HAVTIL FAGDAG PLUG AND ABADONMENT

Magnus Svensson, Manager Subsurface Drilling and Wells

OFFSHORE NORGE

OFFSHORE NORGE

WHO WE ARE

Offshore Norge organises companies producing oil and gas, suppliers to activities on the Norwegian continental shelf, as well as companies in ocean-based renewable energy production and offshore mineral extraction.

We fulfil a range of roles:

- Employer organisation
- Interest group toward authorities and society
- Arena for industry cooperation
- Offshore Norge represents over 100 member companies with around 35.000 employees

PLUG AND ABANDONMENT

WELL CONTROL KEY FIGURES FOR 2024

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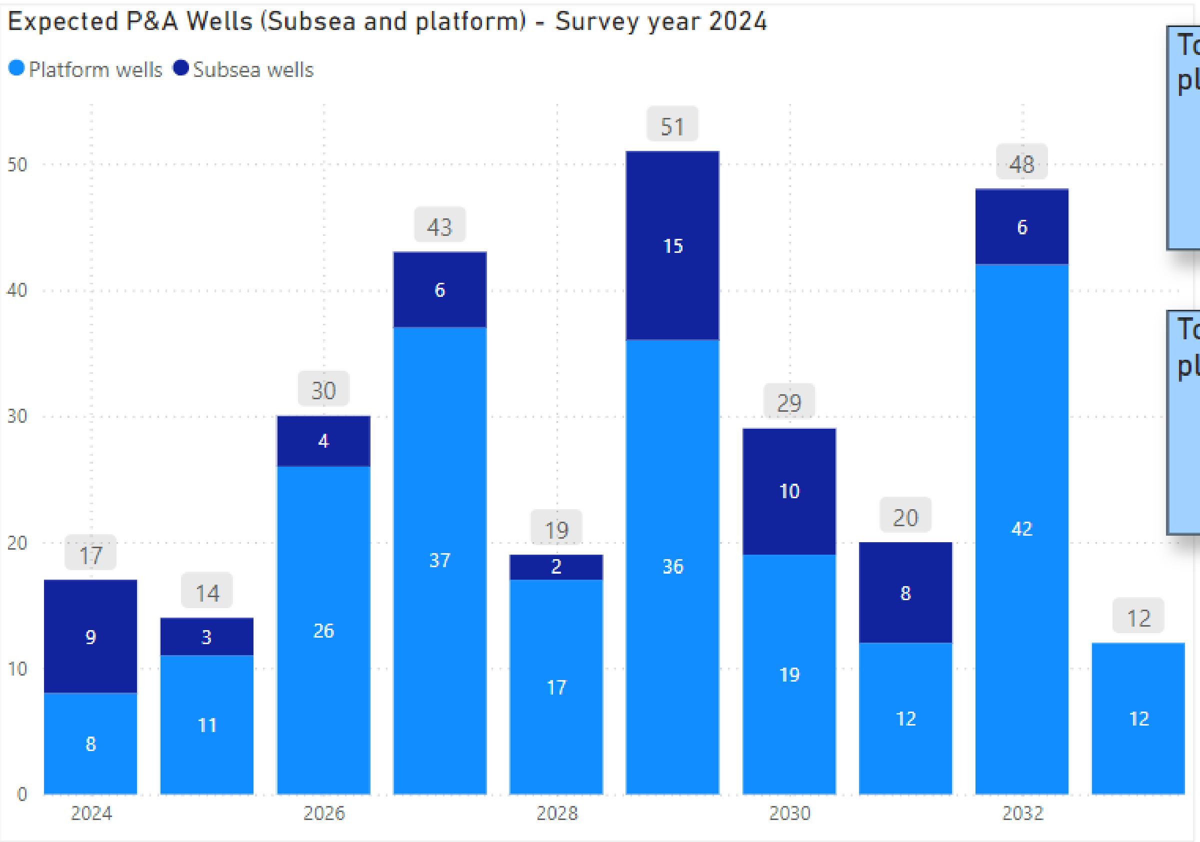
- 1 Green during P&A Operation and recompletion of overburden
- 3 Grey related to P&A e.g. release of gas volumes from old mud in annuli / cracked tubing++

  - Non classified 16 incidents shared for common industry learnings

WELLS DECOMMISSIONING

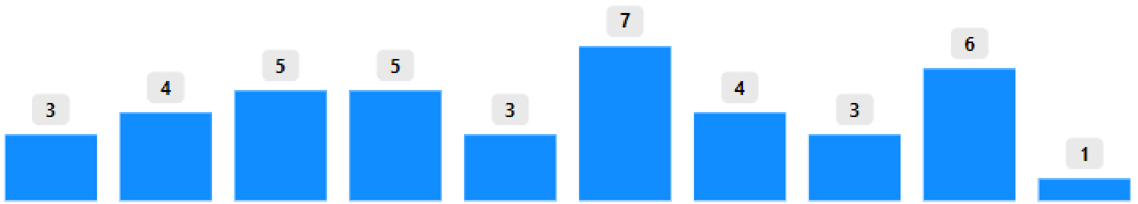


Total platform wells to be plugged 2024-2033

220

Total subsea wells to be plugged 2024-2033

63



Number of assets

*There are **220 platform wells and 63 subsea wells** planned against **250 platform wells and 50 subsea wells** indicated last year.*

OVERVIEW 10-YEAR COST FORECAST (2024-2033)

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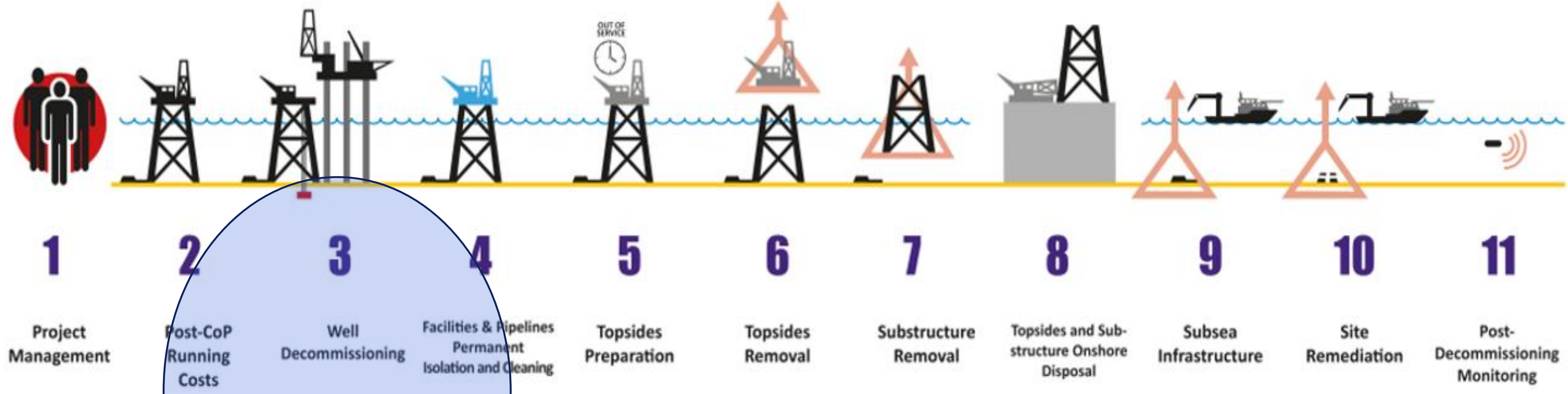
Market potential



1.5	0.7	27.9	3.5	1.2	5.0	3.3	2.0	1.7	0.1	<0.1	47

All values are 2024 BNOK

60%

P&A PHASES

	PHASE 1		PHASE 2				PHASE 3
POTENTIAL FOR COST SAVINGS	?	?	?	?	?	?	?
COST DISTRIBUTION	XX%	XX%	XX%	XX%	XX%	XX%	XX%
	Planning for phase 1	Wellbore diagnostics	Operational planning for phase 2	Access to establish barriers	Establish barriers	Verify barriers	Casing & Conductor removal

How to reduce cost by XX%?
How to reduce time used by XX?
How to increase reuse by XX%?

P&A ROADMAP

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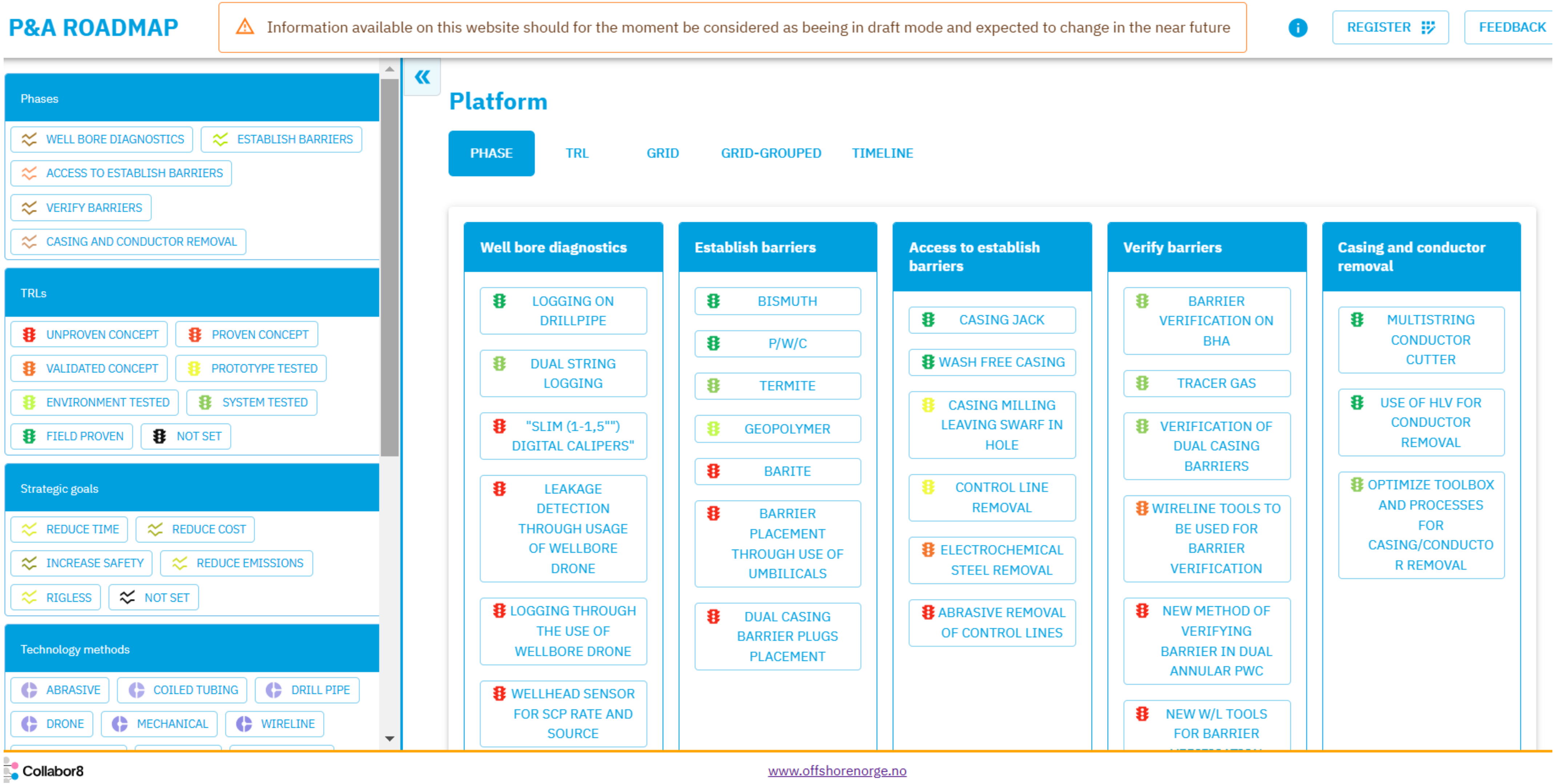

https://pa-roadmap-app.collabor8.no/

Lewis Harper
Programme Manager - Collaborations
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ConocoPhillips equinor Harbour Energy OKEA PETROBRAS REPSOL TotalEnergies

Strong Delivery

£5.37M
Invested with industry, academia & government

£4.77m
Leveraged from industry

5.87+ Mt C02e
Abated by 2030 (forecast)

19
Completed/ Live Projects

35+
Technologies screened

27
Field trials completed, planned or underway

7
Supporting operators

3+
Thought leadership contributions

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4
Continents
North America, South America, Europe and Oceana

8
Countries
Brazil, America, UK, Norway, France, Denmark, Netherlands, Australia

7
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A Problem Shared is a Problem Solved.

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Discover more

Multi-Operator collaboration accelerating the rate in which technology is developed, tested and piloted for well decommissioning.

Alternative Barrier Materials

Alternative materials used solely or in composite barriers have potential to provide more reliable and resistant isolation compared to cement.

Inspection and Verification

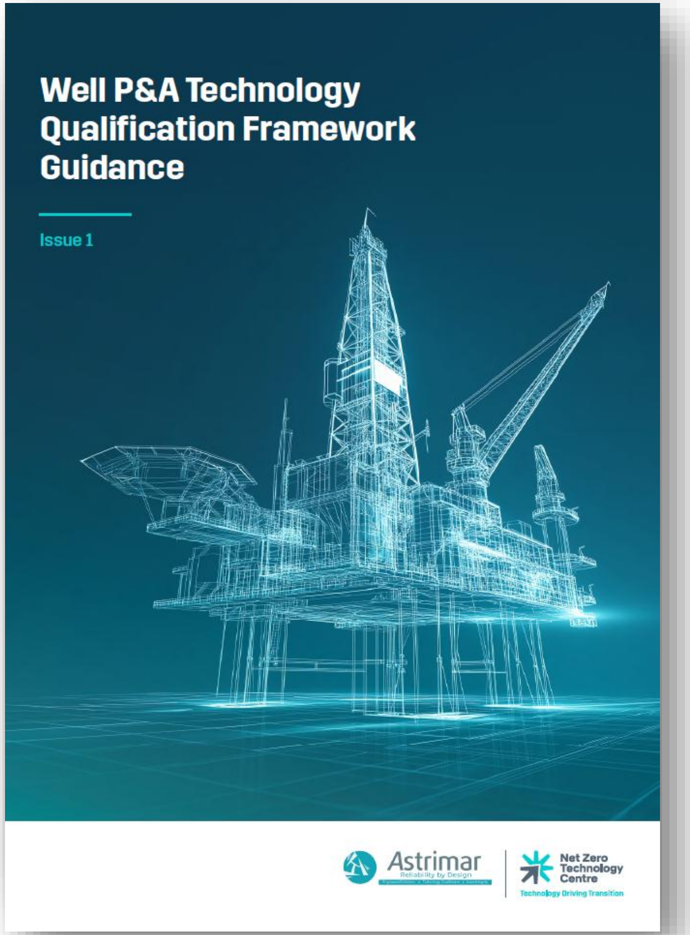
Reliable barrier design and construction relies on assessment of the integrity through existing well construction. Through tubing evaluation allows for this to be completed in advance of the abandonment programme.

Enabling Technology

Enabling technologies provides through tubing services to perform a wide range of task to support barrier placement.

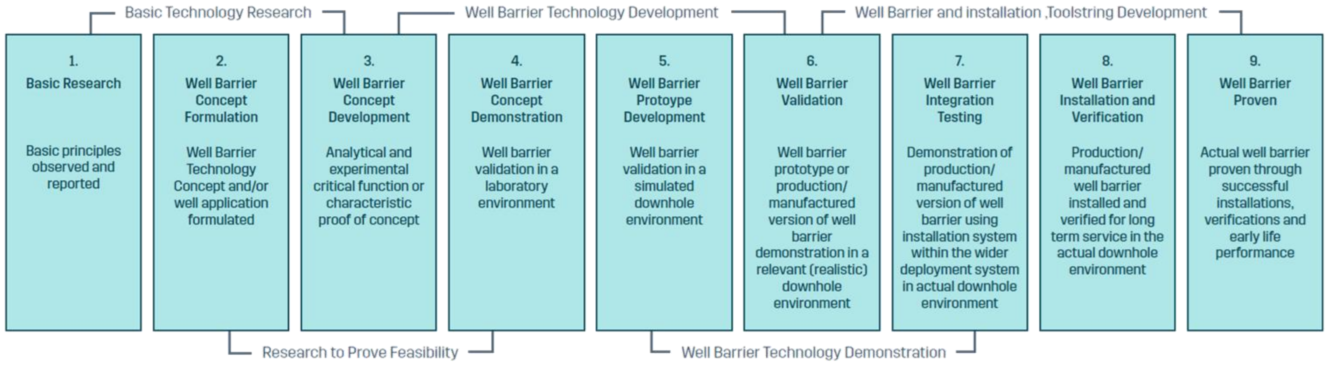
Case Studies: Global TQ Framework

To streamline the acceptance and use of alternative materials for use in the permanent plugging and abandonment of oil and gas wells



- Applies principles and processes from established Technology Qualification Processes such as DNV-RP-A203.
- Incorporates requirements from regulations and standards around the globe such as OEUK and Offshore Norge.
- Bespoke to unique application of Alternative Materials for Well P&A.

Standardised framework across multiple operators and regions, applicable to all material and barrier types which enables early engagement with regulators and similar bodies.



Step 1

Candidate Technology Identification

Before a technology can be assessed for its suitability for use, it is essential to be clear what the technology being considered consists of. Any options within a technology specification need to be confirmed such that the identified technology is clearly defined and unambiguous.

Step 2

Technology Specification against Requirements

The definition of a qualification basis underpins each of the other TQ activities. This is recognised in all of the guidance documents as the initial step in defining technology goals and requirements. The technology specification against requirements step is intended to provide a common approach to defining technology requirements for a specific application and the identified technology's ability to meet those requirements.

Step 3

Assessment of Technology Maturity and Qualification Gaps

This step is recognised by all key TQ guidance documents. However, they differ significantly in how the technology assessment and maturity assessment activities are carried out, the generic TRL ladder (levels 1 – 9) widely adopted across many industries are very high level in their definition and relate to technologies that can follow a traditional concept to prototype to deployment testing programme. Because novel barriers are not fully formed (and material properties developed) until they are deployed in the well, the route to achieving each TRL has to be adapted. The development of the NZTC TQ framework has involved a significant collaborative effort to define what each TRL means for novel well barriers and how they can be achieved.

Step 4

Assessment of Failure Modes (FMECA)

A rigorous threat assessment (often undertaken as a failure mode, effects and criticality assessment, FMECA) is considered an essential step in the Qualification process to define an effective technology plan. Many guidance documents recommend that all technology qualification activities are traceable back to the FMECA.

It is not clear how effectively this is done as part of typical TQ practice as there is relatively limited guidance on how FMECA should be performed as part of a technology qualification process. There is even less guidance on how this should be applied to novel well barriers through the critical life cycle stages of installation (to achieve required material properties and geometries for a permanent seal), verification and validation (to confirm the requirements of a permanent well barrier are met, and long-term integrity (to ensure well barrier integrity is maintained in perpetuity). The NZTC TQ framework therefore provides a guided template to ensure that the FMECA is carried out in a manner to support effective qualification for long term barrier assurance.

Step 5

Identification Qualification and Risk Mitigation Actions

The qualification plan is at the heart of the TQP and is a key output from the earlier steps. All of the industry TQ guidance documents recommend the creation of a qualification plan. The key output of the Assessment of Failure Modes (FMECA) is an identification of qualification actions which may include actions like physical testing of materials and components, analysis and simulation and process development and documentation to name a few. This fundamental input to the creation of a qualification plan ensures traceability between the qualification test plan, the FMECA and the technology qualification basis/requirements.

Step 6

Technology Qualification evidence and Deployment Checklist

All of the industry TQ guidance documents recognise the need to assess or evaluate the results of qualification activities against requirements and ensure that all mitigations have been put in place. The operator needs to be able to demonstrate to the regulator that they have gained sufficient confidence from the Technology qualification activities and remaining risk mitigations that any residual uncertainty and risks have be reduced to as low as reasonably practicable. The deployment checklist developed within the NZTC TQ Framework is a key tool for ensuring all relevant steps and actions have been fully implemented.

Case Studies: Global TQ Framework

To streamline the acceptance and use of alternative materials for use in the permanent plugging and abandonment of oil and gas wells

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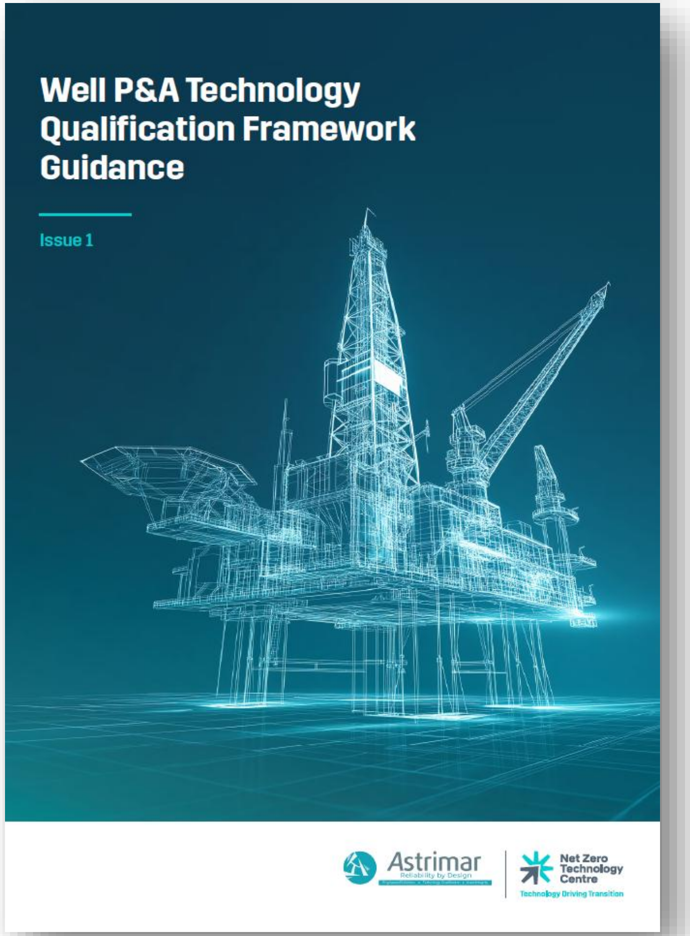
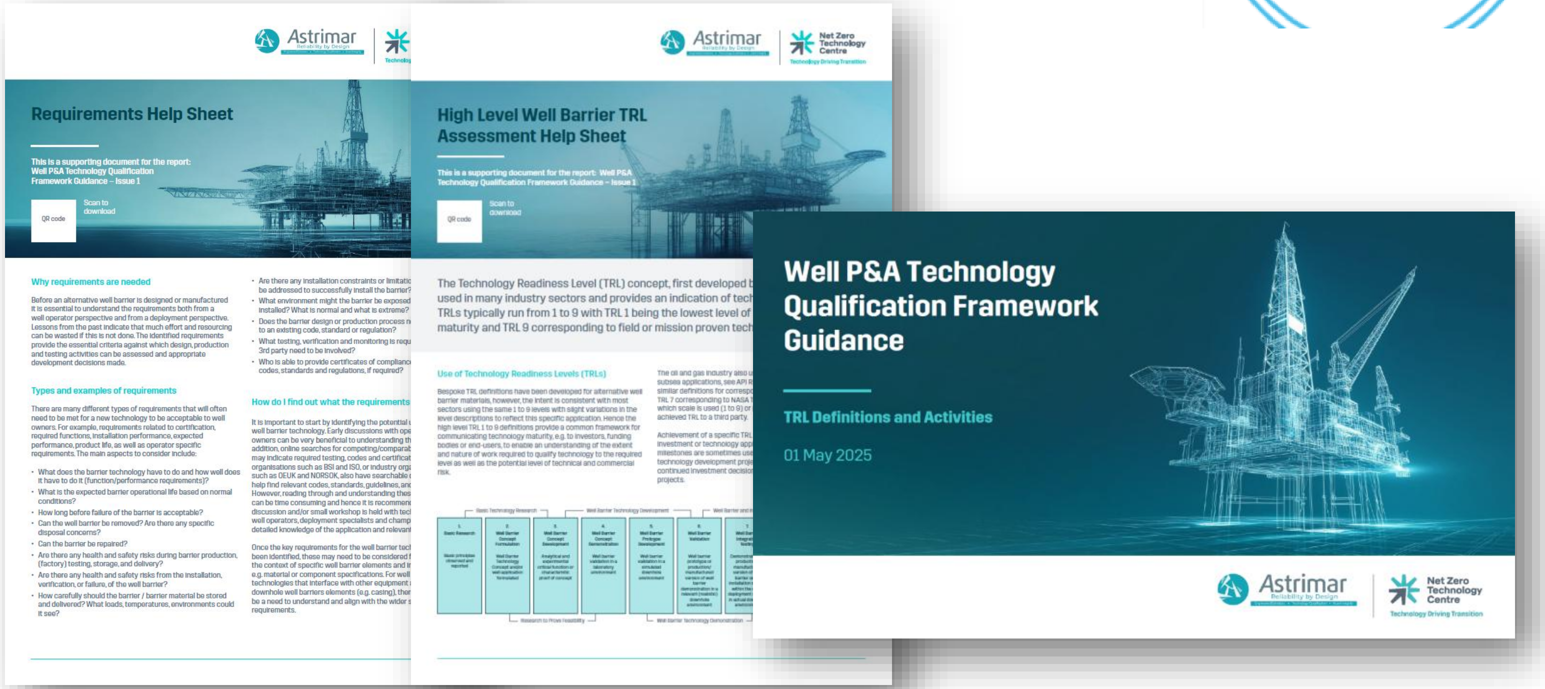


Framework Composition
1. Requirements Proforma and Help Sheet.
2. TRL Maturity Assessment and Help Sheet with TRL Definitions.
3. FMECA Template with >93 pre-populated considerations.



Case Studies: Global TQ Framework

Long-Term Monitoring: How many? How long? What value does this bring?

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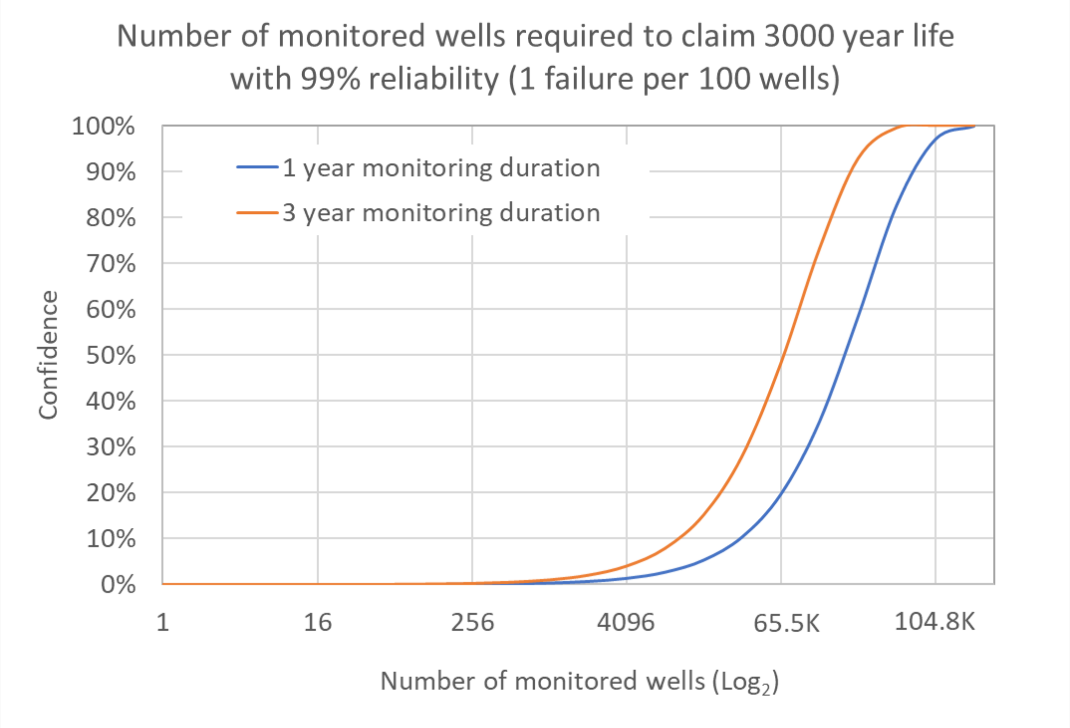
Long term validation will NOT come from field testing → Unreasonably practicable



Source: NZTC Astrimar Technology Qualification Framework for Well Plug and Abandonement

"For technologies where lifetime is a major consideration and a key technology issue, lifetime needs to be addressed as part of the technology readiness assessment"

NASA recommend this is achieved through understanding and testing life limiting mechanisms through the TRLs:

TRL 4 – Identify life-limiting mechanisms and failure modes.
TRL 5 – Characterize, by means of test/ analytical model/ simulation, the physics of the life-limiting mechanisms and failure modes
TRL 6 – Verify by test/analysis that the technology is resilient to the effects of life-limiting mechanisms.
TRL 8 – Complete life tests.

Source: NASA - Technology Readiness Assessment – Best Practice Guide [SP-20205003605]

Case Studies: Global TQ Framework

Binomial Distribution: How many tests to demonstrate reliability?

In order to validate equipment, many standards require the equipment to pass one or more tests. The following equation, can be used to calculate confidence, reliability, or number of test items:

$$CL = 1 - R^n, R = (1 - CL)^{\frac{1}{n}}, n = \frac{Log(1 - CL)}{Log(R)}$$

Where:

- R = test item reliability
- n = number of tests on a single test item or number of test items on a single test
- CL = Confidence level

Equation can be used to answer:

- How much reliability can be claimed if you want to be 90% confident from a single passed test?
- If you are looking to achieve a reliability of 90% how many test items would be needed to pass tests to give 90% confidence of achievement?

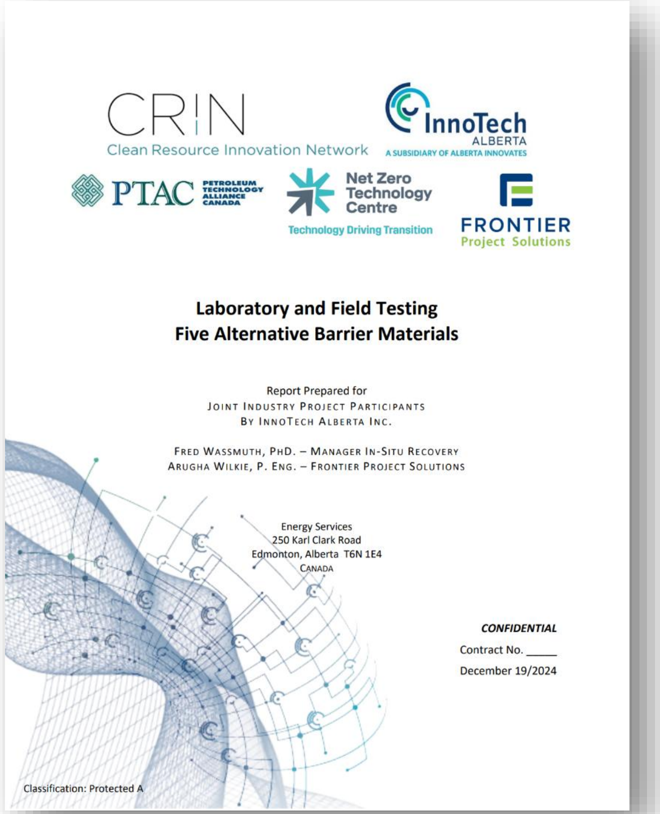
Number of Verification Tests Required

Number of failures	Reliability	Confidence												
		0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	95%	99%	99.0%
9/10	10%	0	0	0	0	0	0	0	1	1	1	1	2	3
4/5	20%	0	0	0	0	0	0	1	1	1	1	2	3	4
7/10	30%	0	0	0	0	0	1	1	1	1	2	2	4	6
3/5	40%	0	0	0	0	1	1	1	1	2	3	3	5	8
1/2	50%	0	0	0	1	1	1	1	2	2	3	4	7	10
2/5	60%	0	0	0	1	1	1	2	2	3	5	6	9	14
3/10	70%	0	0	1	1	1	2	3	3	5	6	8	13	19
1/5	80%	0	0	1	2	2	3	4	5	7	10	13	21	31
1/10	90%	0	1	2	3	5	7	9	11	15	22	28	44	66
1/20	95%	0	2	4	7	10	14	18	23	31	45	58	90	135
1/100	99%	0	10	22	35	51	69	91	120	160	229	298	458	687
1/999	99.9%	0	105	223	356	511	693	916	1203	1609	2301	2994	4603	6904

Source: NZTC Astrimar Technology Qualification Framework for Well Plug and Abandonement

Case Studies: CRIN Alternative Products JIP

Canadian collaboration to accelerate local and international acceptance for cement alternative sealing products by testing them on fifteen oil and gas wells.


CRIN
Clean Resource Innovation Network

InnoTech ALBERTA
A SUBSIDIARY OF ALBERTA INNOVATES

PTAC PETROLEUM TECHNOLOGY ALLIANCE CANADA

Net Zero Technology Centre
Technology Driving Transition

FRONTIER Project Solutions

Laboratory and Field Testing
Five Alternative Barrier Materials

Report Prepared for
Joint Industry Project Participants
By InnoTech Alberta Inc.

Fred Wassmuth, PhD. – Manager In-Situ Recovery
Arugha Wilkie, P. Eng. – Frontier Project Solutions

Energy Services
250 Karl Clark Road
Edmonton, Alberta T6N 1E4
CANADA

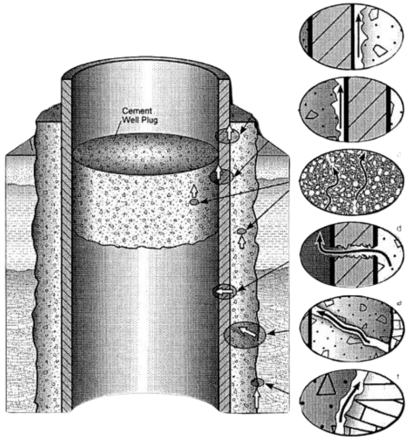
CONFIDENTIAL
Contract No. _____
December 19/2024

Classification: Protected A

Alternative Products Consortium

The objectives of the project were to deliver products that had a performance superior to cement, reduce greenhouse gas emissions from leaking wells by decreasing the number of inactive wells and overall reduce financial liabilities whilst creating business opportunities for Alberta and Canadian companies.

The process steps to achieve these objectives were:



1. Rapid laboratory testing of alternative materials to achieve regulatory acceptance.
2. Subsequent field trials of the accepted technologies.
3. Publicise the results to gain market acceptance.

6	4	15
Products tested in the lab	Products taken to the field	Wells Plugged

Case Studies: Axter Retrieve

The enabler for permanently leaving the tubing string in the wellbore by removing the control line outside the tubing string to permit cementing/plugging the tubing in place.

Operations performed in Ullrigg well U-08 by TE
Tubing size: 4-1/2” 12.6ppf. L80
Casing size 9-5/8”
Operations depth: 545 - 557mRKB
Well inclination at depth: 27˚

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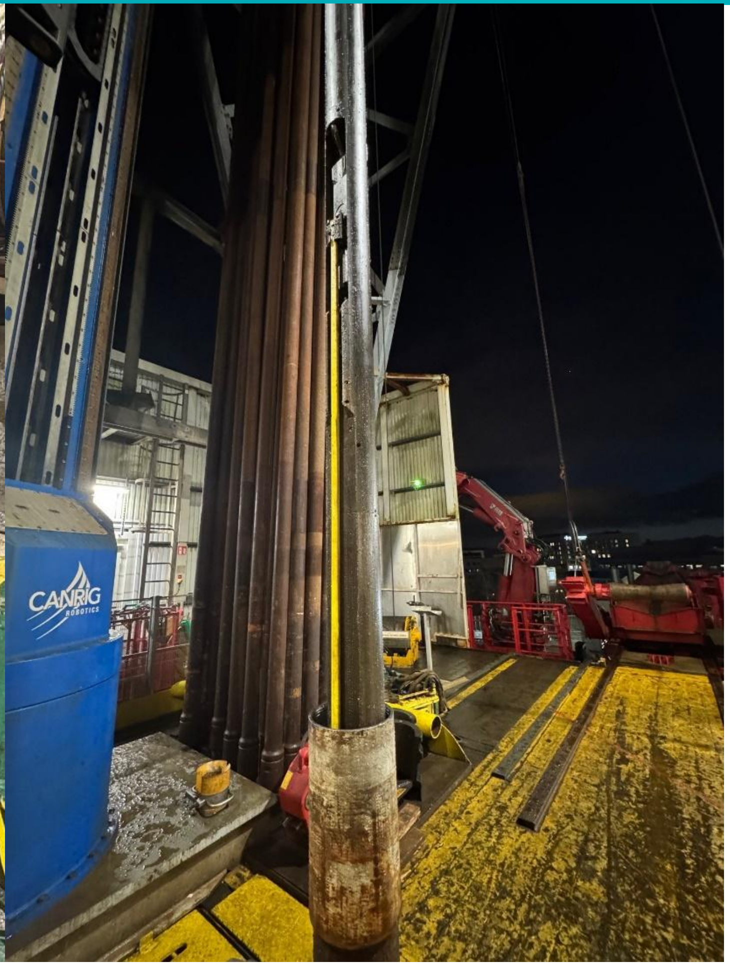
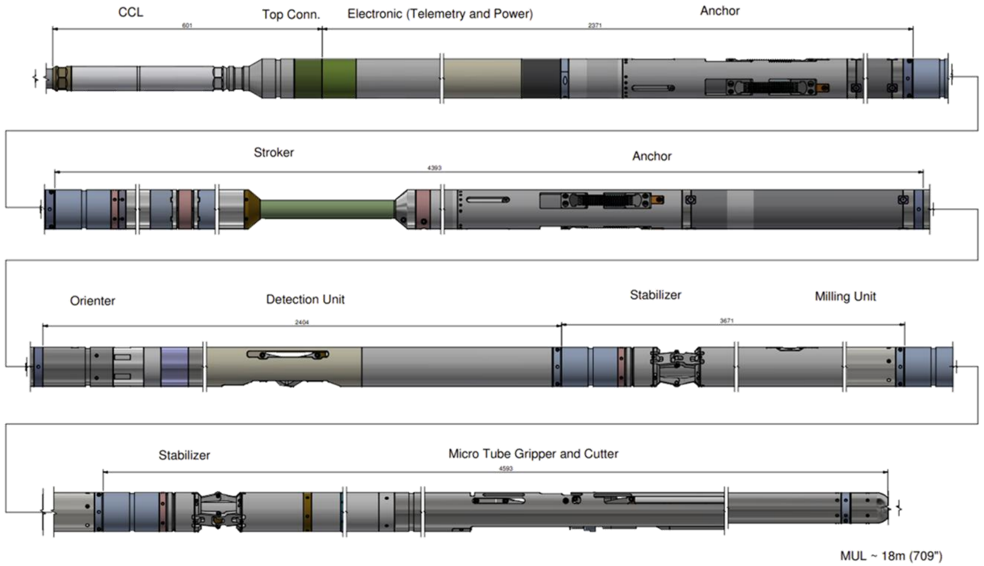


Total Energies & AkerBP successful control line retrieval
Ullrig, Stavanger
27th January 2025

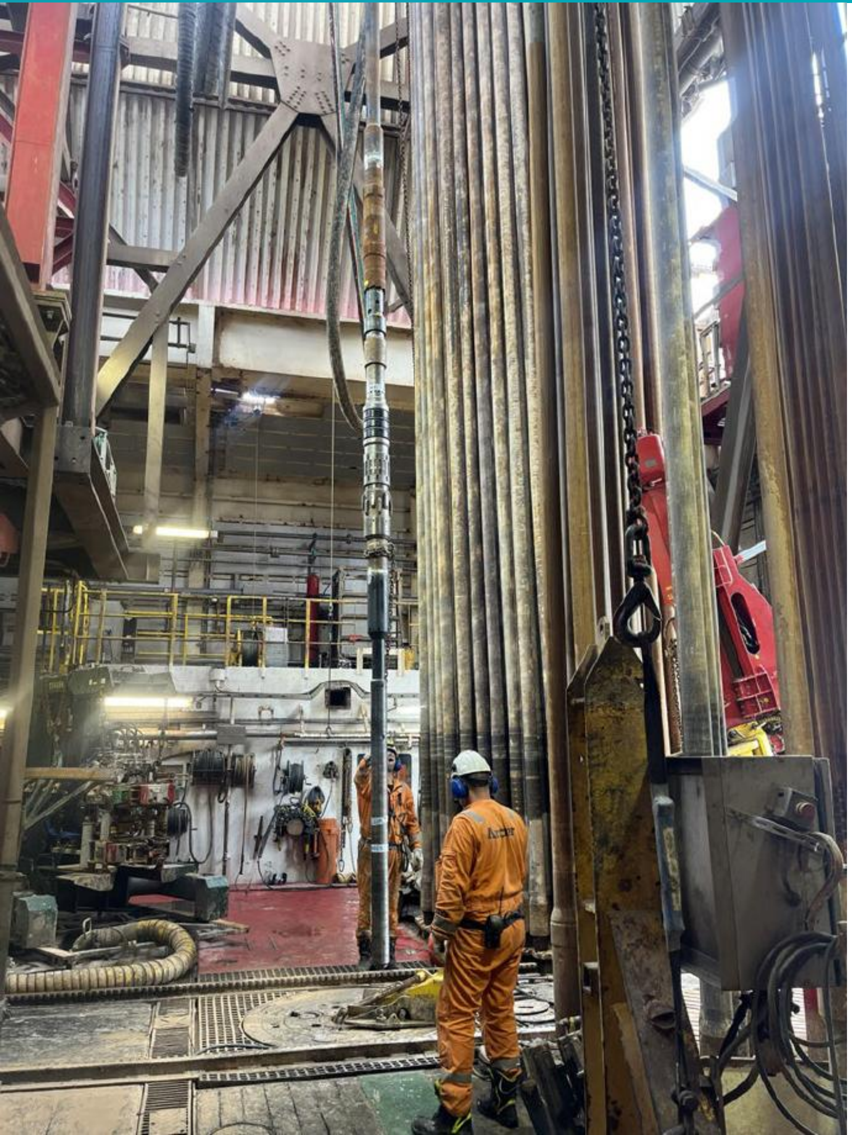
Axter Retrieve Tool String

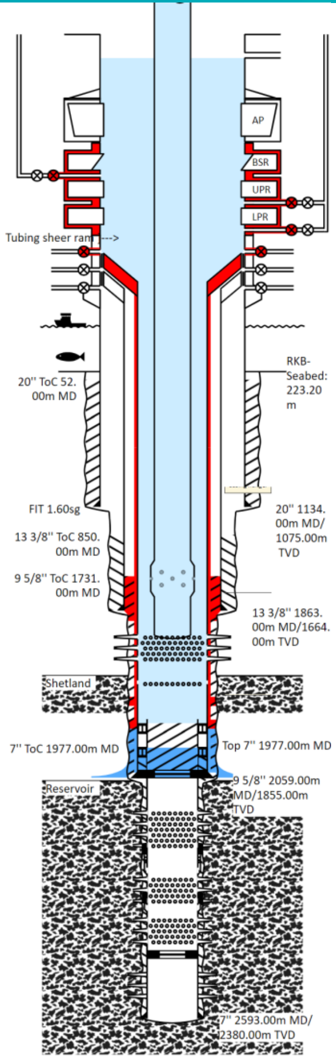
Axter Retrieve Operations - Ullrigg U-08
RIH to position toolstring for lower control line cut (557mRKB)
Identify position of control line, mill window and cut control line. - Total operation time 4 hrs. 10 mins.
Position toolstring for upper control line cut (545mRKB).
Identify position of control line, mill window and cut control line. Retrieve cut control line to surface. - Total operation time 5 hrs. 10 mins.



Case Studies: Exedra Balder Tracer Gas Tool

Tracer-gas-based verification method for P&A operations jointly funded by NZTC, NORCE and The Norwegian Research Council.





The pilot comprised of the following objectives and results:

1. To demonstrate detection of injected ethylene tracer gas below a PWC barrier.
2. To demonstrate downlink functionality of the Balder tool.
3. Demonstrate planning and execution including gas filling which the procedure was observed and certified by DNV.

Three examples of cost reducing P&A methods enabled by Exedra.

- Dual PWC barrier. Today's method of CBL log of casing does not apply to dual casing PWC. Hence, there is a need for an alternative verification method. The need is amplified by the challenges of ensuring good sealing beyond the first casing. Using dual PWC will eliminate the time-consuming pulling of the casing or section milling.

- 'Tubing left in hole' barrier. Leaving tubing in hole will for many P&A operations enable rigless operations, with significant cost reduction, compared with using a semi-sub drilling rig. Note: this proposed method is based on pressure response from Balder tool, not tracer detection.

- Short plug lengths, such as with bismuth. Bismuth is impermeable and expands while curing, hence giving a high-quality barrier. Due to the short length (typically 2-3 meters) it is critically important to verify properly. Bismuth plugs can also be set from LWIV.

Case Studies: Wellstrom T1000 Bismuth Plug

Electrically run bismuth plug than enables abandonments offline and CAN HALVE THE COSTS OF P&A in comparison to section milling and cement remediation.

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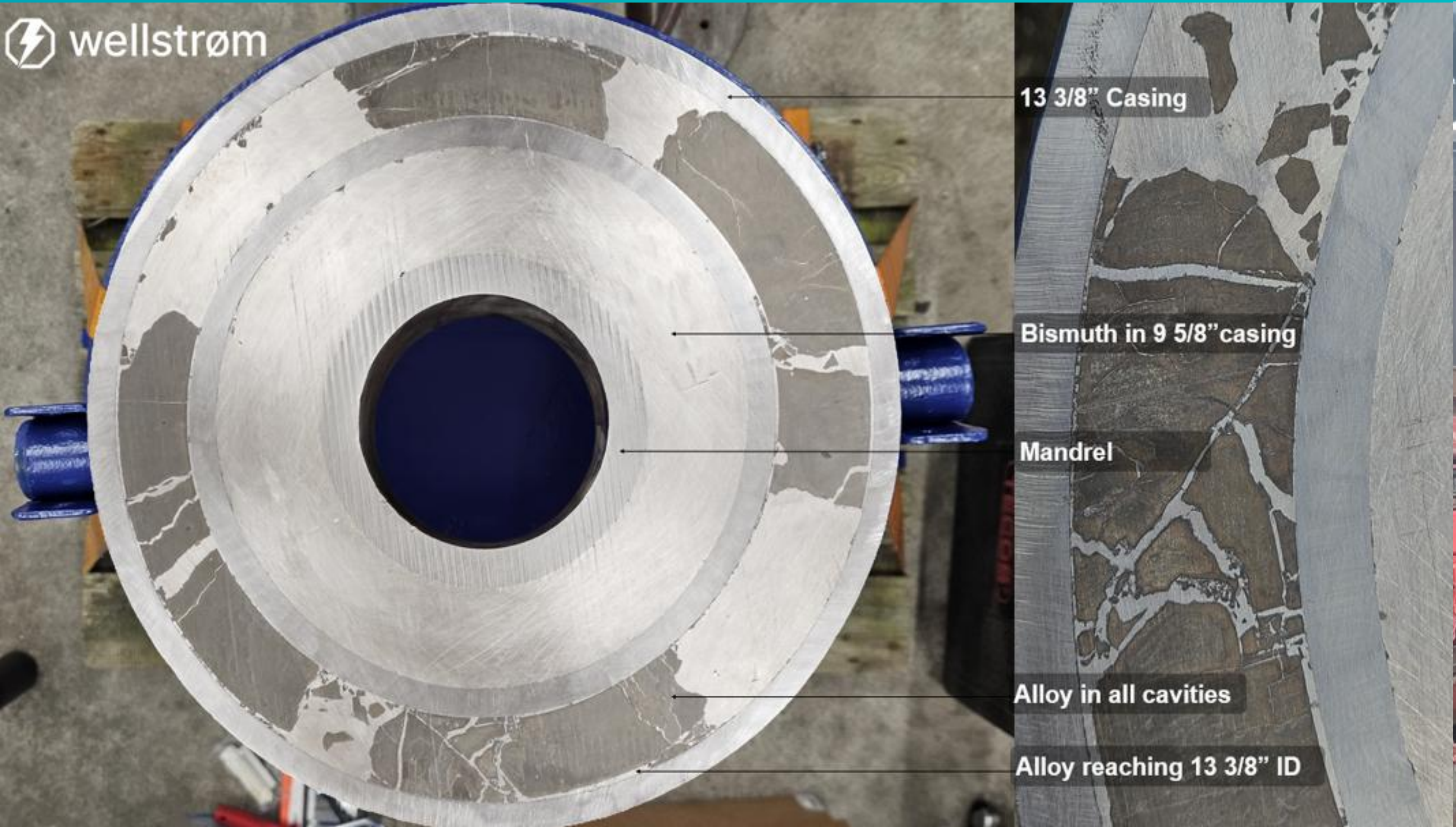

Case Studies: AAI Hydrate Melter Petrobras Pilot

Removing the plugs before setting the plugs…

Piranema 13 400m Hydrate Plug Pilot Well

When a hydrate plug is discovered within the Christmas tree or production string, the preferred solution is to reduce hydrostatic pressure using nitrogen or a lighter fluid.

However, many wells operate within strict pressure envelopes, and such pressure reduction can compromise well integrity.

There is an alternative of circulating heated fluid with coiled tubing but it is not so efficient. Therefore, a thermal tool could be employed to melt the hydrate plug after a glycol slug has been positioned above it.

In most of the cases the hydrate plugs inside the production string or (Wet Xmas Tree) are not that lengthy. The desirable solution comprehends a tool that could be continuously fed by the standard wireline cables.

Regarding Piranema 13, this well, nearing plug and abandonment (P&A), presents an ideal opportunity to test the tool. Hydrate formation is virtually certain in this well, eliminating the need to mobilize the tool from intervention to intervention until encountering hydrates. Based on offset well data, up to 400 meters of hydrate formation is anticipated in PRM-13.

This well was used to inject gas in the reservoir from 2011 to 2020.

Case Studies: Thru' Tubing Logging

Who is going to crack it first? In partnership with Islay Subsurface


Islay SUBSURFACE & ENGINEERING DELIVERING EXCELLENCE

Thru Tubing Logging: Market Landscape 2024

Report No.1 (Draft)

Compiled by Matt Benefield

Review: Iain Whyte & Sigrid Kramer

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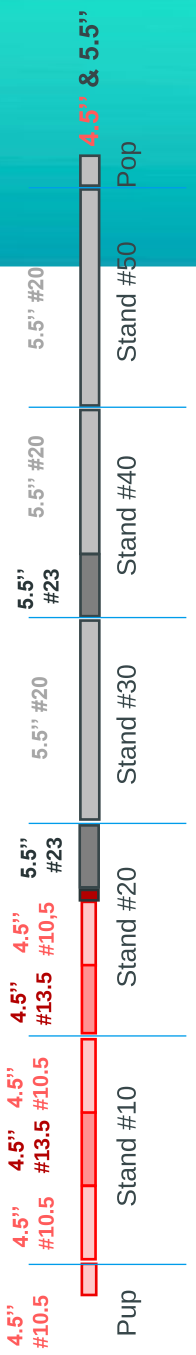
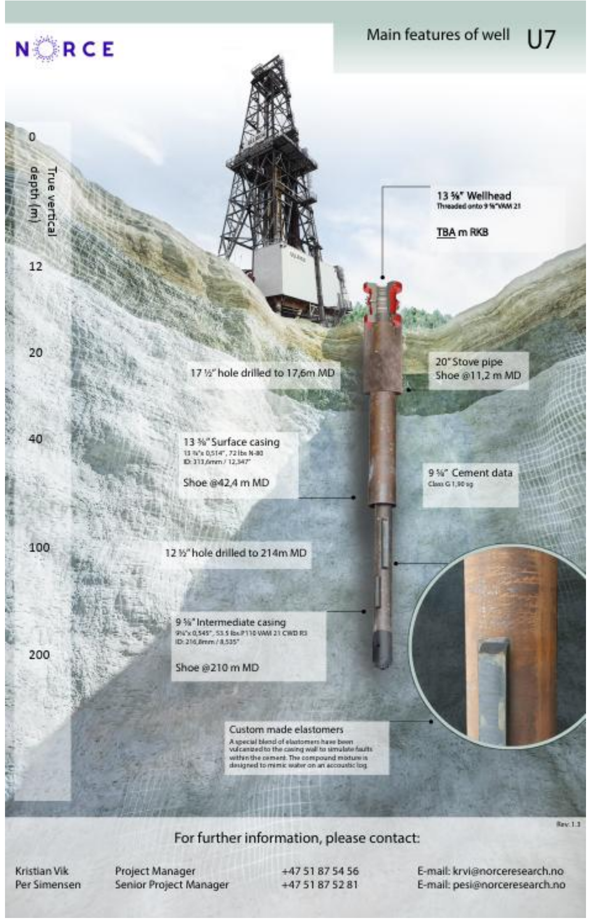


		Measurement Type				Processing			Tubing Evaluation			Casing Evaluation	Cement Evaluation			
Vendor	Current Technology Name	Acoustic	Nuclear	ElectroMagnetic	X-Ray	Machine Learning	Time Domain	Frequency Domain	Tbg Eccentricity	Tbg ID	Tbg Thickness (azimuthal)	Csg Thickness (azimuthal)	Top Cement	Bond Index	Chanelling	Ann A fluid



In recent years there has been a technology race between several vendors in the Through Tubing Cement Logging (TTL) space, with significantly different approaches taken. As one would expect, with different Research and Development budgets, different resources allocated, and manner in which the vendors have approached both tool design and processing, the race has not been equal!

The work comprises of two principal phases with this report summarising Phase 1:

- An overview of through tubing logging for cement evaluation and the various methodologies that are typically employed.
- Companies in the TTL arena – including status of technology development and expected timelines for commercial availability.
- Evaluation of the tools available for thru tubing logging from the four major service companies in the market at moment, in comparison to smaller, independent technology companies.
- The Collaboration will then decide on which companies/technologies to pass through to Phase 2 for the shoot-out at Ullrig.

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A Problem Shared is a Problem Solved.

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Discover more

Multi-Operator collaboration accelerating the rate in which technology is developed, tested and piloted for well decommissioning.

Pilot Opportunity Example

For example, if technology X are going to be run offshore with an operator - NZTC will cover the full cost associated with technology X and any necessary contractors provided the operator give in-kind access to the asset. The results of the trial will then be shared with the 7 supporting operators, once the operator has reviewed and agreed the material.

For example:
TAQA Cormorant North provided access to platform for Wellstrom to set a 9-5/8” x 13-3/8” plug. NZTC covered Wellstrom cost, up-front testing costs and third-party costs.

Benefit to host:

- De-risked use of alternative methods financed by 7 other operators.
- Opportunity to trial solution that can be performed off the critical path.
- International recognition as an operating leader in P&A.
- Access to Astrimar P&A TQ Framework for free.

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REPSOL
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