EXPRO

Case Study; Well Test Flow back Into the Hull of a DNV DRILL(N) Class Drillship

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Global Well Testing Product Line

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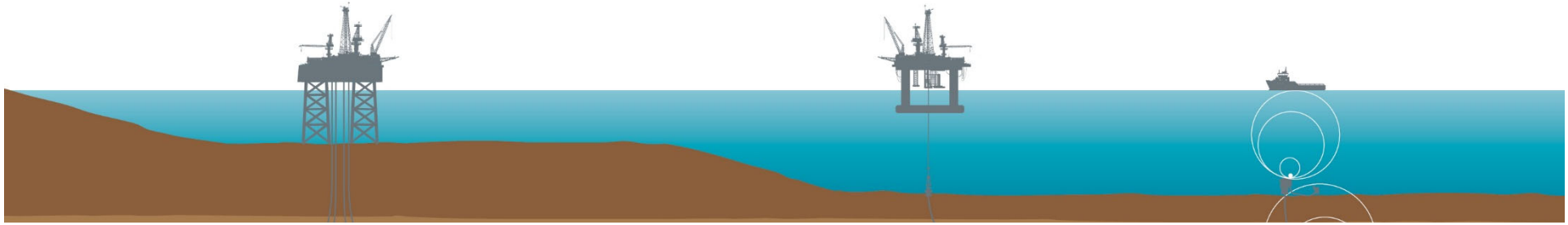
Agenda

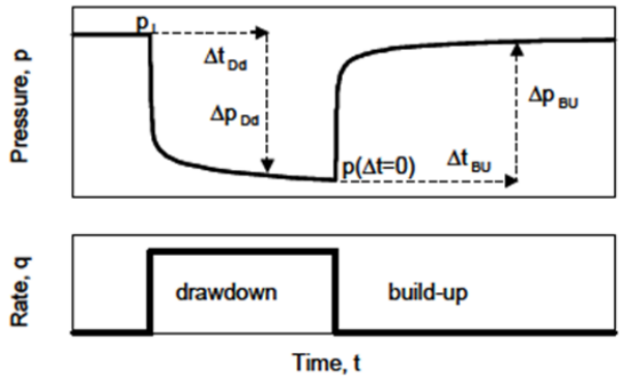
- What is a Well Test
- Practical Well Testing
- Why Surface Well Test Equipment?
- Extended Well Test
- Project Overview
- Design and Approval Process
- Project Execution
- Fluid Handling
- Project Specifics
- Project Outcome
- Questions and Discussion



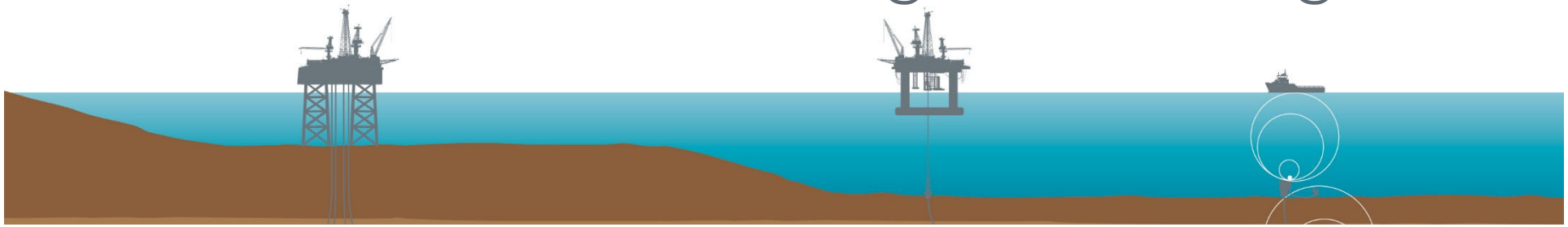
What is a Well Test

Well Testing can be defined as the process of data acquisition to gather the information and data to understand the reservoir properties and the rock information.

Pressure measurements recorded near the productive interval to form the basis for transient well-test analysis, and flow rate measurements to identify producing-formation limits.

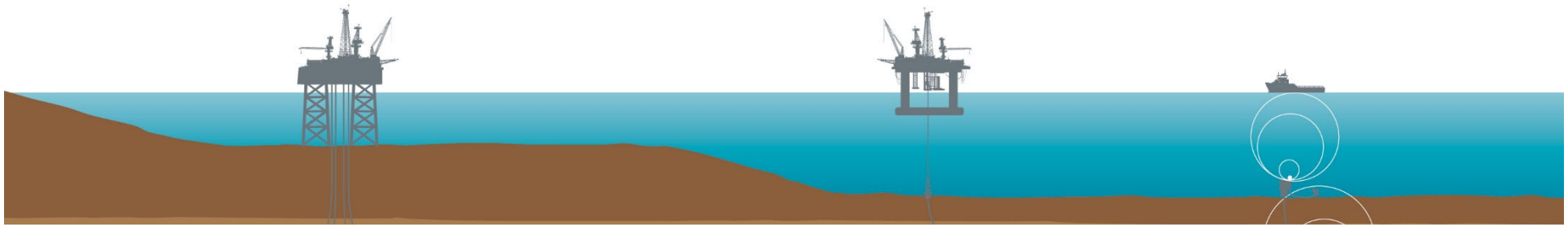


So Well Test can be described as : Flow Rate @ Surface & Pressure @ Down Hole



Practical Well Testing

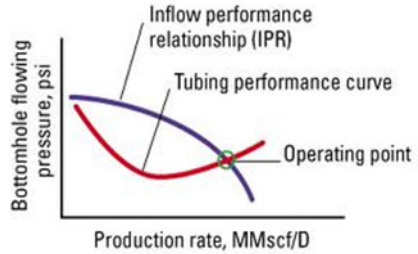
- Well Testing performed at various stages in the life of a well / reservoir:
    - Drilling - Exploration & Appraisal (E&A)
    - Completion - Development & Clean up
    - Production - Production Testing
- Test Objectives at each part of the life cycle range from simple identification of produced fluids and reservoir deliverability through to characterisation of complex reservoir features and attributes.
- Well Tests can be grouped into:
    - Productivity Testing
    - Reservoir Descriptive Testing



Practical Well Testing

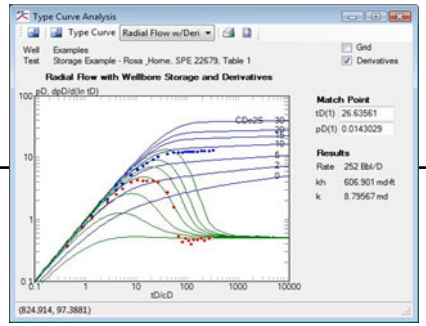
Productivity Testing

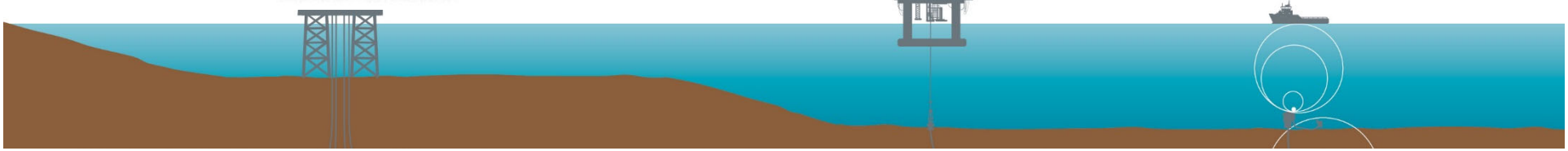
- Produced fluids and respective volume ratios.
- Sampling for PVT analysis
- Well deliverability
- Evaluate Completion Efficiency
- Characterise well damage (skin)
- Evaluate workover or stimulation treatment



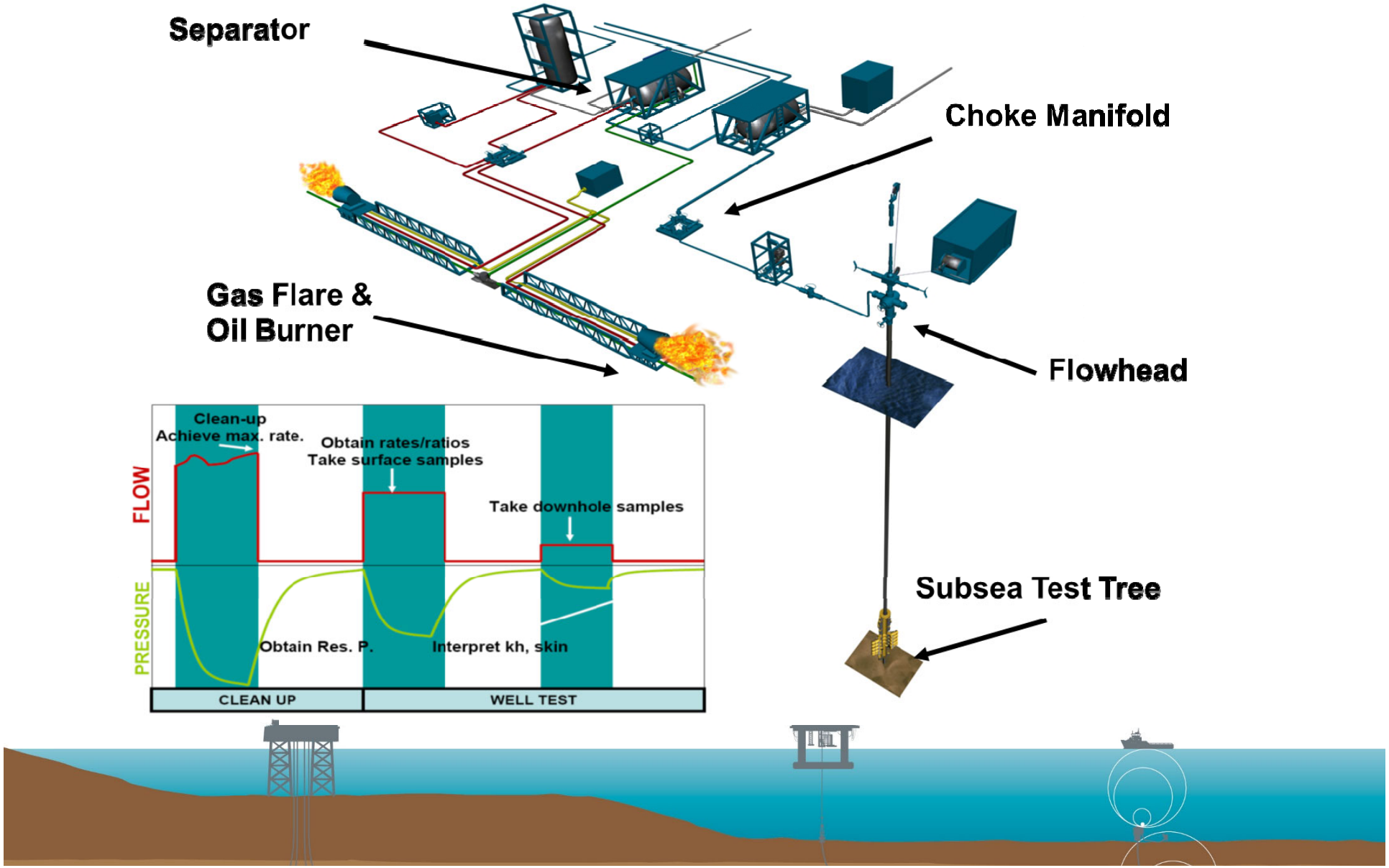
Reservoir Descriptive Testing

- Evaluate Reservoir Parameters
- Characterise Reservoir Heterogeneities
- Assess Reservoir extent and Geometry
- Determine communication between wells





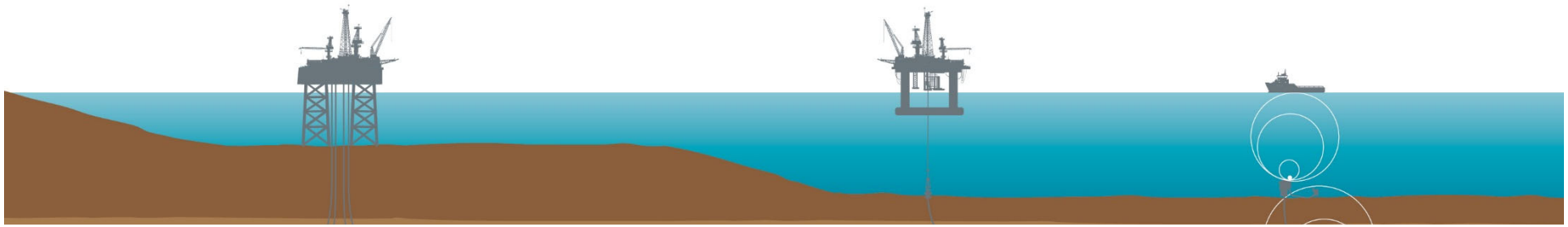
Typical Well Test Layout



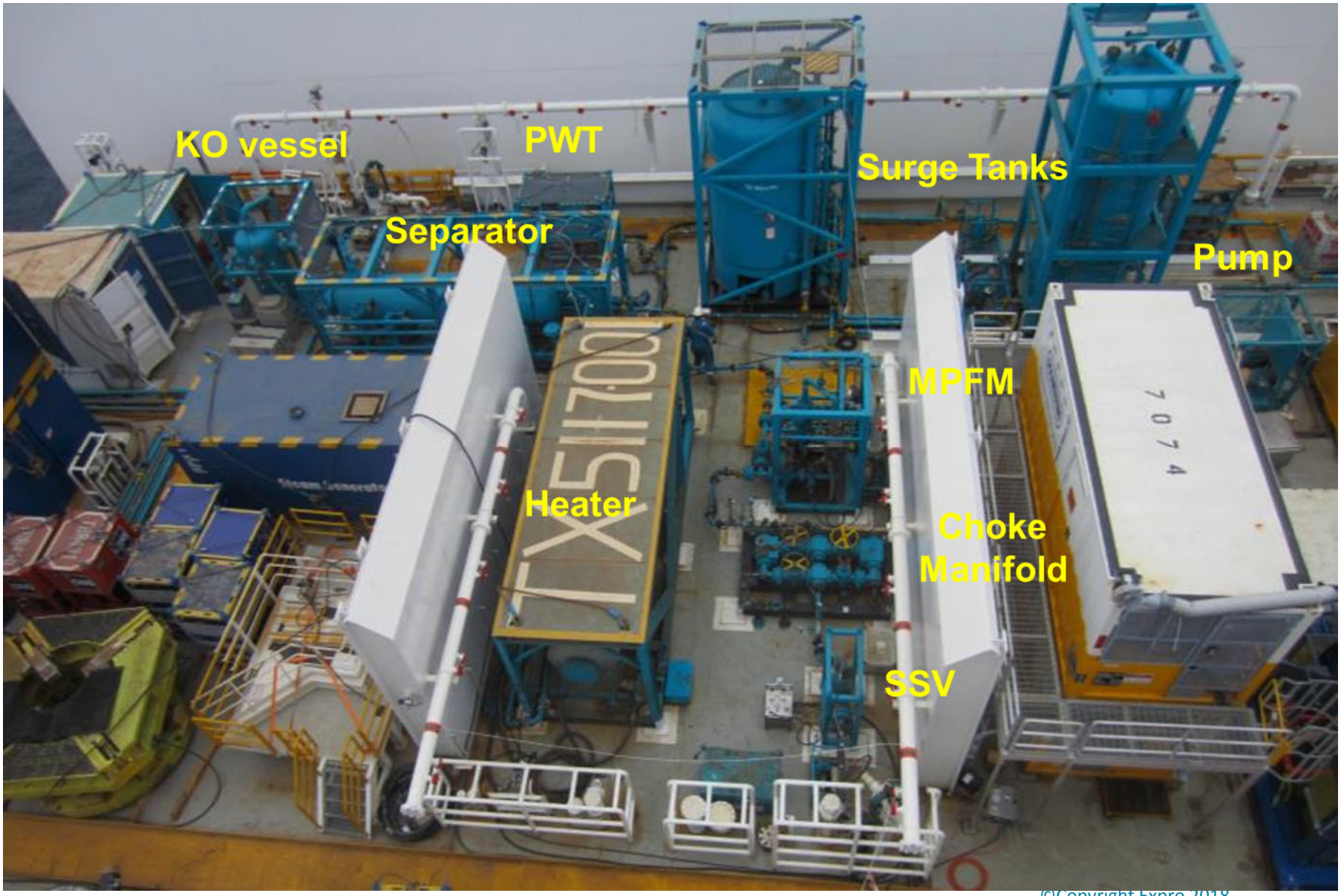
Why Surface Equipment?

Basic requirements for surface well testing equipment:

- Some means of controlling the flow of the well
- Ability to separate the hydrocarbons into individual phases for measurement and sampling
- Accurate measuring of all parameters
- Disposal of produced hydrocarbons



Surface Well Test Spread

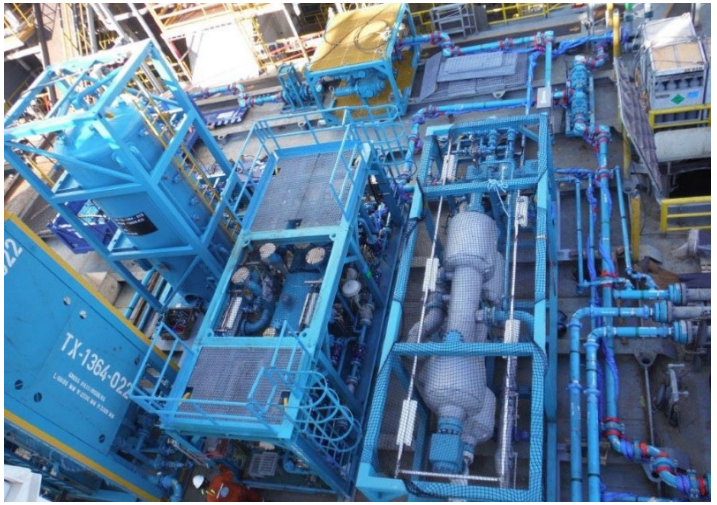


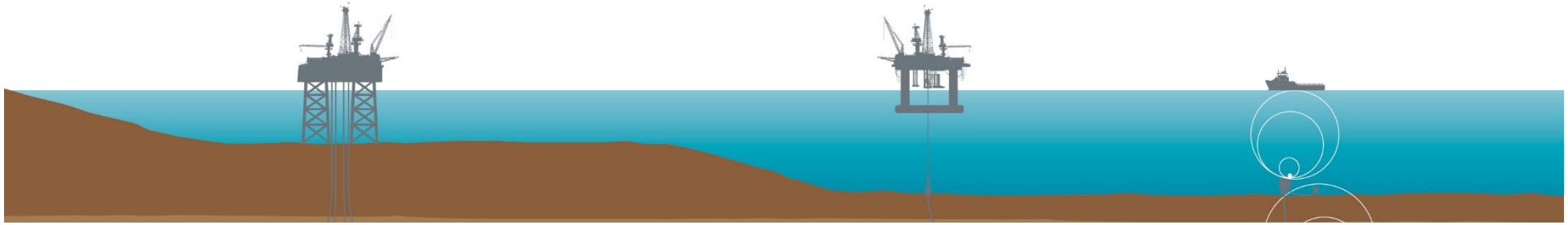
Extended Well Test (EWT)

- EWT is fundamentally the same process as standard Well Test operations, but carried out over a longer duration

- EWT is used to evaluate productivity and characteristics of a reservoir

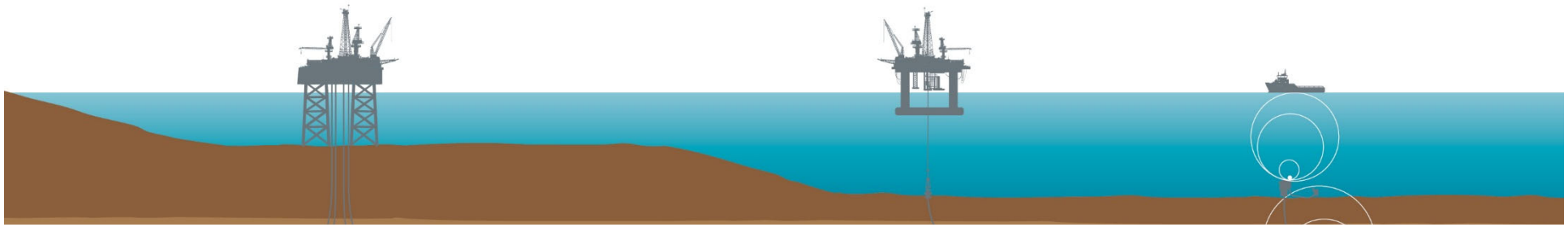
- Understanding the reservoir's potential helps operators reduce risks and reservoir uncertainty by:
    - Confirm long term reservoir deliverability
    - Provide opportunity to estimate wellbore storage
    - Estimate reservoir volume and confirm reserves for field development
    - Obtain additional production related data i.e. water cut, sand production and well deliverability



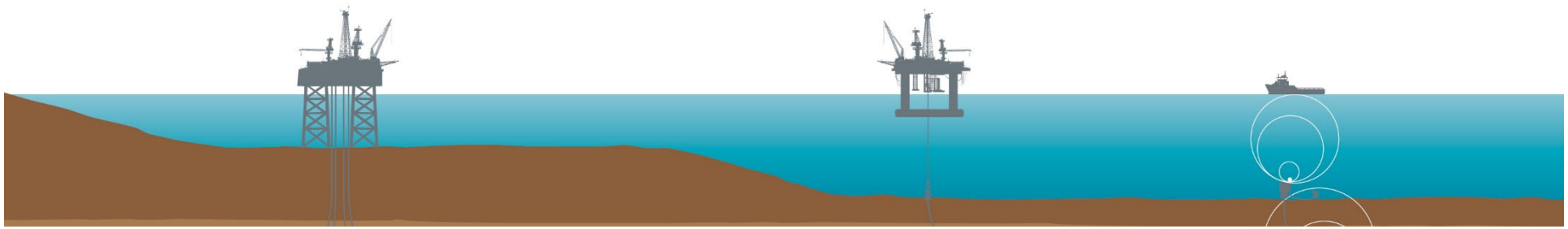


Well Testing in Practice

- Well Testing is essential for understanding and prediction of reservoir performance, efficient management of the asset and ultimately successful commercial exploitation.
- Well Test System Design is critical to ensure a full range of surface rates are anticipated and appropriate equipment selected and available for the fluid types and expected pressures.
- Well Testing needs to be performed in a systematic manner, compliant with safety and environmental requirements, while meeting the challenges set by the reservoir type.
- Data collected shall be of high standard and quality.



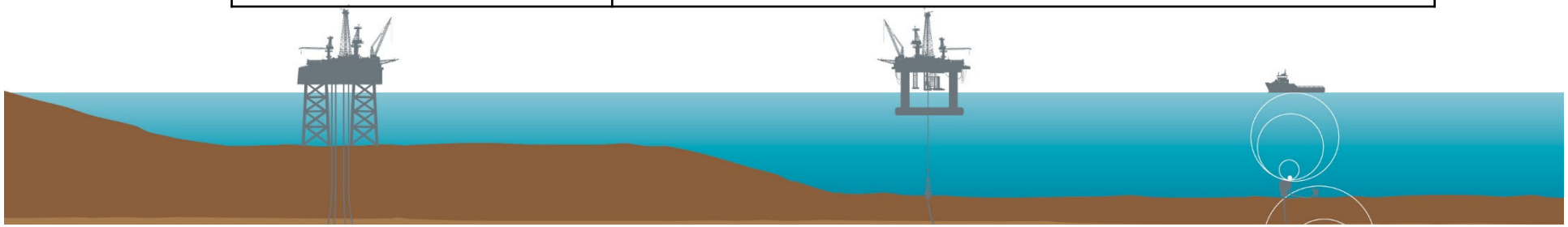
Well Test Flow back Into the Hull of a DNV DRILL(N) Class Drillship



Project Overview

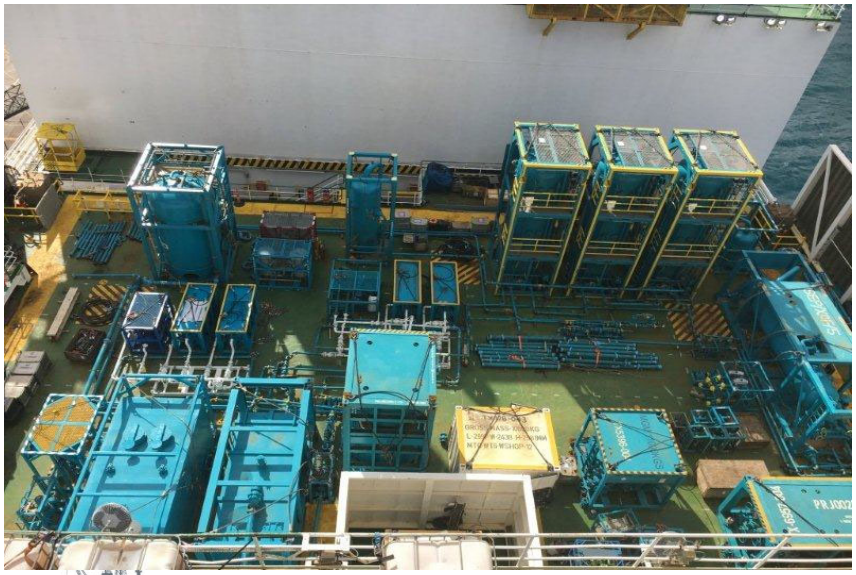
Key Challenges:

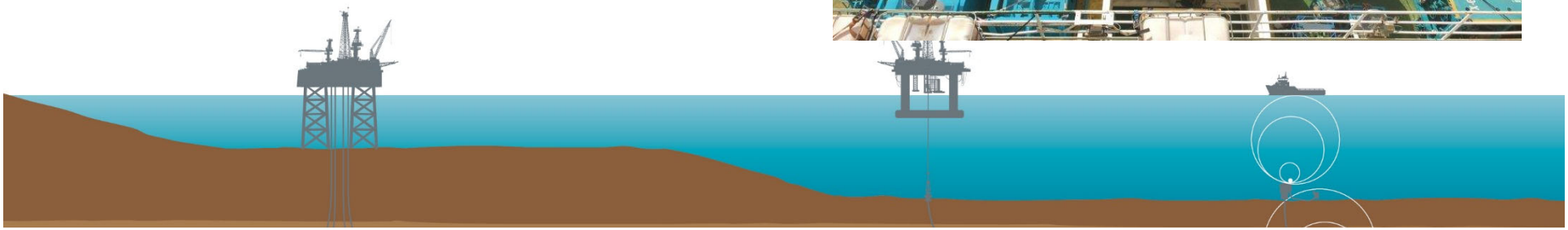
Equipment	• Availability of 15K psi equipment within the region • Additional fluid storage to enable the EWT
Design	• Equipment selection (sizing to meet the expected flowing parameters) • Deck load limitation in the well test area • Heat requirement to above fluid pour point • Compliance to DNV class requirement • Compliance to Maritime Coastguard Agency (MCA)
Project Delivery	• Short delivery (45 days project plan commitment)
Operating Philosophy	• Managing the EWT interface between Expro SWT and the drilling company was identified as a high potential area of risk
Environmental	• Environmental friendly disposal through flaring (smokeless flare without any oil spill) • Environmental friendly water disposal (water treatment for overboard disposal)



Project Overview

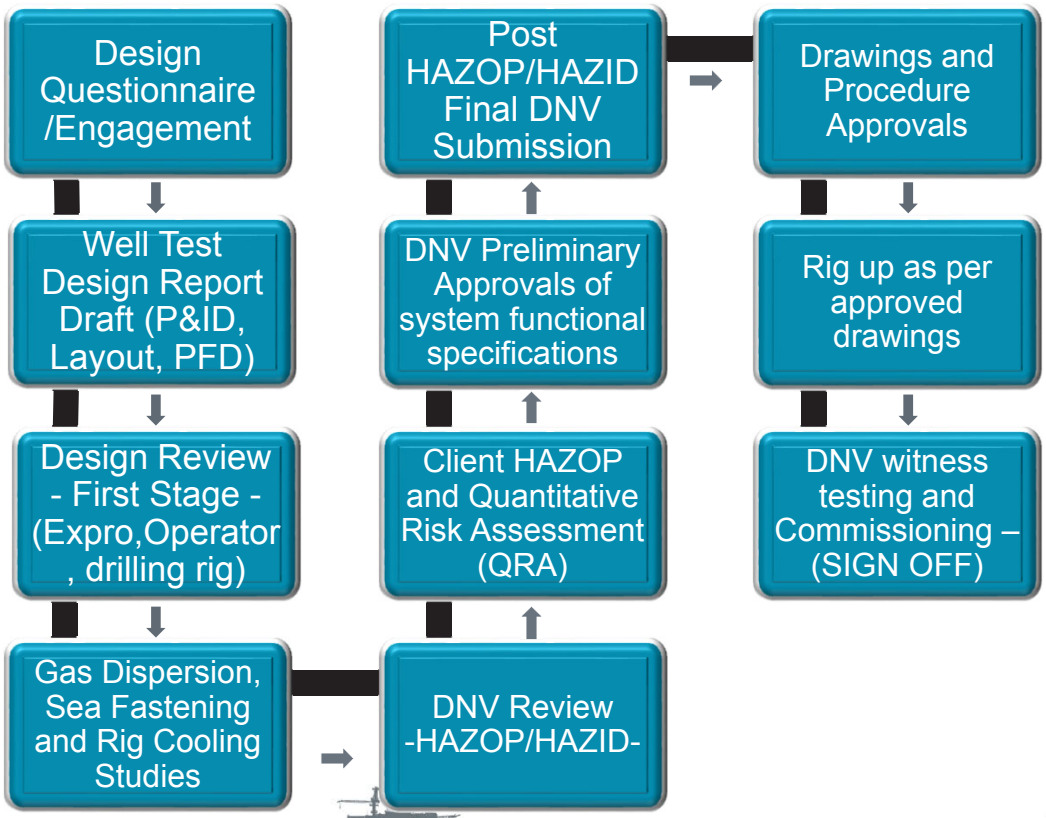
- 15K well test package with additional fluid storage to enable Extended Well Test (EWT)
- Surface system to process fluids and transfer to storage tank in the hull of the drillship with an 80,000 bbls capacity
- Oil Flaring during test and offline flaring was carried out in a controlled manner post test
- Continuous gas flaring during operations
- Water was treated and discharged overboard





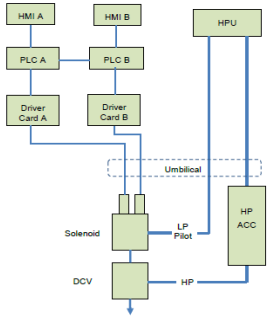
Design and Approval Process

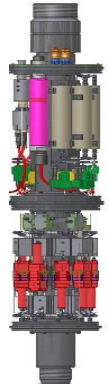
- **Design Process Overview –** Rig Visit, Well Test Design Report (WTDR), Gas Dispersion Studies, Sea Fastening, Rig cooling.
- **Design / Operational Risk Assessments – HAZOPS Performed:**
- First HAZOP meeting with DNV and all stakeholders involved to review design at the drilling contractor office
- Second HAZOP and Quantitative Risk Assessment (QRA) process and structure meeting involving the client and all service providers



Key Design Considerations–

- Fluid handling and disposal
- 15K WT Package design with extra fluid storage
- The use of the storage tanks in the hull of the drillship (TVP and Temp requirement)
- Offline oil flaring operations
- Drip tray to take deluge and accidently spilled oil returns from burner head platform back for treatment.

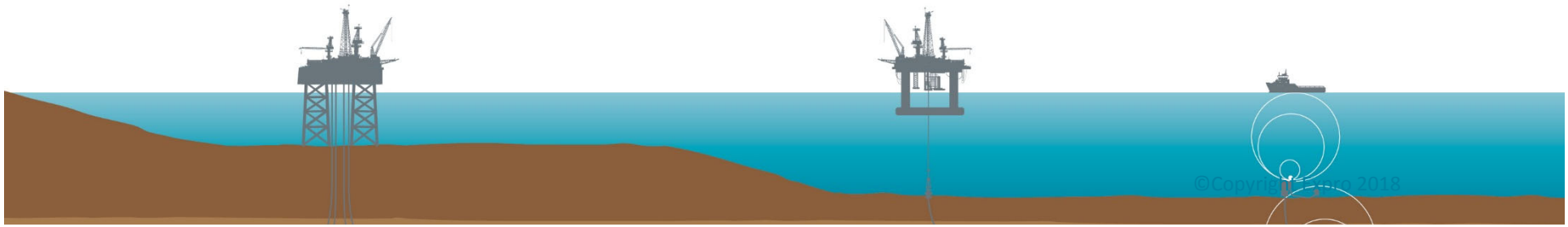




Approval Process

Early engagement with DNV Full design and operational philosophy presented to DNV in Oslo.

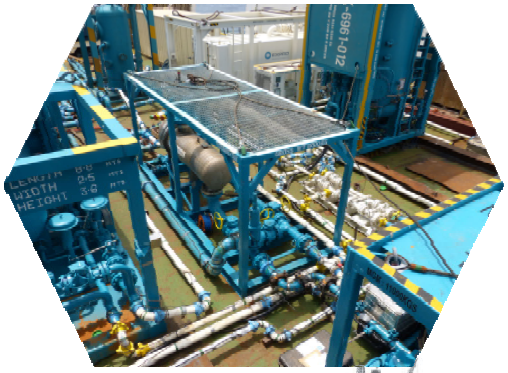
Maritime Coastguard Agency (MCA) Presented DNV approved operating philosophy to. Focusing on the systems compliance with tanker legislation. The key to MCA approval was not looking for exemptions and committing to having a robust set of procedures in the Drillings Safety Management System.

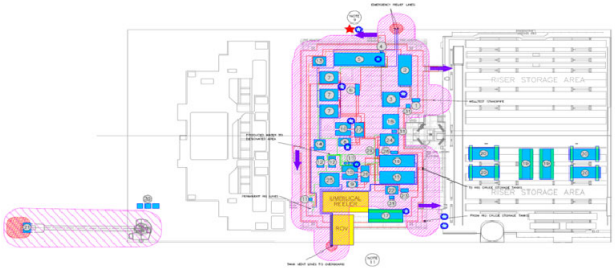


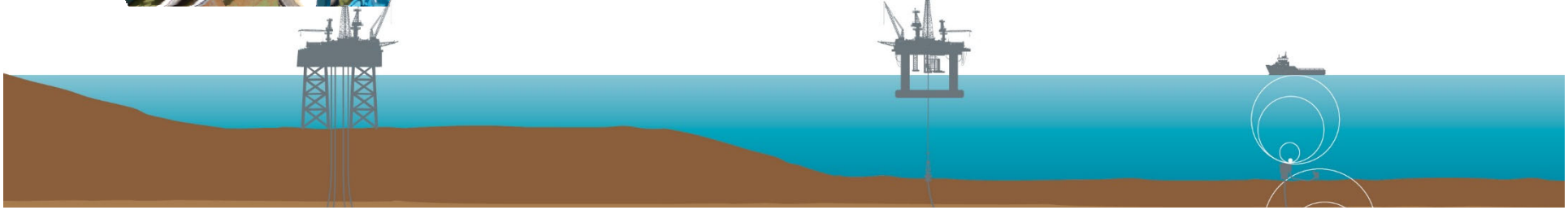
Project Execution

- Project timeline allowed for rig up of Well Test Equipment at the port. 95% of the rig up was completed before the rig sailed.
- Equipment was shipped to the port from different locations.
- Logistics planning was key, as with any successful project.

Project kick off → **Expro / Drill Ship Engineering** → **45 Day project plan commitment** → **Open Dialogue DNV & MCA** → **Project Manager Onsite** → **DNV Commissioned**

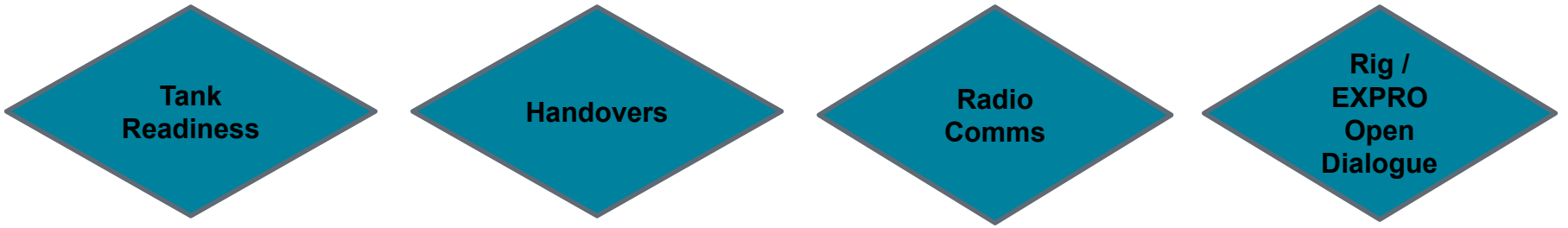


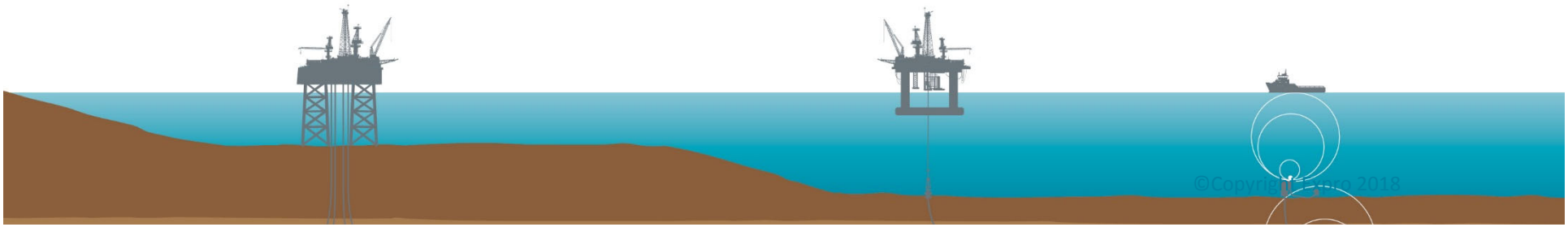




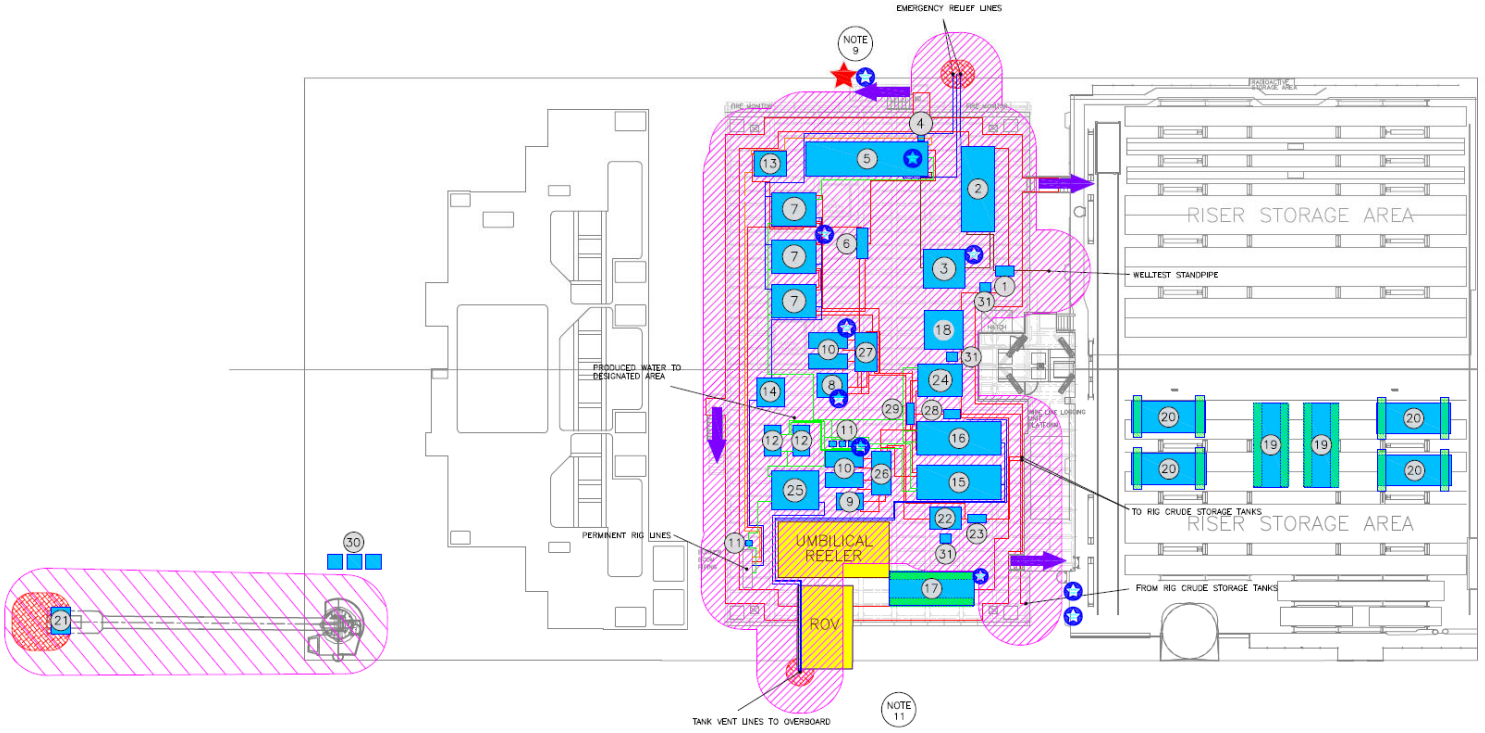
EWT Interface: Drillship and EXPRO SWT

- The interface between the EXPRO well test and the Drillship was identified in the HAZOPS as a high potential area of risk.
- Interface document was prepared and controlled by drilling company.
- The Interface document concentrated on four main headings;

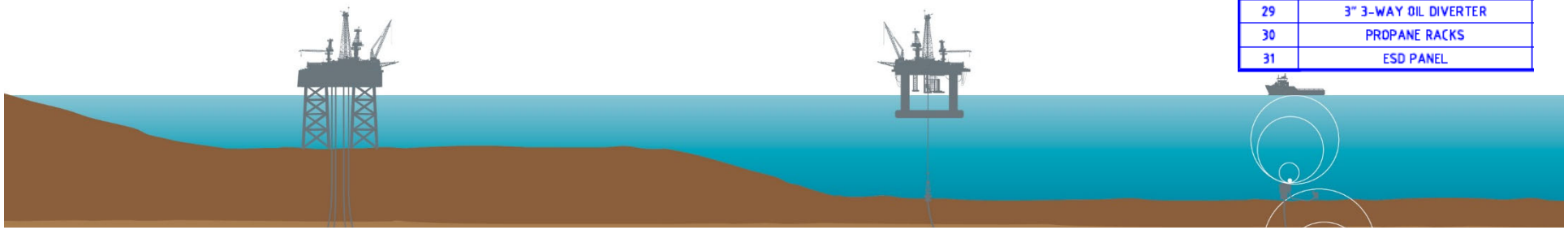




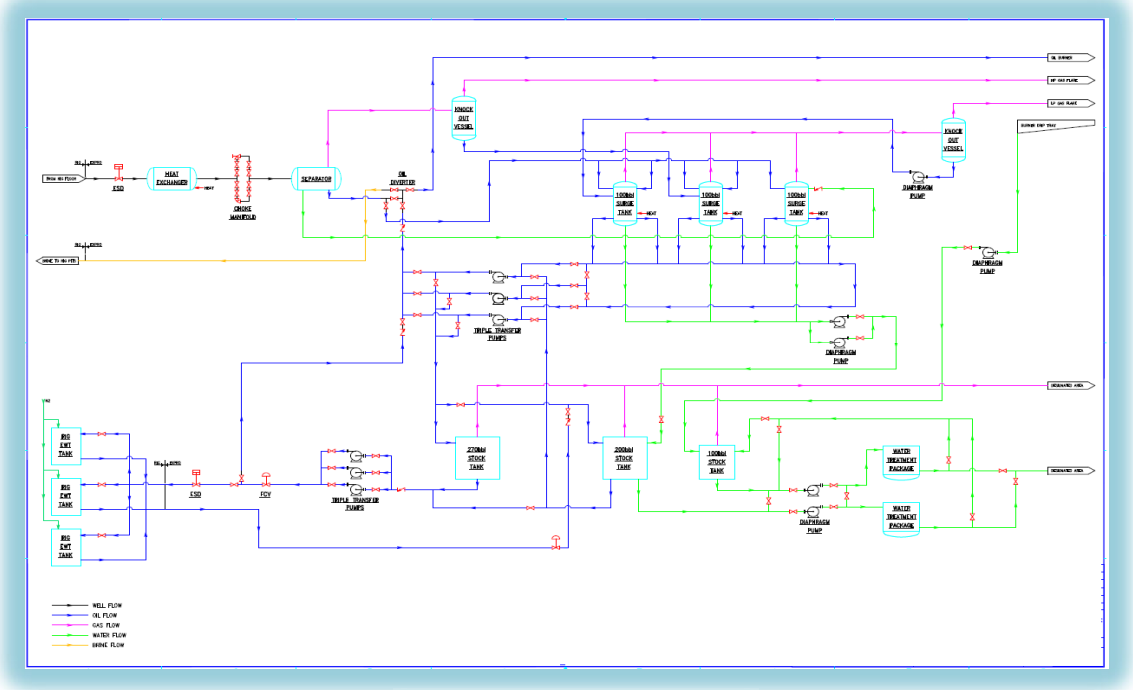
System General Arrangement

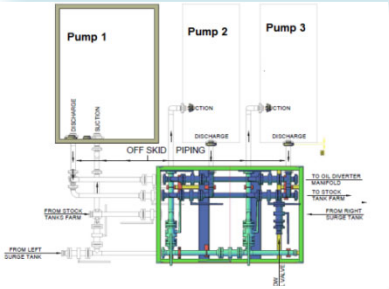


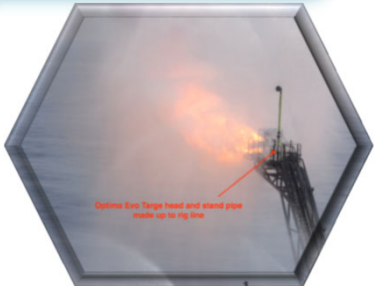
ITEM	DESCRIPTION
1	ESD VALVE
2	STEAM HEAT EXCHANGER
3	CHOKE MANIFOLD
4	GAS SONAR METER
5	TEST SEPARATOR
6	5-WAY OIL DIVERTER MANIFOLD
7	SURGE TANK x 3
8	TRANSFER PUMP TX5300-001
9	TRANSFER PUMP PBA-001
10	TRANSFER PUMPS x 4
11	DIAPHRAGM PUMP x 5
12	WATER TREATMENT PACKAGE
13	HP GAS KNOCK OUT VESSEL
14	LP GAS KNOCK OUT VESSEL
15	200BBL STOCK TANK
16	100BBL STOCK TANK
17	DAQ LAB
18	WELL TEST CONTAINER
19	STEAM GENERATOR x 2
20	AIR COMPRESSORS x 4
21	SUPER GREEN BURNER
22	FLOW MEASUREMENT SKID
23	SURFACE SAFETY VALVE
24	SURGE TANK TX6961-012
25	WATER FILTRATION TANK TX5872-002
26	PUMP MANIFOLD CRN-MAN-200
27	PUMP MANIFOLD CRN-MAN-100
28	SURFACE SAFETY VALVE
29	3" 3-WAY OIL DIVERTER
30	PROPANE RACKS
31	ESD PANEL



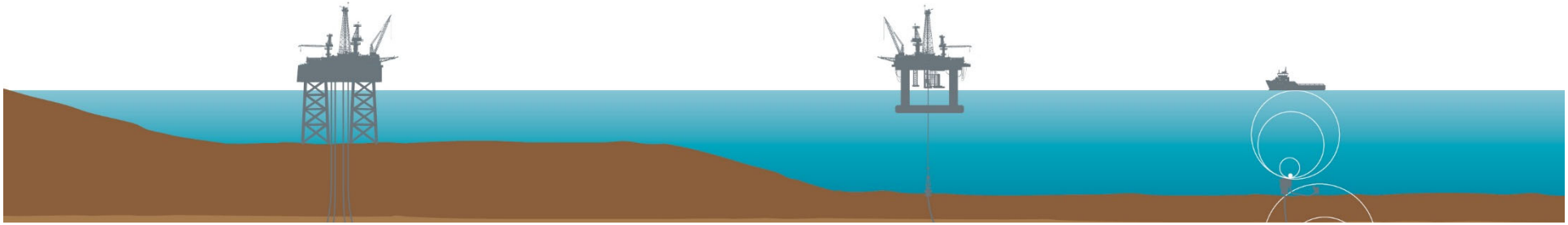
EWT Fluid Handling Plan







- 3 stage separation was performed using 800bbls+ of tank space (surge and stock) achieving adequate retention time required to meet the TVP (below the spec of the rig storage tanks.)
- Oil was initially pumped from the drillship storage tanks to the WT stock tanks before flaring was carried out. Pumped fluids passed through a water cut meter and flow meter to correlate volumes.
- An average of **28bbls** was pumped to rig tanks every **few minutes** during flow back.
- Following two DST operations, a total of approximately **24,500bbls (Calculated Rig Volumes)** was processed.



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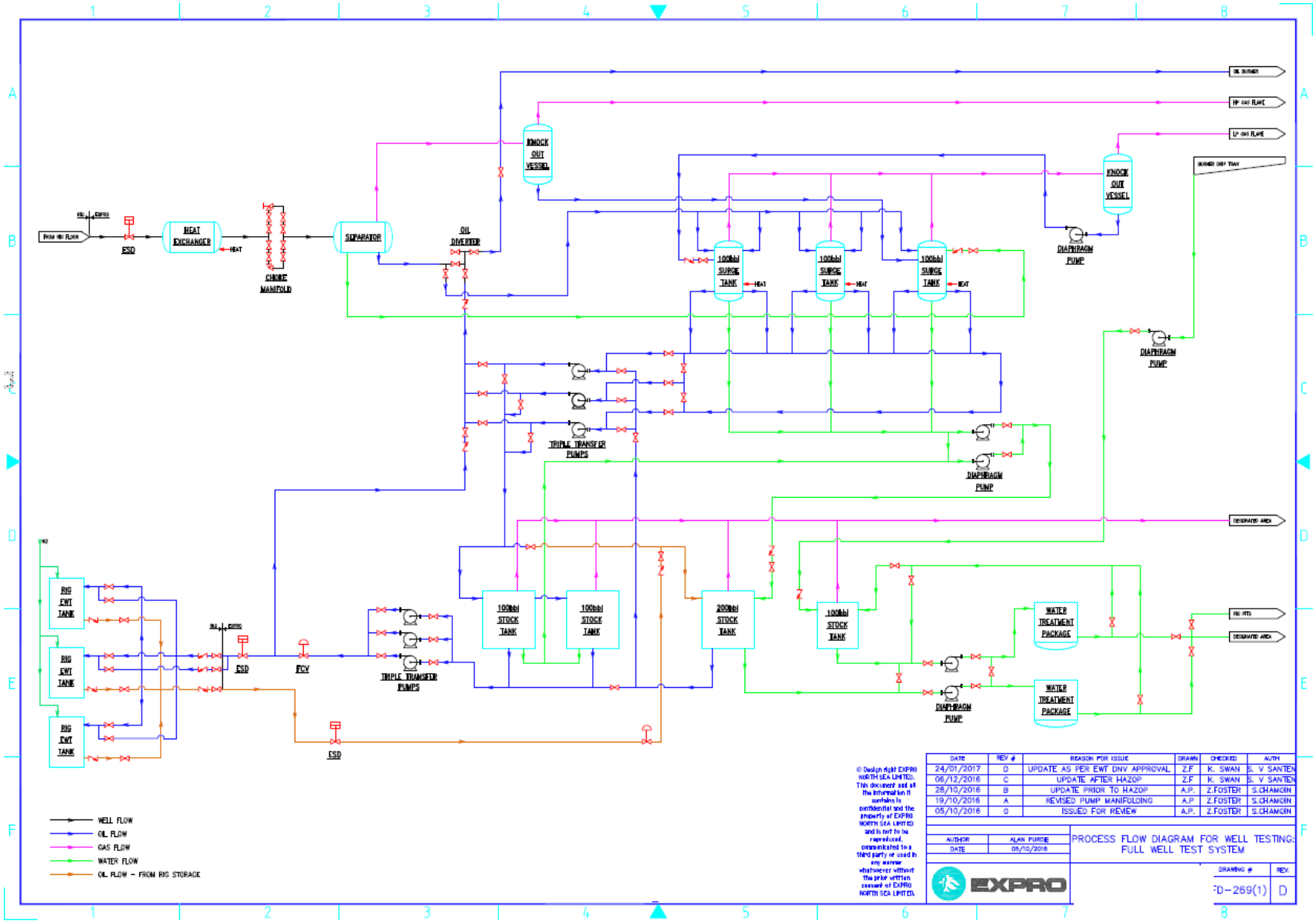
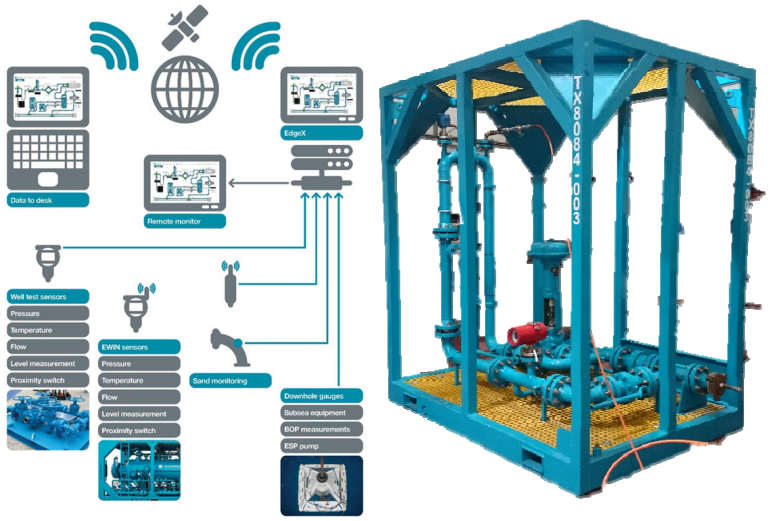
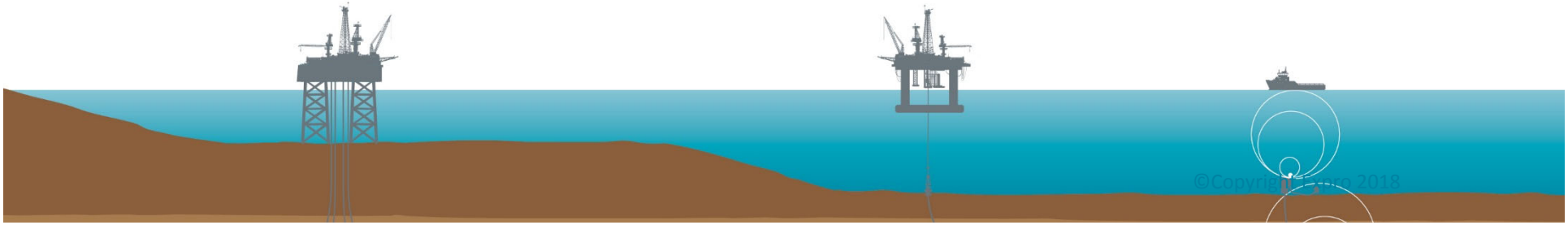


Project Specifics

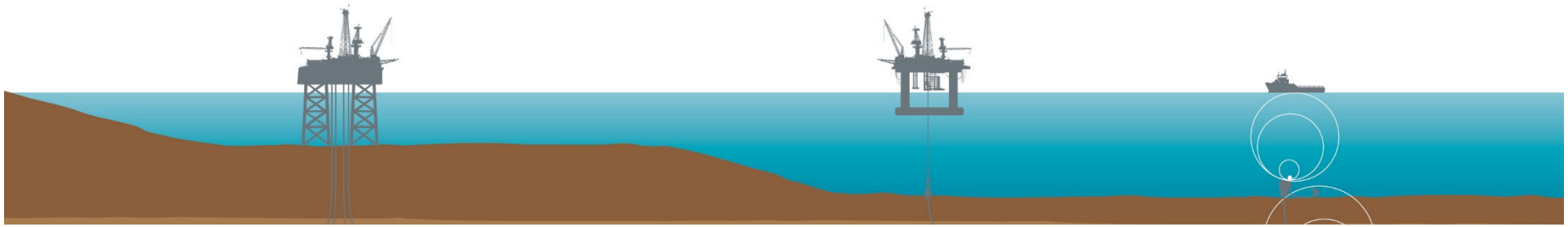
- 10K and 15K wireless Data Acquisition (DAQ) system to reduce running of cable from WT area to rig floor and avoid any cable to in DP movement.
- Data to Desk (D2D) for client information and technical support.
- Utilised Expro Water cut meter skid in oil line to the hull tank to detect any water volume in the hull to adjust sump pump.
- Flow meter on oil line to measure volume that have been pumped to the hull tanks.
- Flow meter on oil line to measure return from the hull tanks.
- Flow meter on oil line to burner to ensure flow rate at optimum to burner head.
- Air flow Meter on air line from air compressor to ensure optimum flaring.
- HMI to display at choke manifold and separator parameters.
- Control and display panel of the hull tanks level and pumps shutdown in DAQ cabin.





Hydrocarbon Hull Storage – Project Outcome

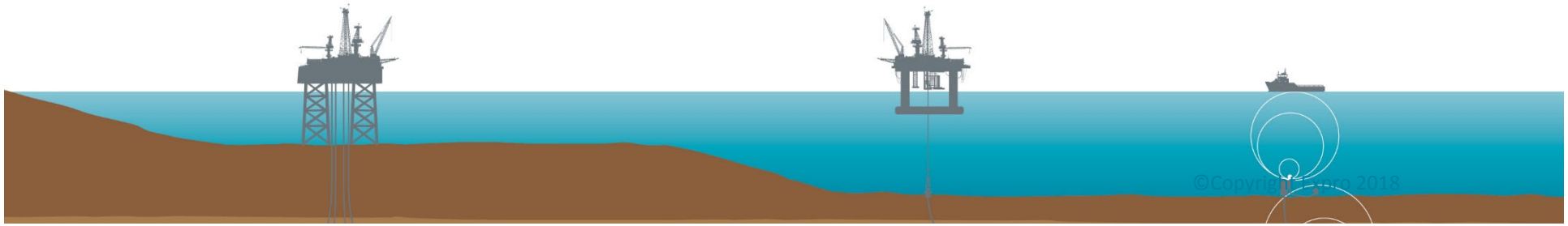
- 1st Extended well testing performed using the storage tank in the hull of a drillship
- The stability of flow and hence data quality was significantly better when flowing to tanks rather to the burners and the ability to QC the cumulative flow rates against tank volumes was wholeheartedly an added bonus.
- Validated accumulated crude volumetric measurement “Storage tank gauging versus metering”.
- Environmental Successes
- Relegating Crude Flaring from an on line critical path operation to an offline one/ removing both environmental risk (No wind) or operational unplanned shut in (Data compromise) .
- Improve burner efficiency by achieving the required back pressure / flowing to rig storage tanks, then pumping at regulated back pressure
- Improved DST Clean-up environmental efficiency 80,000bbl tank volume caters for large interface, high water cut or heavy oil



Hydrocarbon Hull Storage – Future Opportunities

- Offloading the 80,000bbls of crude oil / well fluid to a another vessel
- The Drillship had a platform in place that can take a hose reel and 300m of 8” hose
- Reduced emissions testing
- Environmentally Friendly
- Potential for fitting heating coils in tanks. This could assist with heavier crude oil transfer, improve with water separation on wells with a high water cut and potentially improve the flare quality.
- Early development EWT prior to *FPSO

*FPSO (Floating Production Storage and Offloading)

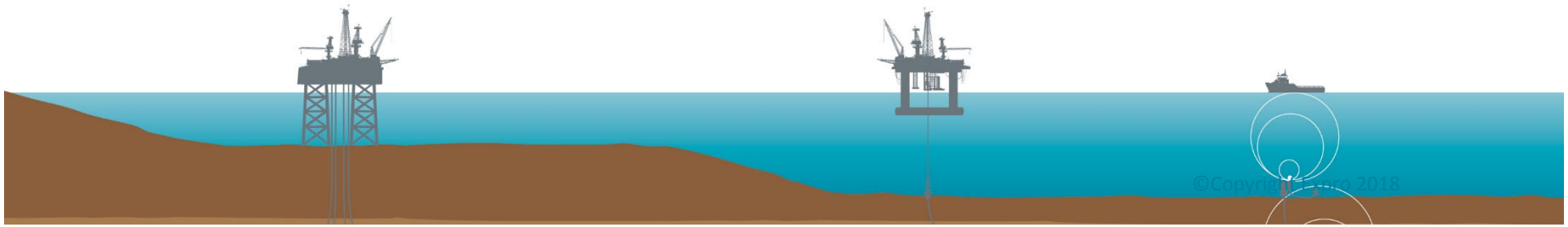


Questions, Answers & Discussions

End of Project Feedback:

"*The modification of the Drillship tanks for crude storage and pre-installation of the test equipment was particularly beneficial in eradicating the majority of teething problems ahead of the first test, so the operations ran smoothly from the outset.*

In my mind, the testing spread set-up with the flexibility of onboard crude storage provides a new benchmark in testing for the industry, which simply wasn't possible in the past"



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