NOV Process Partner

Conversion of Production Separator to Induced Gas Flotation Unit

November 11, 2025

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Conversion of Production Separator to Induced Gas Flotation Unit

| Understand-Define-Validate-Deliver-Support |

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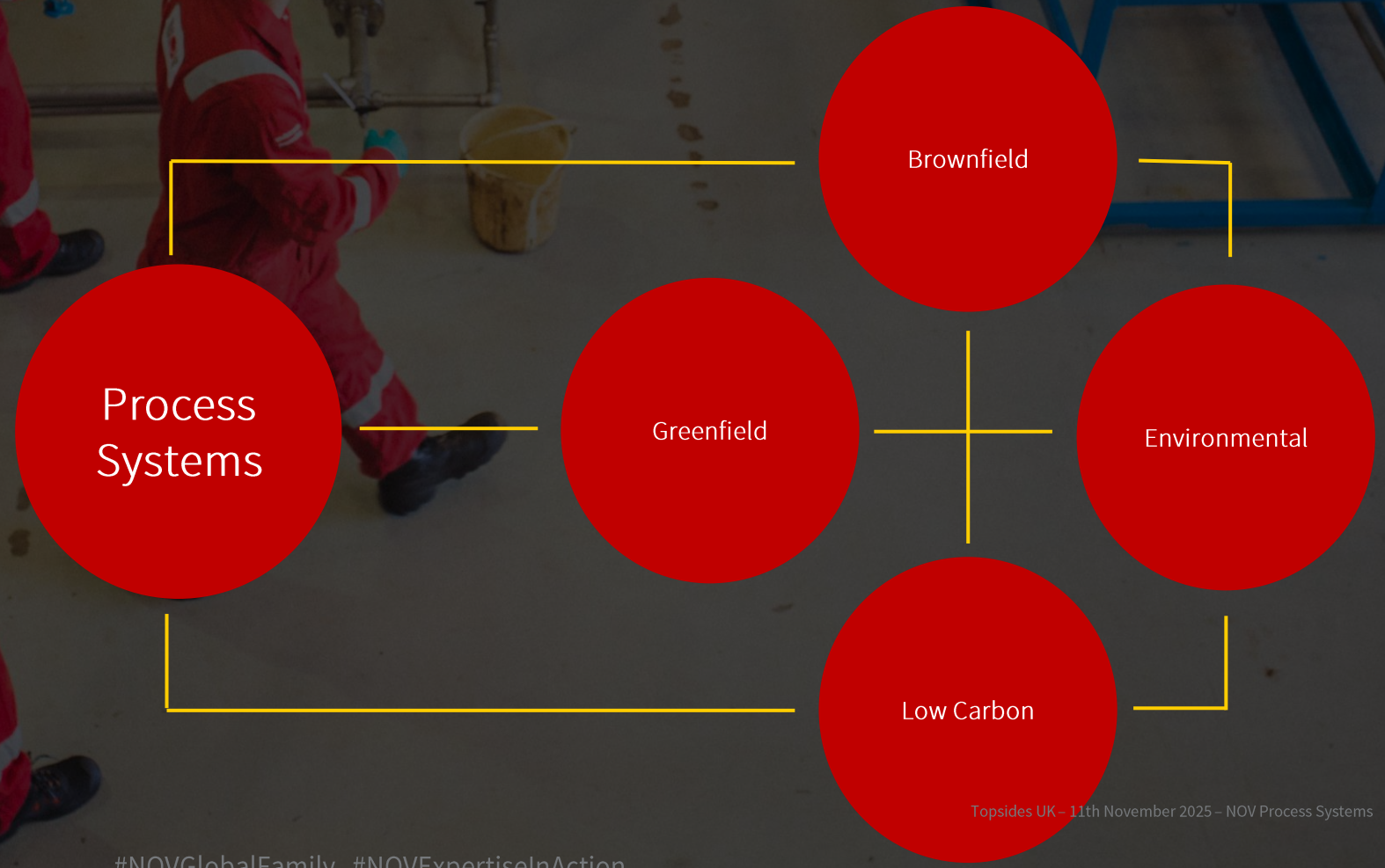
#NOVProcessPartner

Energy Equipment

Energy Products & Services

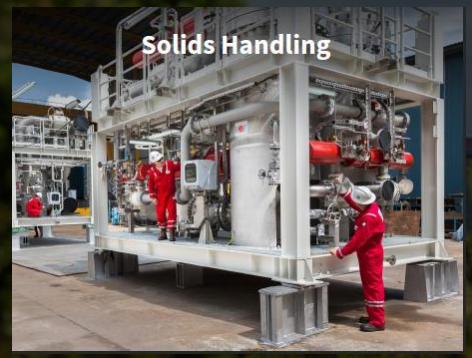
#NOVGlobalFamily #NOVExpertiseInAction

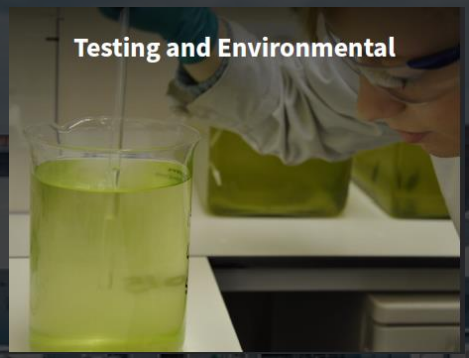
Energy Equipment



Process Systems

Your value creation energy partner

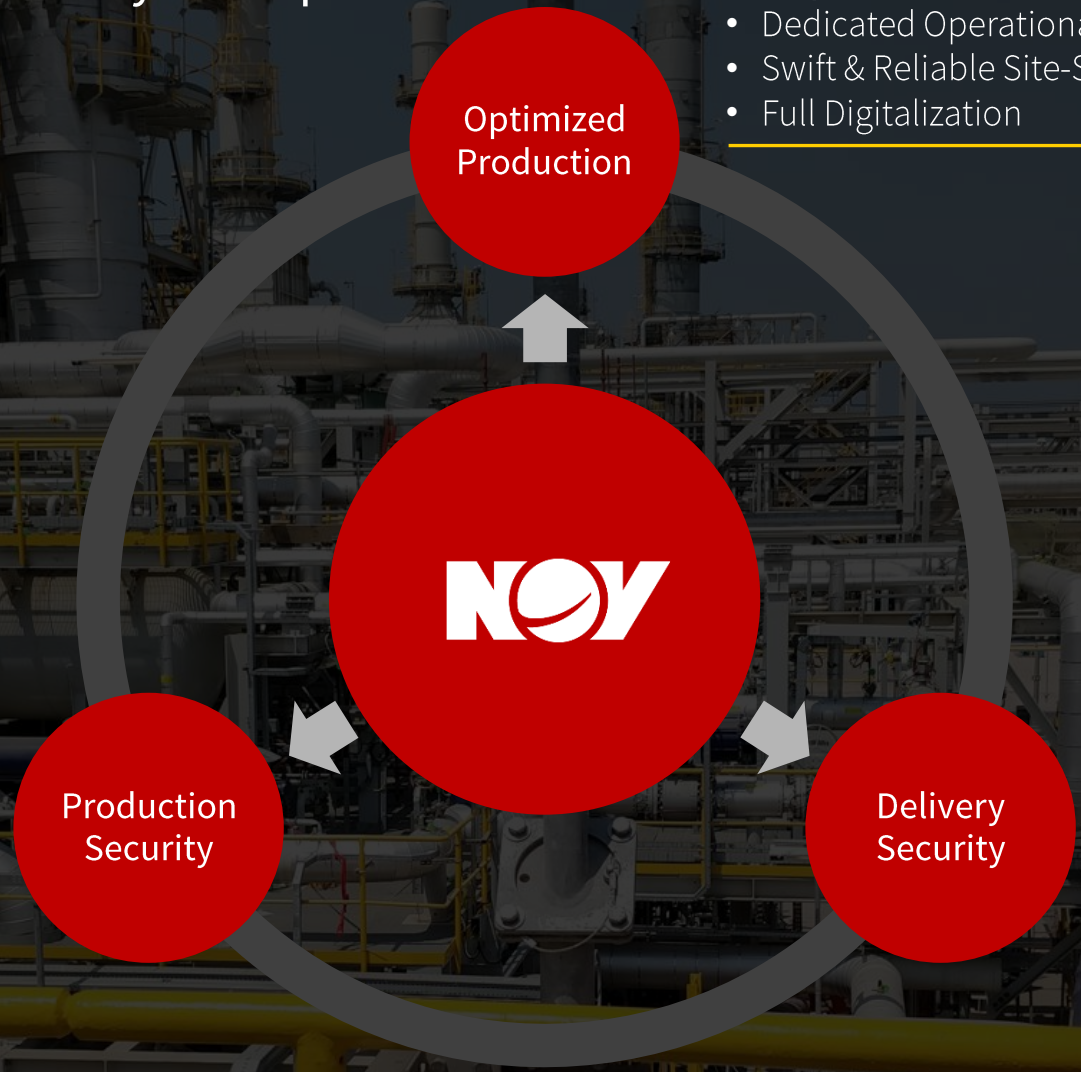




NOV Process Partner

We Ensure Production Security, Stability and Optimization

OPUS
- Process Optimization
- Upgrade, Debottleneck, Extend Life
- Dedicated Operational Expertise
- Swift & Reliable Site-Support
- Full Digitalization

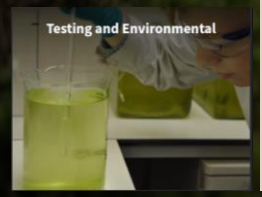


AVAILABLE
- Process Guarantee Partner
- Digital & Remote Support & Advice
- Low-manned Approach
- Quality Products & Systems
- Worldwide Service Crew
- Fluid/Chemistry Knowledge

RIGHT
- Right Execution Models
- Excellence In Risk Management
- Partnerships With Critical Technology & Equipment Suppliers

Process Systems

The OPUS Approach



Customer Pain Points
Capacity | Performance | Reliability

Understand
Data collection | Site Assessment | Fluids Characterization

Phase 4 – Sustain
- Operations and maintenance support
- Spare parts management
- Digitalization/remote support services
- Process studies for increased production

Phase 1 – Understand
- Identify root cause of challenges
- Detailed analysis of the existing process
- Site assessment if needed to gather data
- Careful assessment of fluids chemistry

Sustain

Phase 3 –Deliver and Optimize
In order of priority:
- Optimize the existing process
- Upgrade existing process equipment
- Design and install new package
  - Install, start-up and optimize
  - Guaranteed on-spec performance

Phase 2 – Define and Verify
- Specialist process and detailed engineering
- Performance models built on 30 years of process verification & optimization
- Physical modelling
- Computational fluid dynamics (CFD)
- Finite element analysis

Deliver / Optimize
Optimization | Retrofit | Package Supply | Lifecycle Services

Define / Verify
Study | Modelling | Design

The Motivation

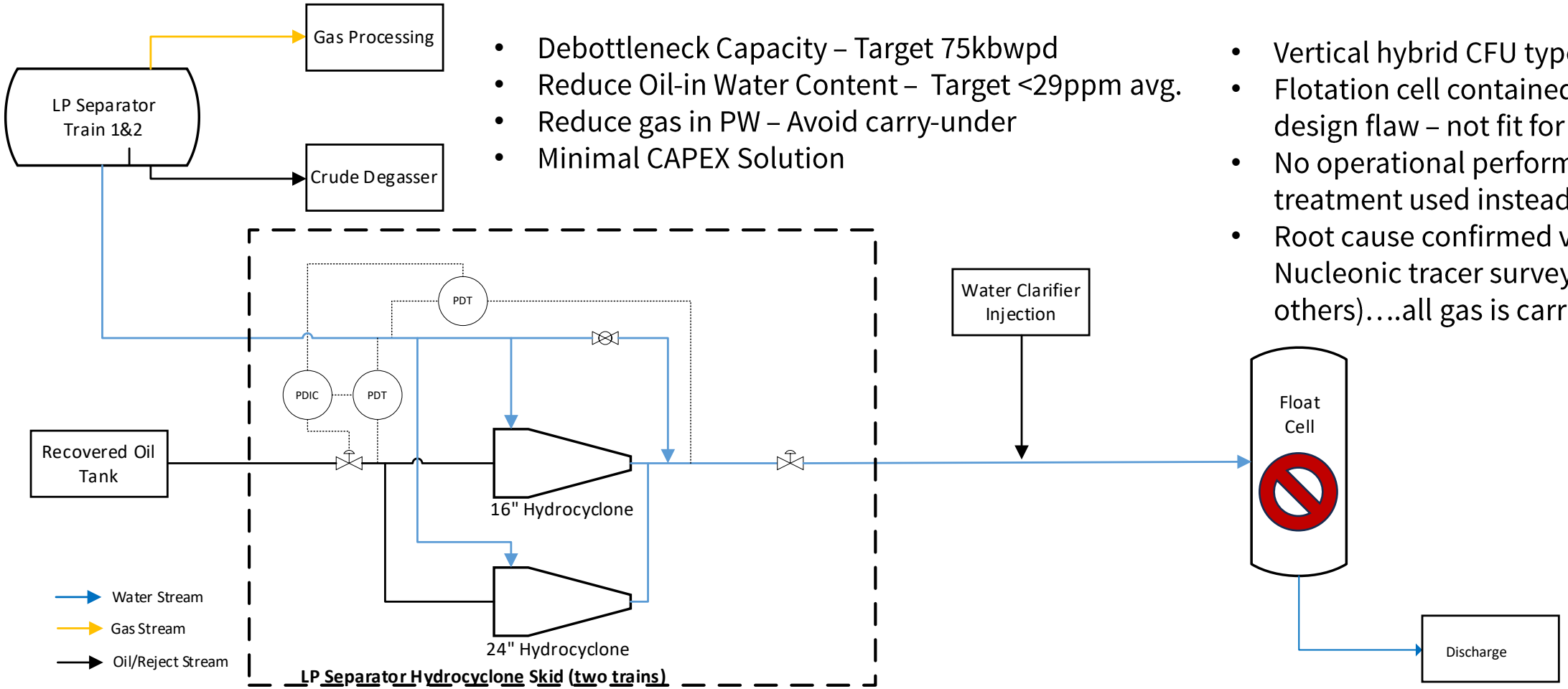
Where does it all begin…

Objectives:

- Debottleneck Capacity – Target 75kbwpd
- Reduce Oil-in Water Content – Target <29ppm avg.
- Reduce gas in PW – Avoid carry-under
- Minimal CAPEX Solution

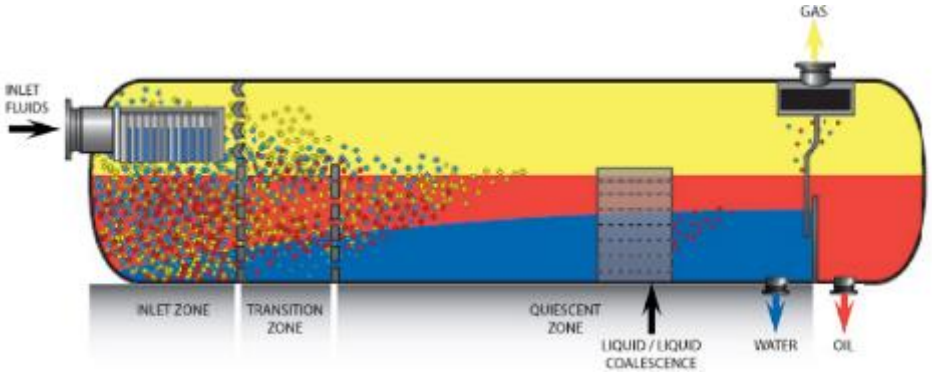
Original PWT System:

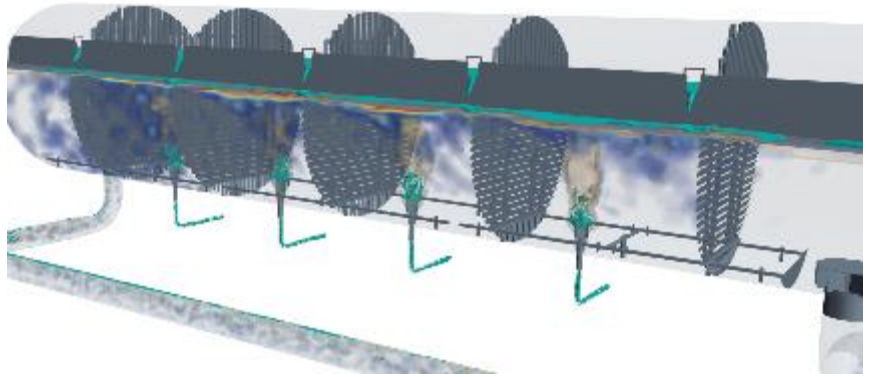
- Vertical hybrid CFU type flotation unit.
- Flotation cell contained a severe design flaw – not fit for purpose.
- No operational performance - rental treatment used instead (high OPEX).
- Root cause confirmed via CFD and Nucleonic tracer survey (by others)….all gas is carried under!



The Challenge

What did we do…





Donor Vessel Requirements:

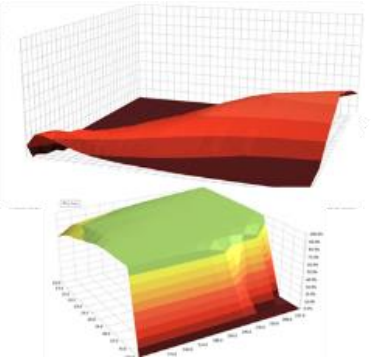
- Horizontal or vertical vessels considered.
- Suitable number of nozzles needed; advantageous placement helpful but not essential.
- Suitable number of internal clips needed – no welding no bonding allowed.
- Adequately sized to get meaningful performance, but did not have to be limited to ‘Standard Norms’.

Selected Candidate:

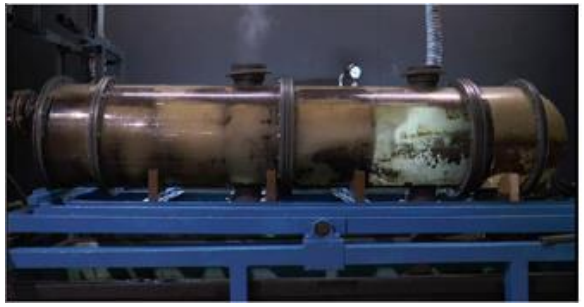
- Horizontal IP Separator.
- Several drain nozzles intended for sand handling system present → flotation gas bubble inlets.
- Feed/outlets & instrumentation nozzles also well placed.
- Several baffles already in the vessel → clips!
- Well (but aggressively) sized.
- Moderately helpful location on the facility.

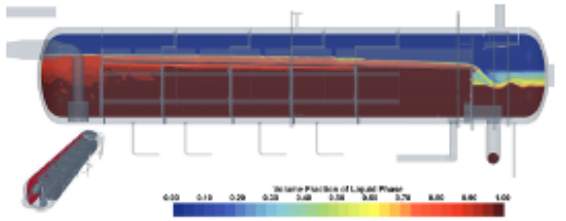
The Approach – OPUS

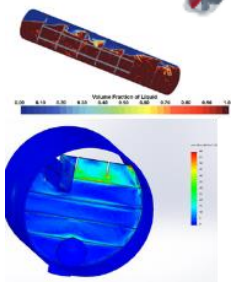
Risk Management & Optimised Expenditure



Note: some details deliberately obscured to protect NOV IP.







Site Survey

Desktop Study

Flotation Modelling

Physical Modelling

Computational Assessment

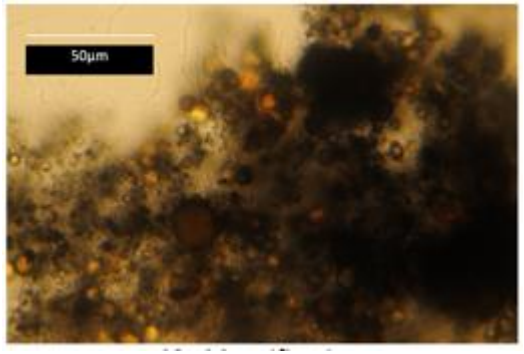
Design & Build

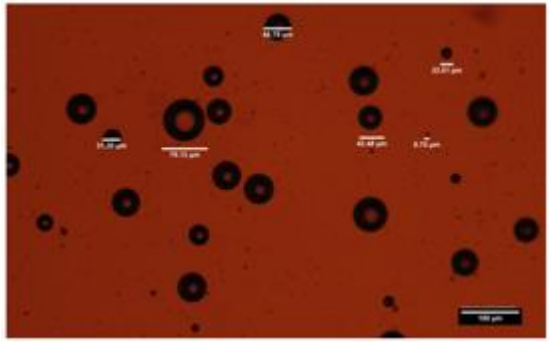
Installation

Start-up & Performance Benchmark

The Site Survey

Building Understanding





At NOV Orkney Water Test Centre:

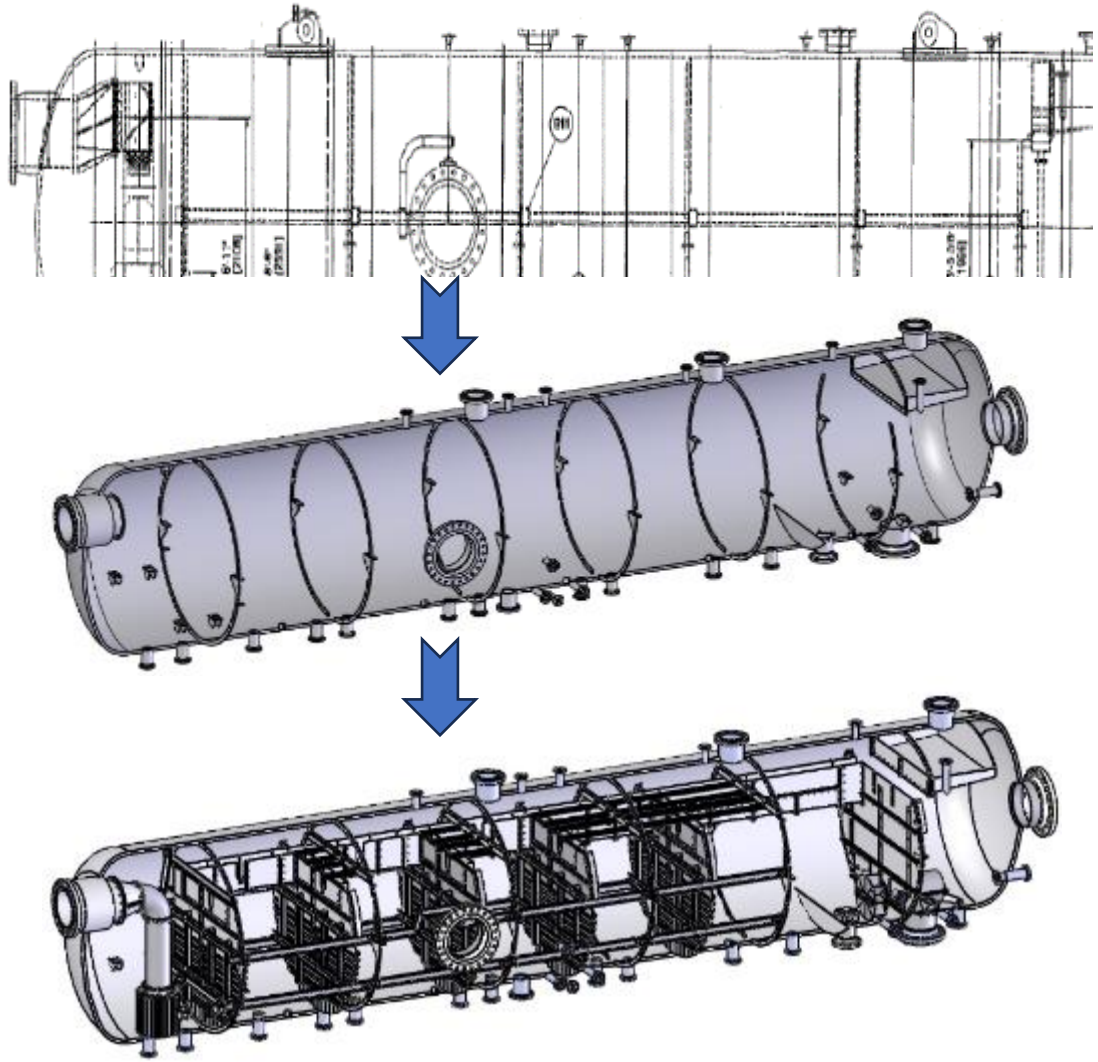
- Client water and oil.
- Fluid microscopy.
- Technology compatibility (Mare's Tail pre-coalescer).

At Site:

- Droplet sizing.
- Performance Analysis (site test of DOHC and Mare's Tail pre-coalescer).

The Desktop Study

Understanding Options & Defining Solutions



Repurposing of equipment:

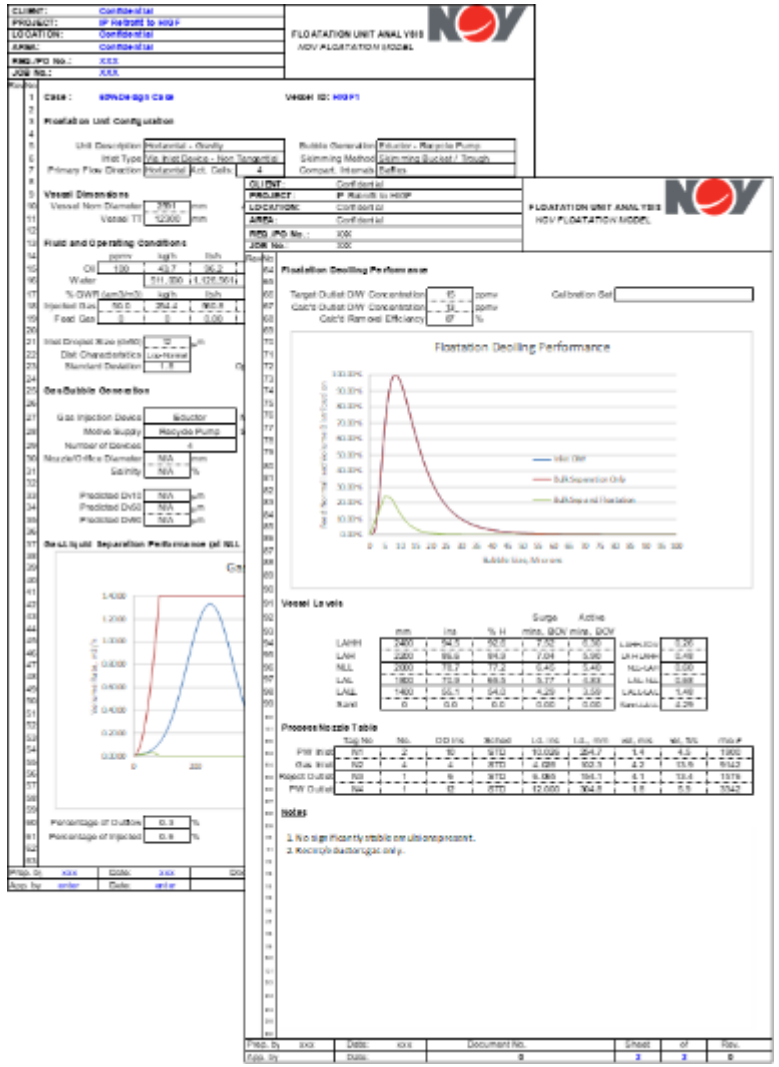
- Multiple vessels considered as donor vessel – unused production separator selected (2.5m ID x 12m TT).
- Repurposing existing float unit microbubble pumps also considered – not viable, ejector technology preferred.

Uncertainty:

- Best available vessel did not have as much residence time as typical for HIGFs – flotation model used to quantify short fall.
- Scaled physical testing (580mm ID) of final solution considered as a risk mitigation step.

The Flotation Modelling Tool

Validating the Solution



The Model:

- Semi-empirical universal model based on various separation and flotation correlations, benchmarked against Flotta and Field data.
- Jointly created by NOV and a SuperMajor to offer technology independent hydraulic and performance analysis of flotation units

The Output:

- Determine impact of smaller-than-typical vessel size.
- Confirm gas bubble and oil removal performance.
- Estimate performance with and without deoiler chemistry.
- Confirm impact of droplet size, flow rate, gas rate.

Note: some details deliberately obscured to protect NOV IP.

The Physical Modelling Set-up

Validating the Solution in the Test Hall

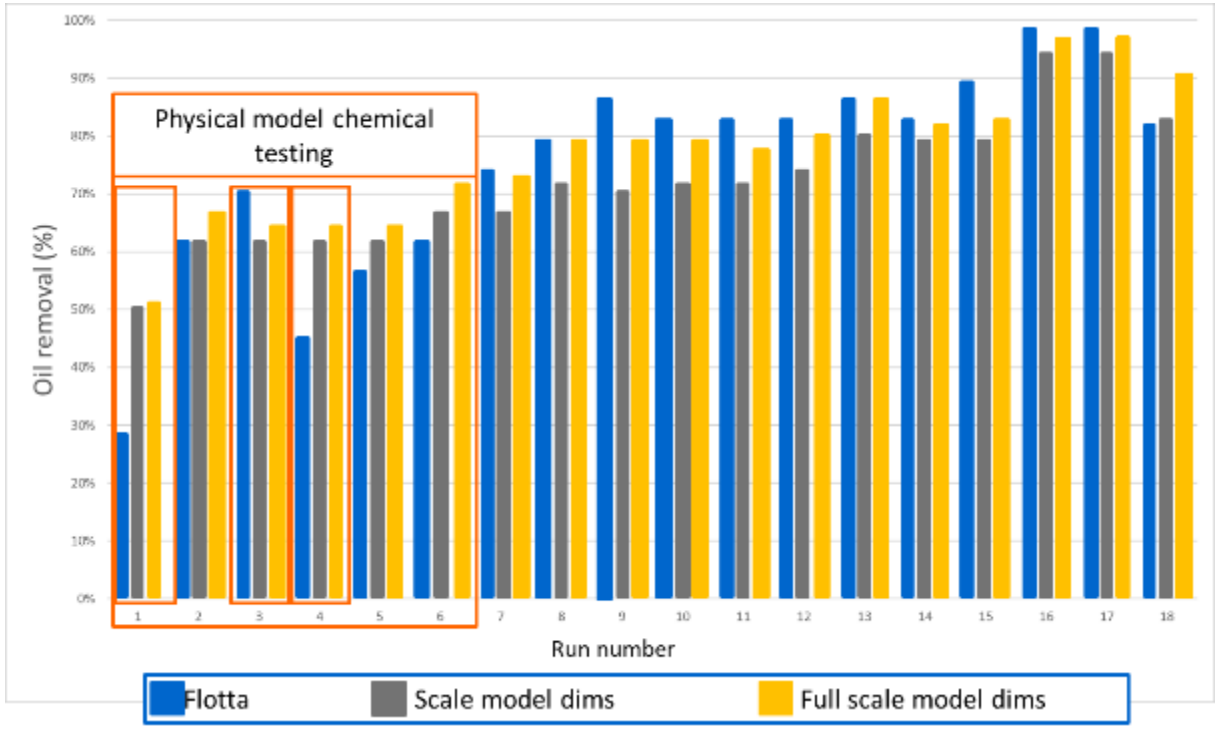
5ppm Deoiler Chemical

10ppm Deoiler Chemical

20ppm Deoiler Chemical

100ppm Deoiler Chemical

Visual testing demonstrating deoiler overdosing



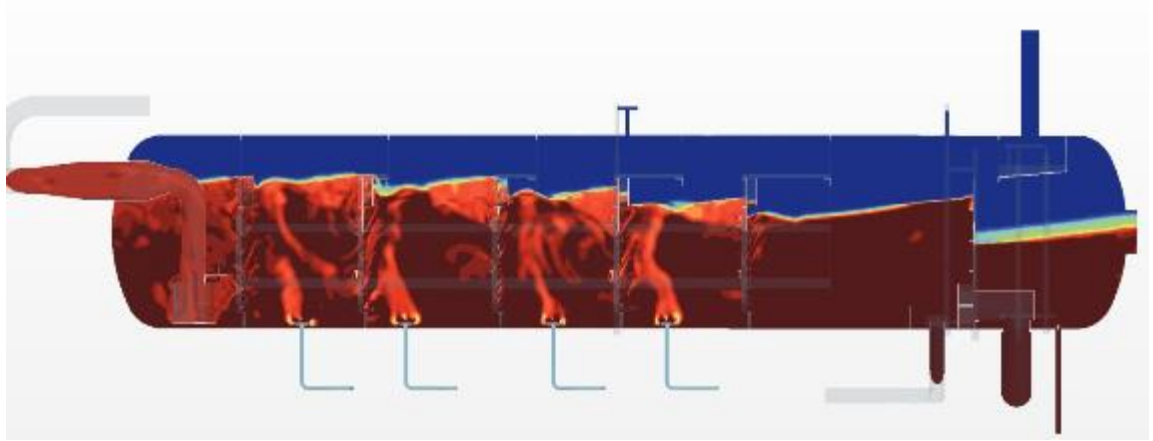
Test Conditions:

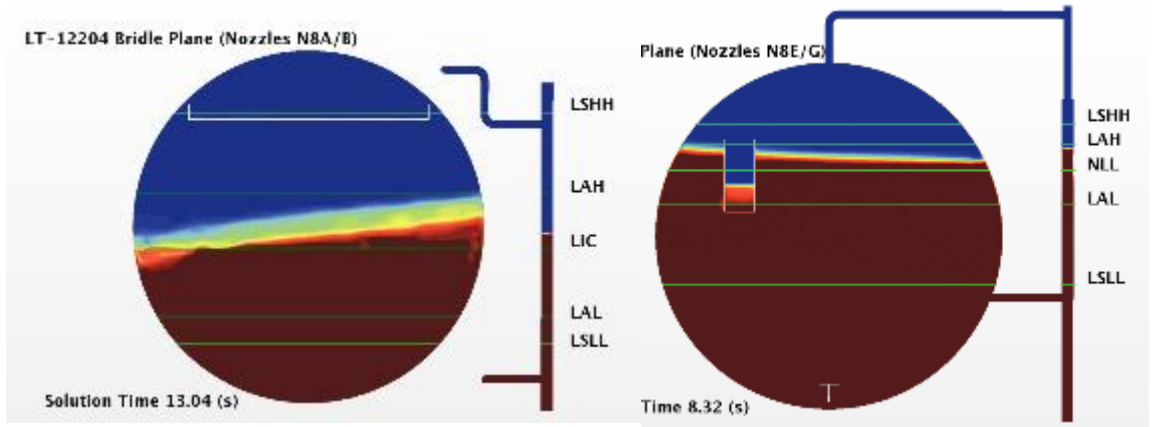
Client crude + seawater.
100-300mg/l inlet OiW.
7-24um dv50 droplet size

W/wo chemicals.
Low/med/high gas rates.
Low/med/high flow rates.

The Computational Modelling Set-up

Validating the Solution with CFD



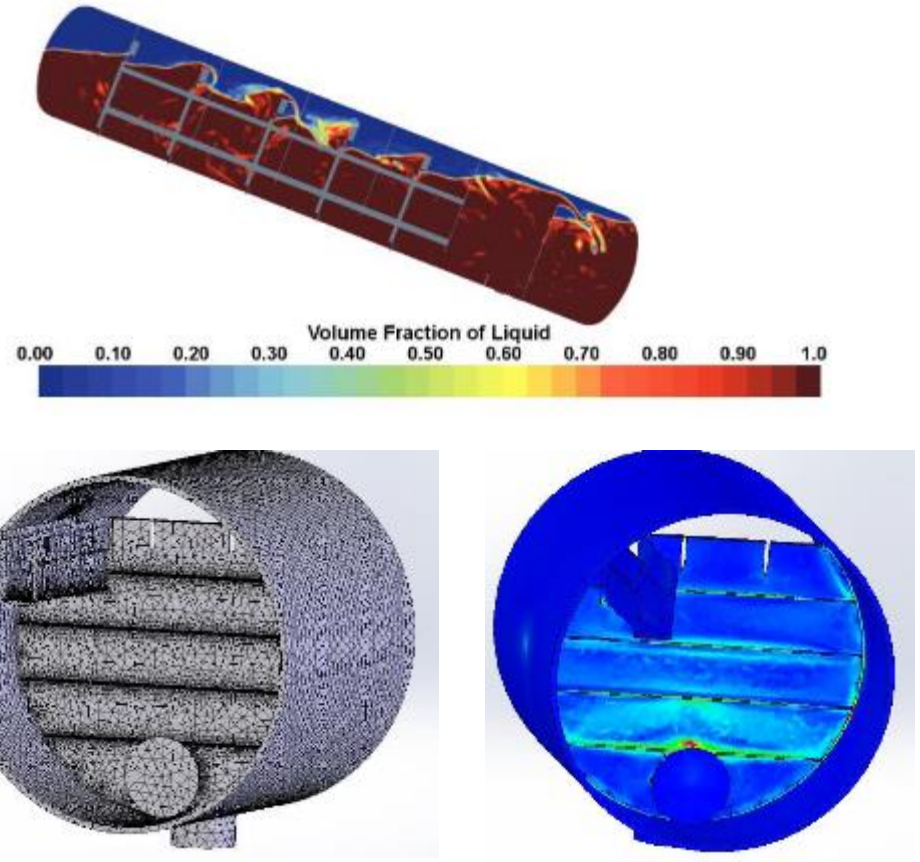


CFD

- Verify liquid behaviour during rough sea states (facility motion, operating and survival cases).
- Verify level instrument response vs actual liquid behaviour (bridles used).
- Check skimming behaviour and oily water compartment sizing.
- Generate force loading data for FEA (survival condition).

The Computational Modelling Set-up

Validating the Solution with FEA

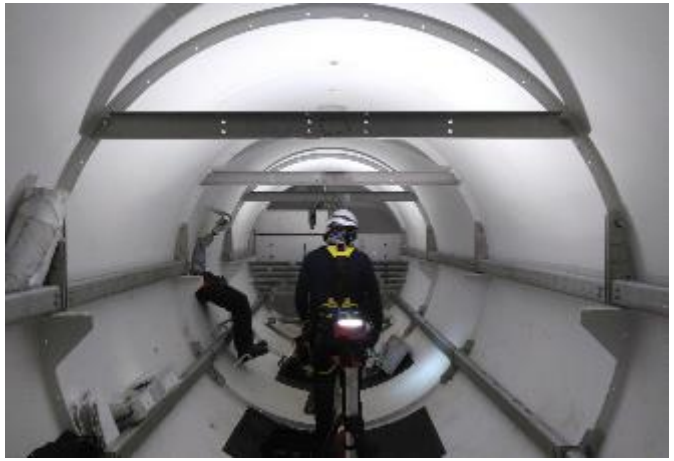


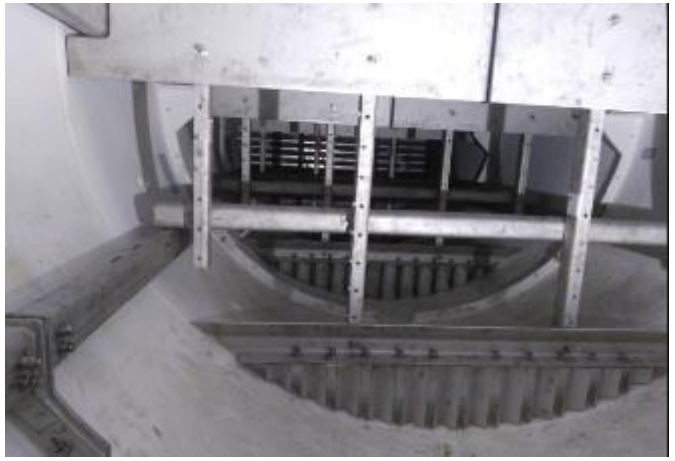
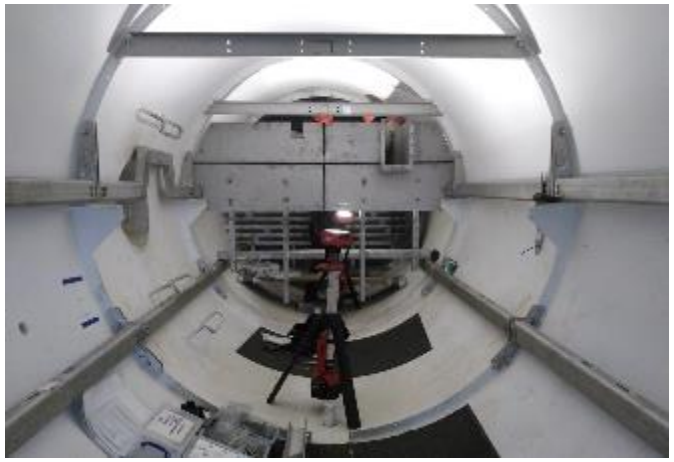
FEA

- Confirm existing vessel clips can withstand loading during survival conditions.
- Maximum corrosion allowance applied to clips.
- Force loads from CFD (extreme survival case) applied into the FEA model. A ‘force monitor’ was applied in the CFD model to record the expected force loading at important points over the course of multiple motion cycles.
- Attention paid to verify no resonance behaviour is occurring.

The Solution Delivered

Designed – Built - Installed



Vessel retrofit timeframe: 2 weeks

Performance Assured

Start-up & Performance Benchmarking

Data Redacted

Very fine margins…. to prevent erroneous / overly optimistic outputs the float Model is normally ‘capped’ at <5mg/l or <15mg/l depending on the application …..very difficult to predict reliably below this value!

Performance Assured

Start-up & Performance Benchmarking

Data Redacted

Data with 5mg/l cap applied suggests that it is a good ‘bottom end’ for the model (in this case), overall efficiencies line up well..

Conclusions

Collaborative Approach – Proprietary Technology – Assured Performance

- **Collaborative Approach:**
  - Several years of diligent validation design work has led to a robust retrofit design.
  - Cross-party planning of the retrofit and subsequent startup scope minimised interfacing issues
  - Versatile & experienced team efficiently dealt with execution challenges.

- **Proprietary Technology:**
  - NOV's Flotation Model provided clarity on the initial direction taken, no possible solution using standard design rules.
  - Test Hall modelling and CFD to validate flow dynamics in extreme cases.
  - Complete supply of retrofittable NOV IGF hardware.

- **Assured Performance**
  - Validation of Process & Mechanical design throughout in recognition of complexity of the work.
  - Site-based install, commissioning and early operational support.
  - Benchmarking and backchecking performance against model and physical test data offered confidence and a good basis for operation going forward.

NOV as Integrated Process Partner for Life of Operation

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Questions?

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TOPSIDES® UK 2025