 1ft, 2ft, & 3ft spacings.
  - The annulus was then filled with a barite, sand and cement mix and left to cure.
  - Nozzle angles re-configured to achieve optimum flow and cleaning of annulus through Gator casing cuts.

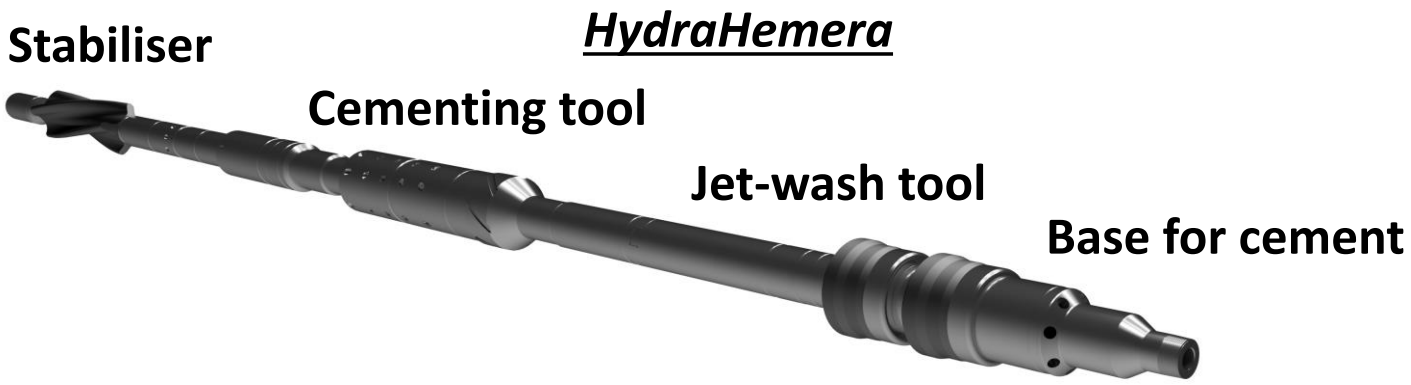
3.3 2 ft. spacing flow test

The annulus was successfully cleaned except for two small remnants of annulus fill (±95% clean).



3.4 1 ft. spacing flow test

The annulus fill was successfully cleaned out across the entire perforated interval (100% clean).

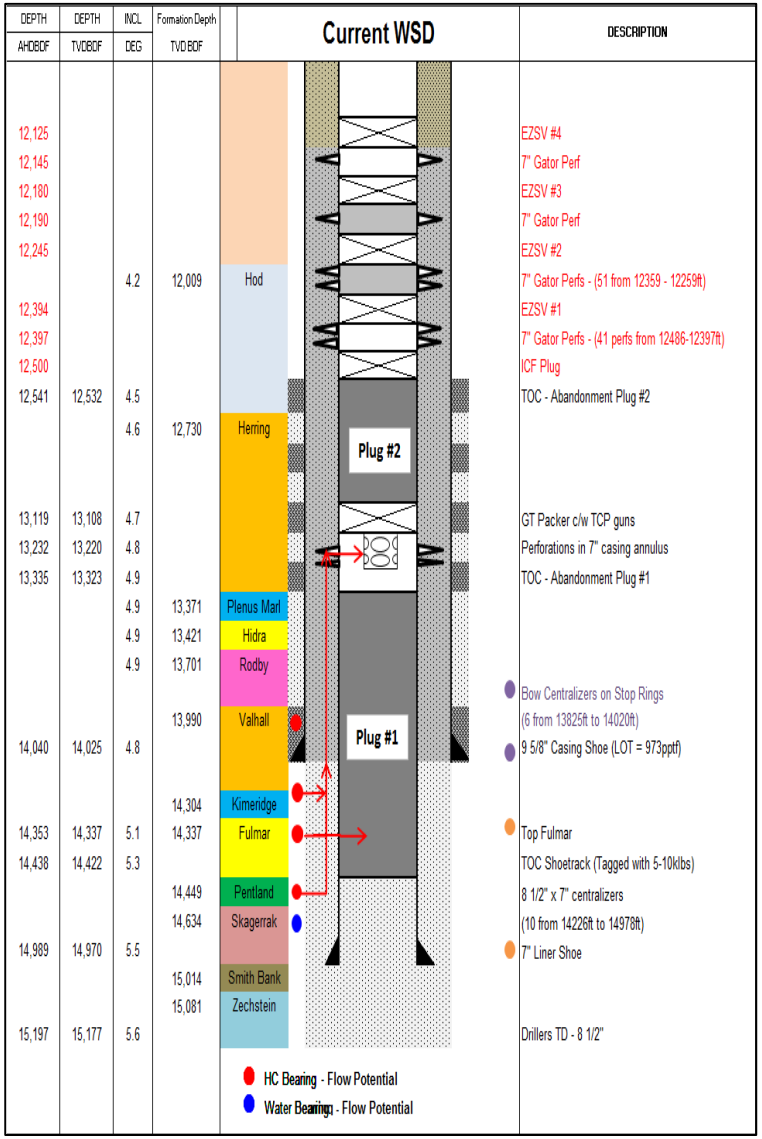


Results & Summary

Abandonment Summary:

- Challenging Deep 7” Annulus Barrier set successfully and inflow tested – enabled with Gator tool and use of HydraHemera™ PWC® system for cement placement .
  - Lost ~ 2500bbls of due to losses event.
  - 4 cement squeezes performed to create base for PWC operations.
  - Total of 146 Gator Perforations performed, world 1st centralising casing to enable annulus remediation with HydraWell HydraHemera™ system.

- Total of 500bbls cement pumped, 4 cement squeeze jobs , with 1 PWC cement job (71bbls) providing the deep well control barrier to enable full abandonment.



Questions