Lessons Learned from the Abandonment of the Knarr and Gaupe fields

Lars Endre Hestenes
GM Wells Operations
PTE – Well Completions & HWU/Snubbing

AkerBP Harbour Energy INPEX

Agenda

01 Decommissioning Scope and Phases

02 Contracting strategy

03 Operational execution

04 Key lessons learned

05 AOB + Q&A

Decommissioning Scope and Phases

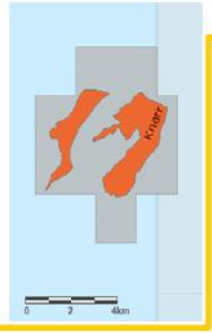
- The Knarr and Gaupe fields are owned by two different licenses - planned and executed as one project

- Abandonment to be completed by latest end 2028

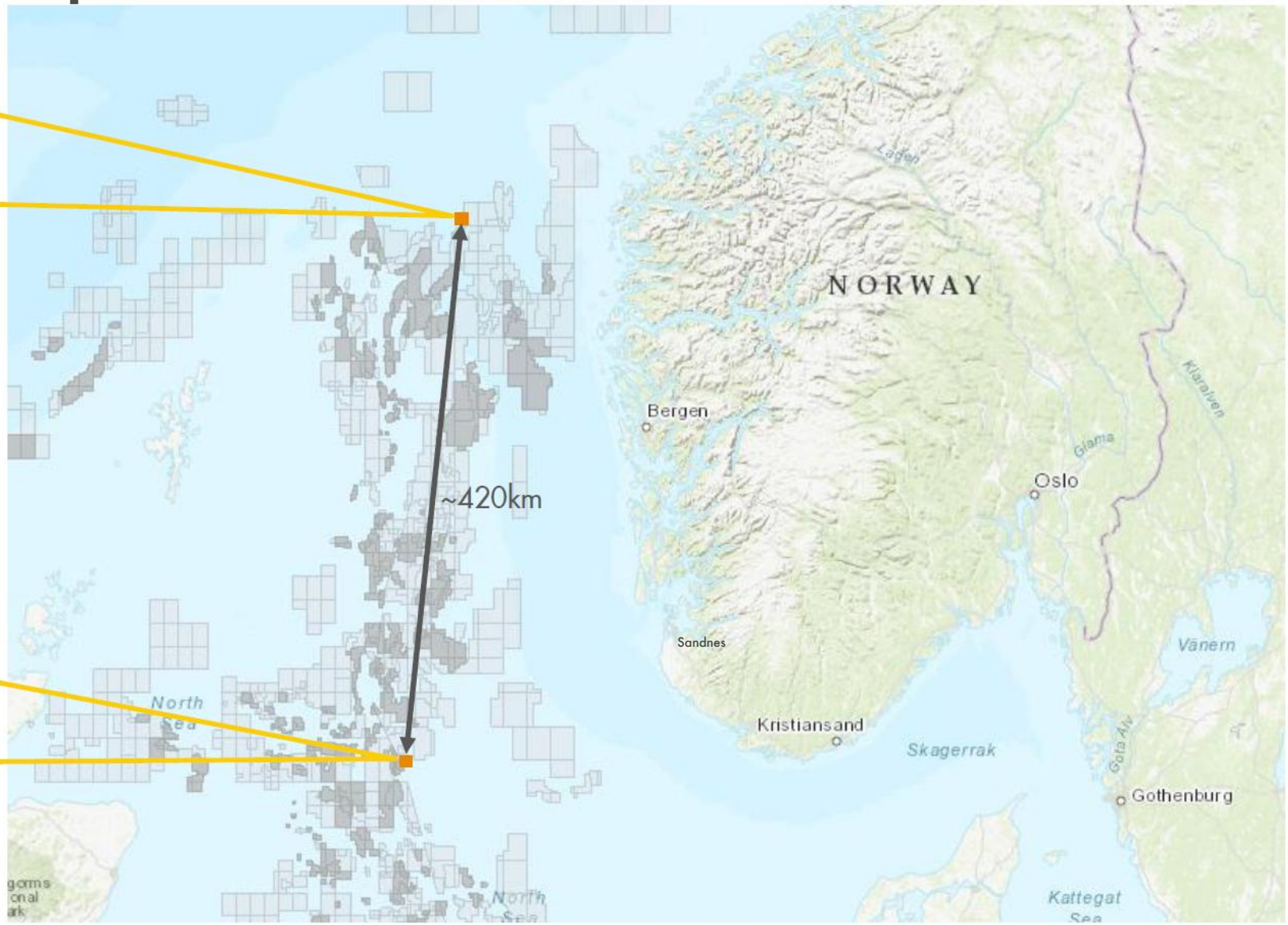
- Split Decommissioning project into 3 Phases;
  - Phase 1 completed in 2023
  - Phase 2 PP&A of wells 2024
  - Phase 3 Subsea infrastructure recovery & disposal 2025 & 2026 (ongoing)

Knarr and Gaupe Field Locations

Knarr:
2 templates
4 x prod wells; 3 x WIs
~2km between templates
Water depth 405-412m



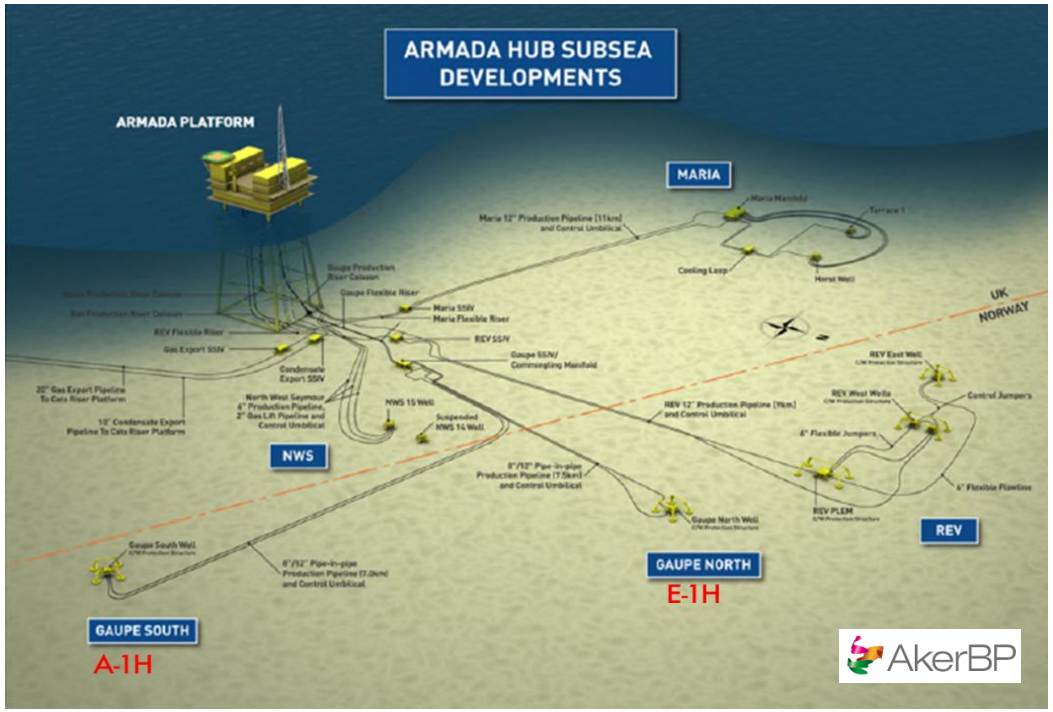
Gaupe:
2 satellite wells
~6km between wells
Water depth 85m



Abandonment Scope

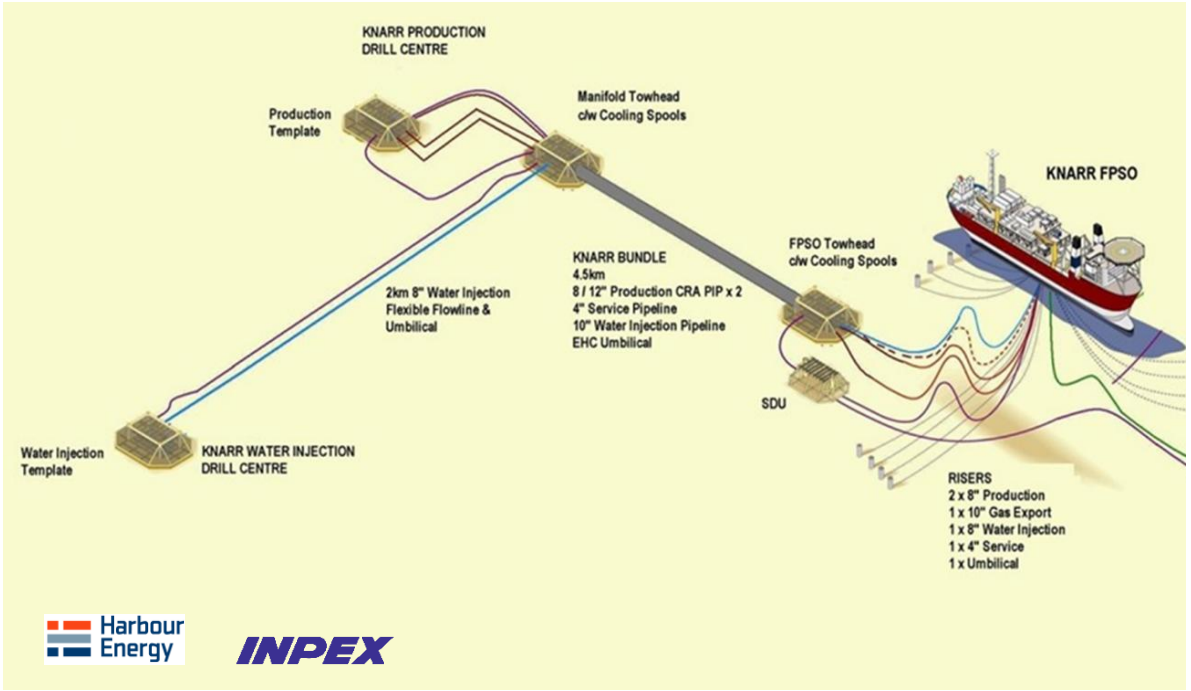
Gaupe – 2 wells (Drilled & Completed 2011)

- NPNT oil producers Southern North Sea
- "Smart Completions" with CLs thru production packers
- Suspended with Seawater
- Both wells assumed to have poor cement quality and planned to be logged with potential PWC.



Knarr – 7 wells (4 Producers & 3 Water Injectors D&C 2014, infill well A-3H D&C in 2020)

- HPHT oil reservoir
- 7" and 5-1/2" completions, with super Duplex 25Cr in WIs
- Two wells assumed to have poor cement quality and planned to be logged with potential PWC
- A4 well had gas lifted completion retrofitted



Contract and Execution Strategy

Ph2.1 Pre-work – Utilize Light Well Intervention Vessel

Utilize the smallest work unit as possible to deliver the Plug & Lubricate (P&L) scope

Early investigation of well status

Include Gaupe Pipeline Flushing scope from Phase 1

Ph2.2 Rig – PP&A scope

"Gap filler" Contract

HXT "Tree on Wire"

Ph2.3 Wellhead Severance

Transfer scope to Phase 3

Phase 2.1 – LWIV Scope

"Plug & Lubricate" (P&L)

- Remove hydrocarbons from tubing
- Punch tubing and displace annulus fluid
- Install and test deep barrier plug
- Install and test Shallow barrier plug

Additional Gaupe Scope

- Flushing of Gaupe flowlines up to SSIV

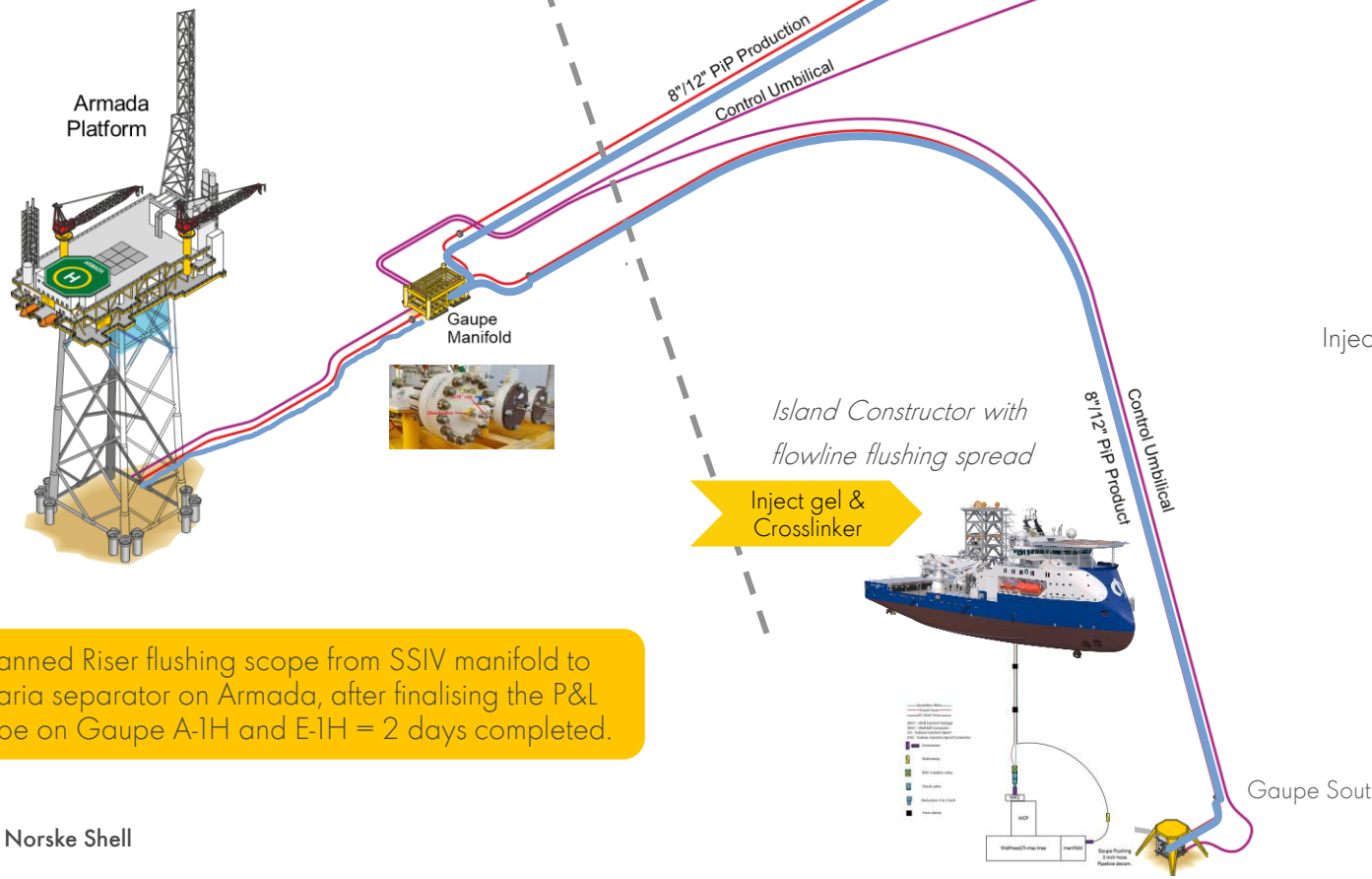
REACH SUBSEA

IWI vessel operator: TIOS

Flushing contractor: HALLIBURTON

Pipeline Cleaning

Planned flow line flushing scope = 3 days
Actual flowline flushing scope = 2.8 days



Planned Riser flushing scope from SSIV manifold to Maria separator on Armada, after finalising the P&L scope on Gaupe A-1H and E-1H = 2 days completed.

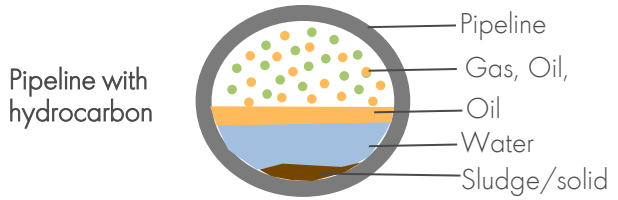
Problem Statement

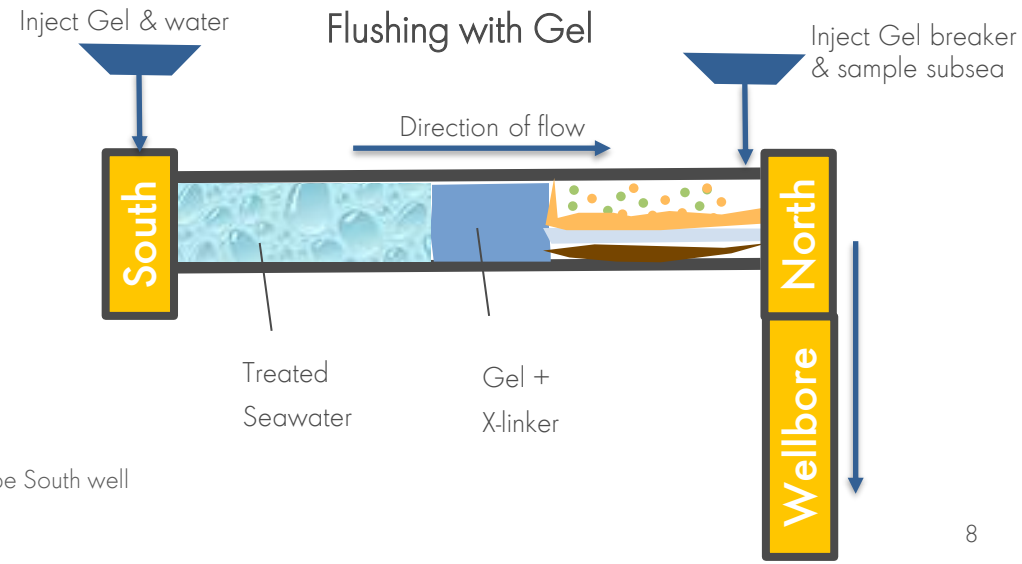
Effectively displace hydrocarbon content in pipeline into well

- At **Low pressures** within Operating Envelope of pipeline
- Minimize risk of hydrate formation
- Requirement <100ppm oil in water spec

Why?

Government Regulations to abandon pipeline in place & leave buried

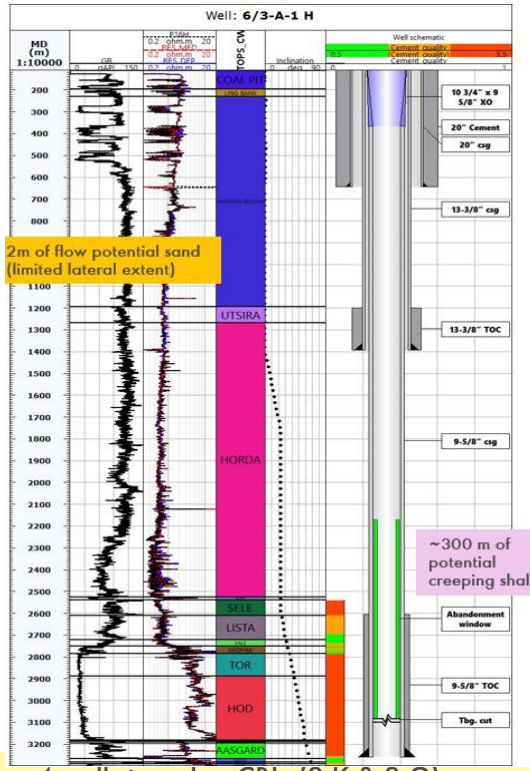




P&A Operational Journey (2 Gaupe + 7 Knarr)

SIS (2019)
WAFS (2020)

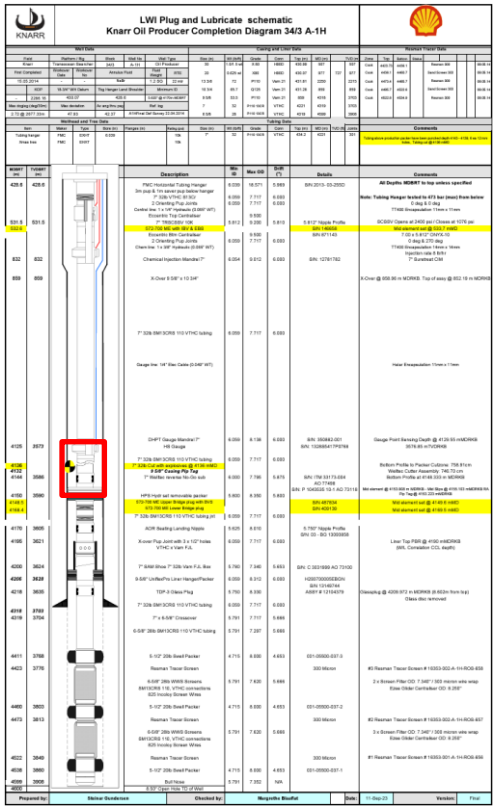
- Identify abandonment window
- Identify if potential flow of HC in OB
- Validate cement quality over ab. window (60m of good cement is needed)



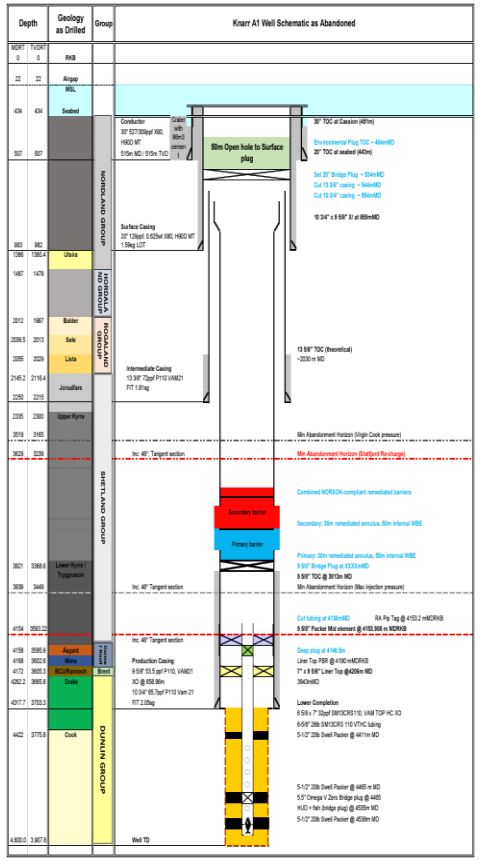
- 4 wells to re-log CBL (2 K & 2 G)
- 1 Gaupe well with potential HC flow in OB

P&L (2023)

- Set bridge plugs
- Cut tubing below ab. window



P&A (2024)



Two (2) categories of wells to P&A

1) No CBL log required = 60m good cement and no shallow HC

- Pull tubing
- Install cement plugs

2) Four (4) Wells to re-log CBL

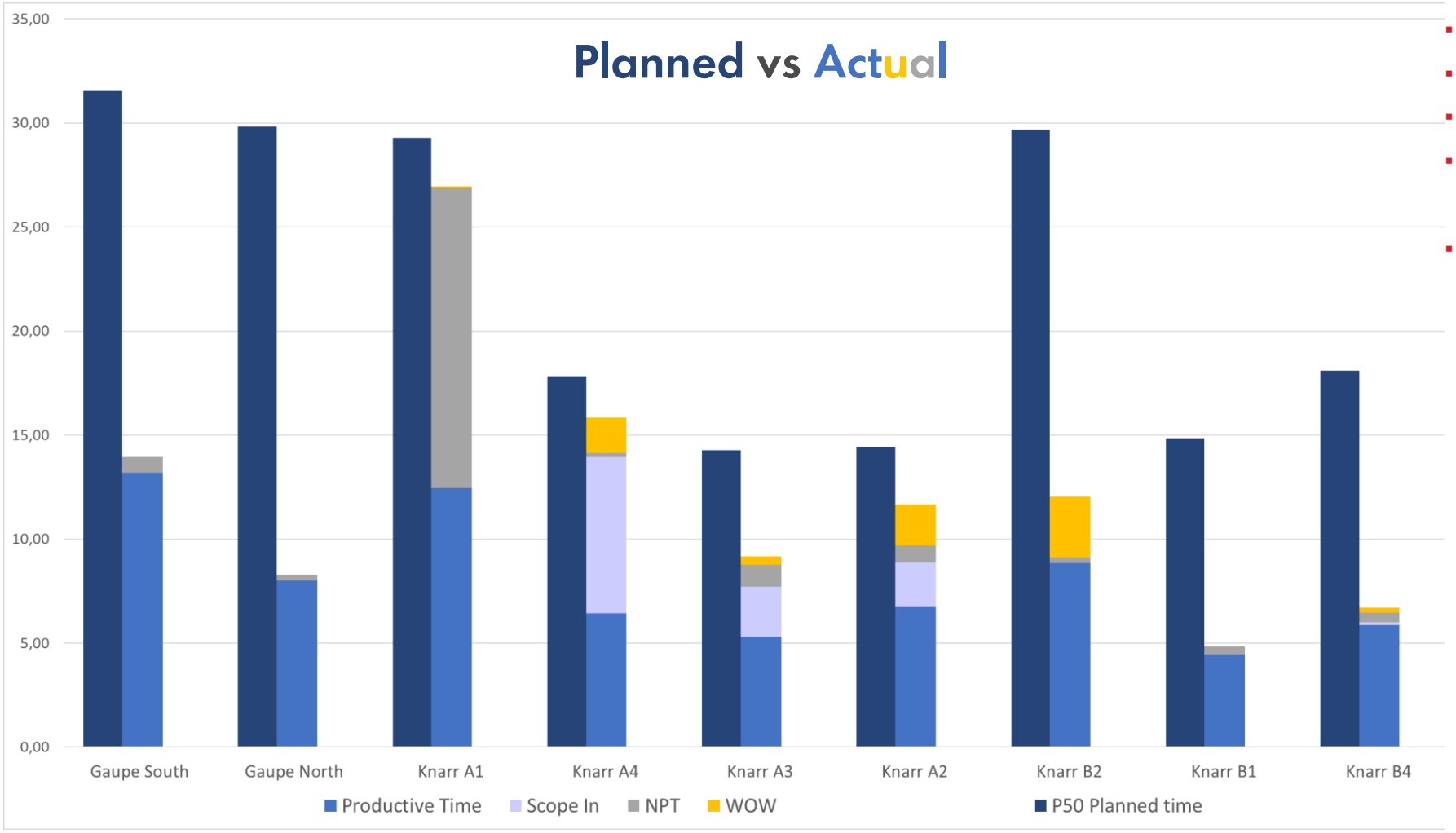
- Pull tubing
- Log CBL to quantify **60 m of permanent barrier** within ab. window to define further P&A ops

Norsok D-10

- Three independent logging measurements/ tools
- Azimuthal data

CBL-VDL-PowerFlex (ultrasonic cement and casing measurement)

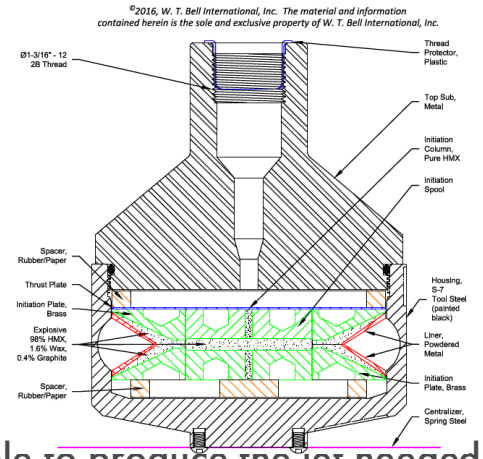
Knarr and Gaupe P&A Performance Overview



- **Planned Time:** 200 days
- **Actual Time:** 110 days
- **NPT:** 18 days (17%)
- **Scope In:** 12 days (14%)
- **WOW:** 7 days (8%)
- 35.000m of casing & tubing recovered to the rig
- 9 ea HXT's lifted off and stored on seabed

Optimized Activities	Days Saved
No PWC	40
DP and batch ops on Knarr	10
XT wet storage	7
Omit shallow plug for XT removal	4
Good weather	20
Surface scope	3
Fast tubing pulling	6

NCR#: WE24-169: Knarr A-4 and A-3 tubing not cut during LWI campaign 2023



NCR: WE24-169

Baker Synergi: Project no. 300203 / 300204

Case summary:

- Unsuccessful cut is most likely due to damaged explosive disk in the cutter head.
- Damaged explosive disk means that the cutter loses its ability as a shaped charge and is no longer able to produce the jet needed to achieve the cut.
- Damage to the explosive disk can be caused by rough handling during transport, placement, rig up, entry Sub Sea lubricator, RIH, or a combination of the above.

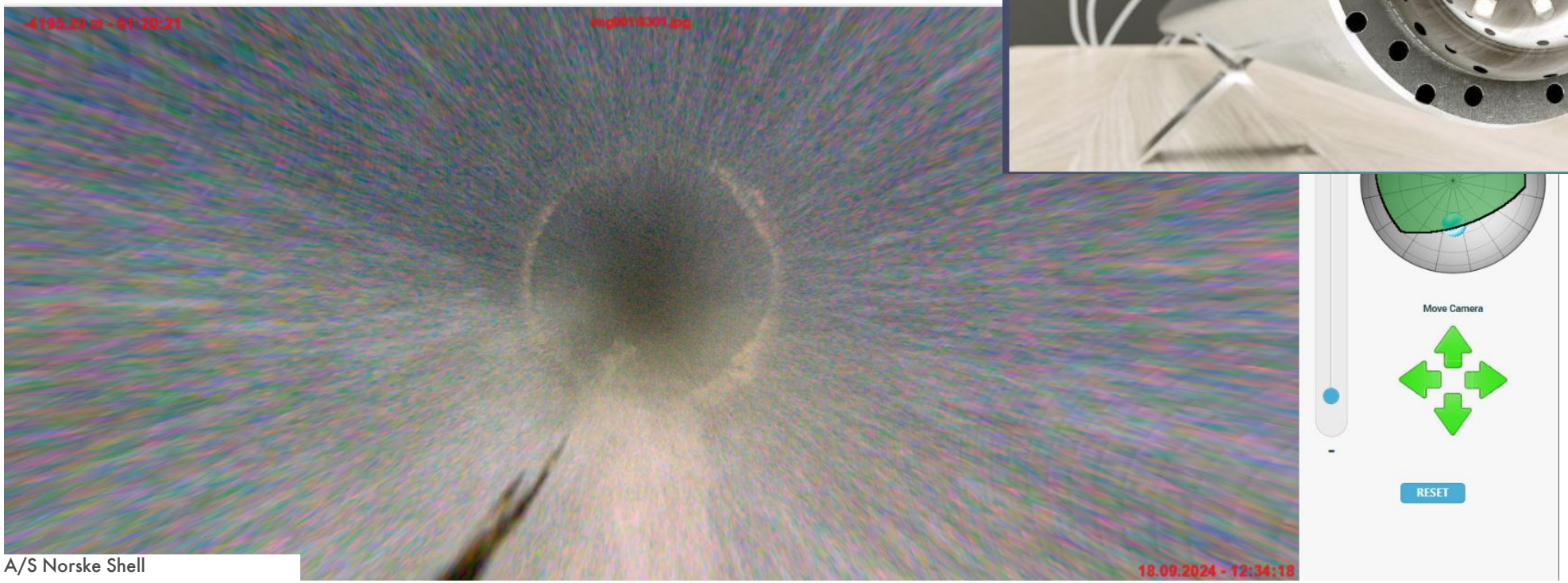
Corrective action:

- Thorough visual inspection of explosives during assembly prior to rig up. Be vigilant when handling the cutter BHA during the rigging phase, note incidents where the BHA is inadvertently subjected to shock or impact, evaluate if action is required. Added point in checklist, document cutter Top Sub witness plate verification and upload to project.

Knarr 34/3-A-2 H well

- Vision IO Camera Confirmed Dynablade cut in A-2 (LWI campaign 2023)
- However, during P&A, uncertain of cut, so assurance cut was made. On pulling tubing, original cut was found to have been successful.

Vision IO camera



Knarr 34/3-B-4 H well

Spear prematurely set in 13 3/8" casing

- Combined BHA with casing spear and marine swivel to pull seal assembly
- Heave compensator turned off to make connection
- Spear unexpectedly engaged the 13 3/8" casing
- Rig heave of 1.2 – 1.5m applied 592 – 721 MT hookload (537 MT pull on drillstring and 512 MT overpull on casing hanger)
- Overpull caused the 13 3/8" seal assembly to yield and the cut casing and hanger released from wellhead
- The drill line on the draw works jumped causing the spooling to be incorrect and draw works inoperable.
- An initial gain of 0.35m3 was seen in the trip tank and gas expansion was seen in the riser up to 4.4m3

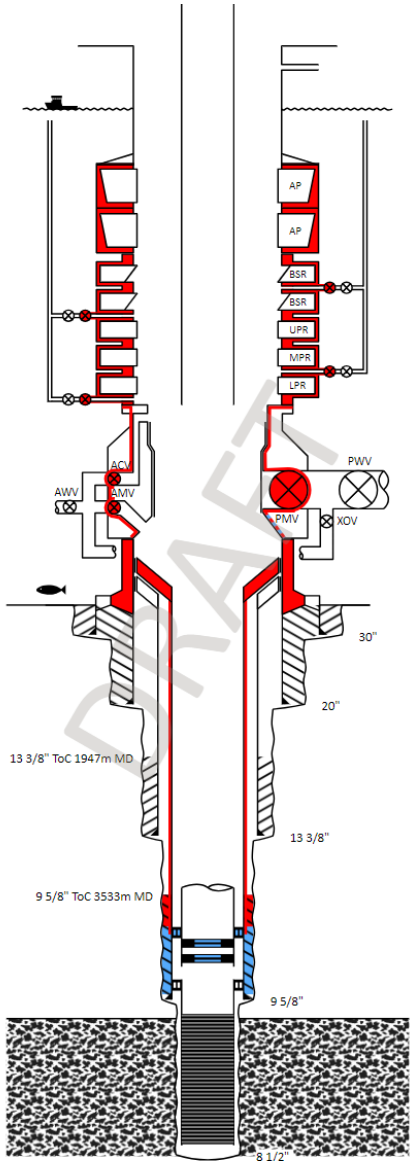
<u>Learnings:</u>

- Evaluate need for connection between spear and marine swivel
  - Pull S/A above BOP before engaging the spear

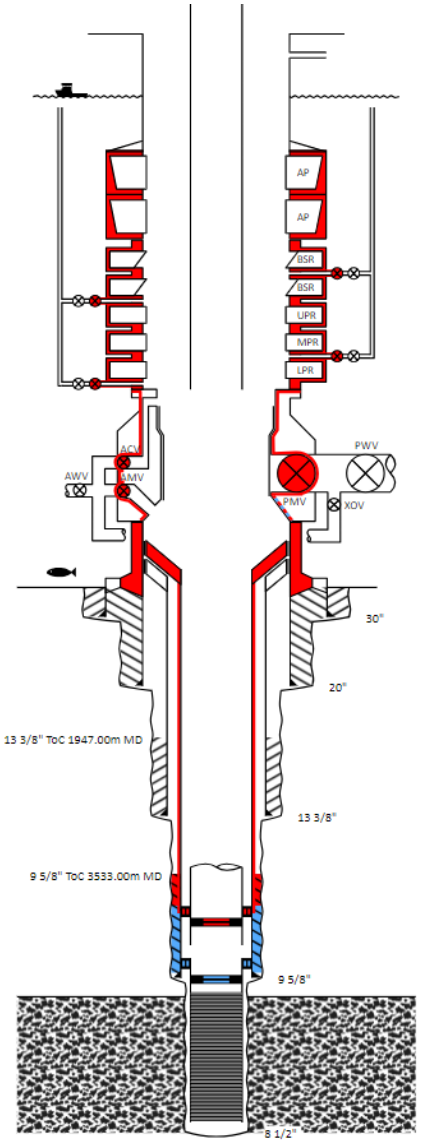
Other learnings

- Consider installing one barrier deeper in the well in the lower completion and one in the upper completion. Then the two barriers are independent from each other
  - Reason was requirement for High Expansion plug if installed in lower completion. High-cost plugs compared to ME plugs
  - Requirement for small volume between the two plugs due thermal expansion and pressure exceeding ratings of the plugs

As installed

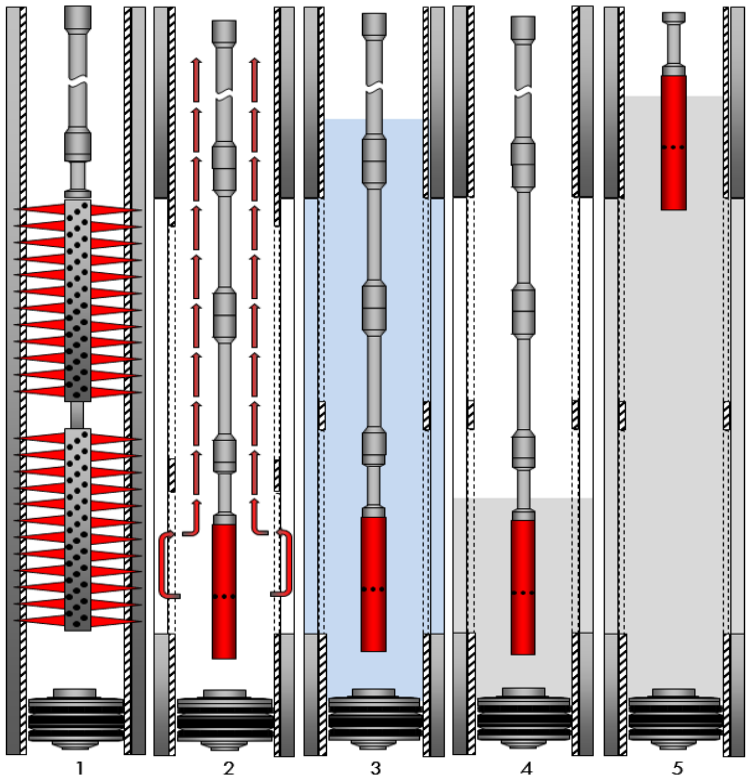


2 independent barriers



Logging Impact – No PWC

**PWC interval = poor cement intervals identified by CBL*



1 – RIH with perforating guns, position on depth and fire same. POOH with spent gun string

NOTE: If sufficient sump length is present the gun string can be dropped and (LIH)

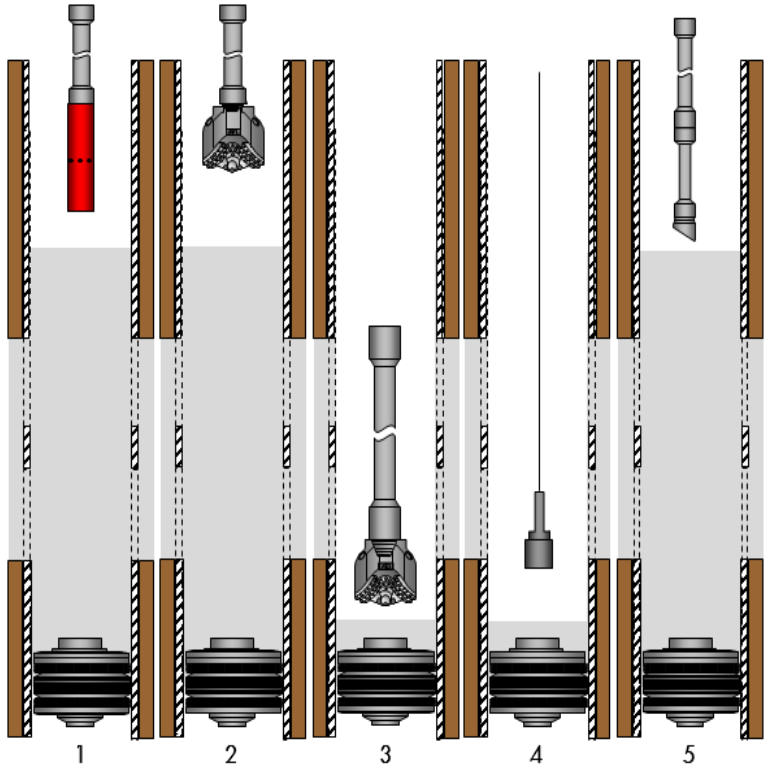
2 – RIH with jet type wash tool assembly. Perform wash operation

3 – Spot spacer via jet tool ports

4 – Place cement plug across perforated interval via cement spray nozzles

NOTE: The operational schematic above does not detail the cement spray tool

5 – POOH with PWC assembly



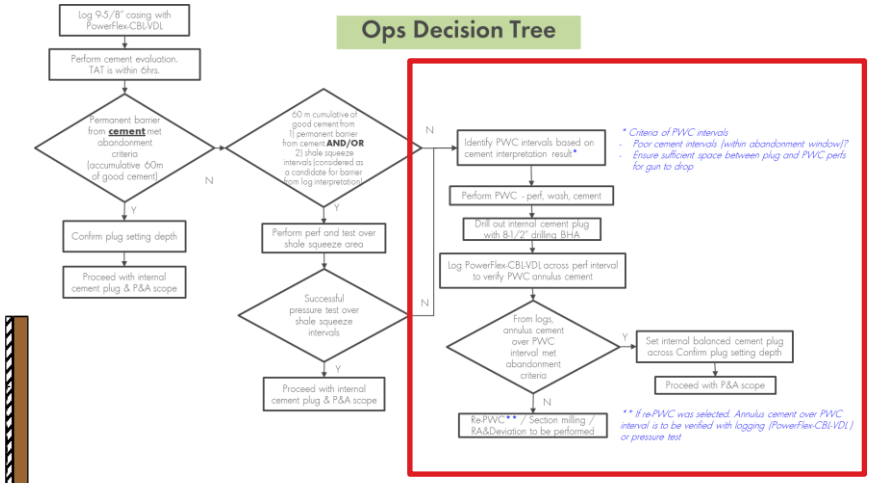
1 – PWC operation completed as per standard operating parameters

2 – RIH with cement drill out assembly and WoC (WoC time may have elapsed dependent on time for cement to set versus time to round trip)

3 – Drill out cement across perforated interval and POOH

4 – Rig up E-Line and perform log across perforated interval to verify an acceptable bond has been created in the annulus. POOH with logging tool string and rig down E-Line

5 – RIH with cement stinger and place internal cement barrier. If required, cement plug can be tagged and pressure tested



Logging Status

4 CBL logging completed, confirming sufficient annular barrier to place cement in tubing

Potential Cost Saved (Estimate)

~$20 million

Time Saved

4 weeks (1 week per well)

Rig rate

~$630,000 per day

- Excluding material and personnel cost

Knarr 34/3-A-1 H well

Stuck THMRT in Tubing Hanger

- Run #1 with the THMRT was a misrun. Was not able to enter in with the Isolation Sleeve on the bottom of the THMRT - *NCR!*
- Removed the Isolation Sleeve on Run #2. Able to land and latch to the TH
- Not able to pull TH free with up to 365 tons overpull
- Not able to release THMRT from TH. Tool stuck inside TH
- XT with TH and THMRT wet stored on seabed. Was recovered a year later and tool disassembled at base to for the root cause of the incident
- Learnings: Min ID thru tool and inspect tool prior to load out

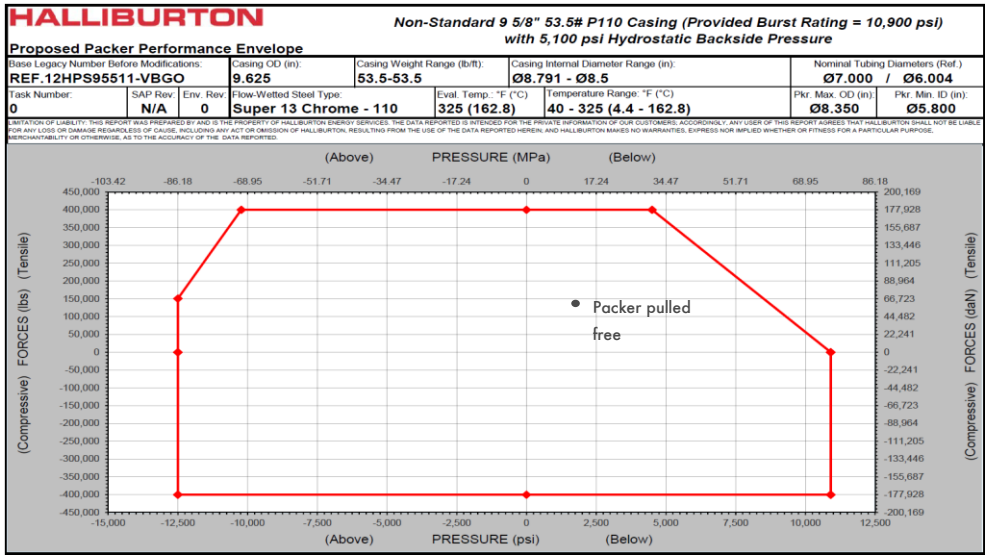
Knarr 34/3-A4 H well

Parted Tubing

- Root cause for failure still unclear
- Findings indicates that the tong mark has cold worked the 13Cr which makes it more susceptible to Stress Corrosion Cracking (SCC)
- The base oil injection into the annulus during the retrofit gas lift installation in 2019 could have introduced a lot of oxygen which caused cracking initiation
- The subsequent seawater introduction may have pushed the tubing "over the edge"

Production Packer pulled free

- Packer pulled free with 70 tons overpull when it was rated to 180 tons (40% of rating)
- CCL from DynaBlade run verified – depth reference OK
- Oxygen in seawater could corrode carbon/low alloy steel, P110 casing and also pit 13Cr material



Knarr/Gaupe Decom Phase 2 (Well PP&A):

- Completed 90 days ahead of plan

Conclusion

- Goal Zero - Efficient P&A operation
- Operational efficiency suggestions / improvements welcomed and embraced
  - DP and batch operations, hopping, BOP hang off tool, cement through TD, XT handling & wet storage
- Consistent tubing pulling at up to 30 joints/hr including control lines (!)
  - No NPT on TRS (35.000 m tubing recovered)
- 10 days savings during Knarr batch operation using BOP shuttle tool for well hops
  - A total of 14 jumps after BOP was installed first time on A1 (including 2 lift offs on A1)
- Wet storage of HXT saved HSE exposure and 7 rig days compared to pulling them to the rig
- Excellent ROV operations
- No PWC saved 40 days rig time
- Successfully Subsurface Abandoned Nine (9) Gaupe and Knarr wells → 90 days ahead of plan