

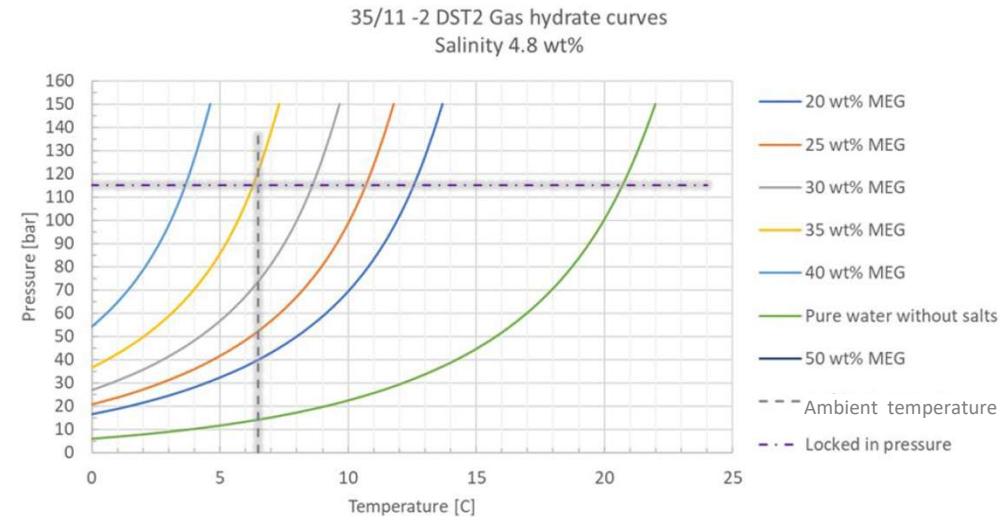


Hydrate Management by Anti-Agglomerant Qualification Field Trials in the Vega Field

Stephan Hatscher, ALFA Team, June 2026

Natural Gas Hydrates and Management

- Natural Gas Hydrates
 - Ice like structures that form with gas and water
 - High pressure and low temperature
 - Come as slushy or sticky
- Flow Assurance
 - Hydrate plug formation is the single largest risk in subsea flow assurance
 - Management tends to be very conservative
- Standard methods in the North Sea
 - Insulation (PiP), active heating (DEH)
 - Depressurization (incl flaring)
 - Chemical inhibition
 - Thermodynamic Inhibitors, such as MEG or Methanol
 - Either “one shot” or in regeneration / reclamation loops, limits formation water production
 - Low Dosage hydrate inhibitors
 - Type Kinetic Hydrate Inhibitor
 - Type *Anti Agglomerant*



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The Vega Asset

■ General

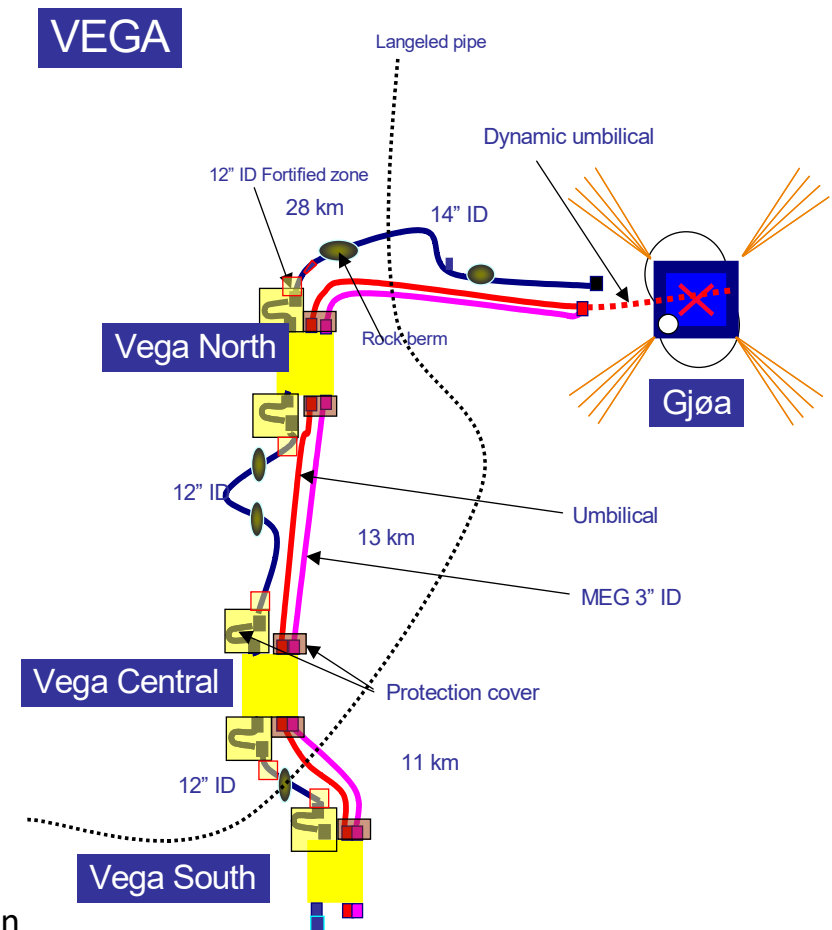
- Subsea gas condensate asset offshore Norway
- 375 m water depth
- Three templates with 3+2+2 wells
- Daisy chained on a long subsea pipeline (52 km)
- Originally high temperature, high pressure
- Produced by depletion

• Current operating mode

- Continuous MEG injection to the templates
- MEG reclamation on topside host facility
 - Design capacity about 220 Sm³ rich MEG per day
 - Design capacity about 10 Sm³ saline formation water per day

• The challenge

- Increasing rates of saline water being produced
 - Salt from this water cannot be handled in MEG reclamation unit
 - Formation water producing wells need optimization and intervention



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Background for the tests

- Vega infrastructure uses continuous MEG injection and reclamation as hydrate philosophy
 - Handling of saline water from the formation is limited by MEG reclamation
 - Cannot allow further (saline water producing) assets in the infrastructure

- Potential solution: Anti Agglomerant products
 - Hydrates are allowed to form
 - Hydrate particles are dispersed into the liquid hydrocarbon phase
 - Application concentration about 2-4% (volume on water)
 - Up to now, no commercial product on NCS



for comparison without AA



with AA 1 hr after starting rocking motor

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Product Environmental Data

■ Primary chemistry

- Biodegradation according to OECD 306 (seawater specific) >60%
- Aquatic toxicity (crustaceans, algae, fish) > 10 mg/L
- Non-bioaccumulating
- LogPow according to OECD 117 2.06
- Biodegradation study analogues to OECD 301F indicate dominant terminal product
 - Readily biodegradable
 - Low marine toxicity (>30 mg/L)

■ Secondary chemistry

- Biodegradation 71%
- Aquatic toxicity >150 mg/L



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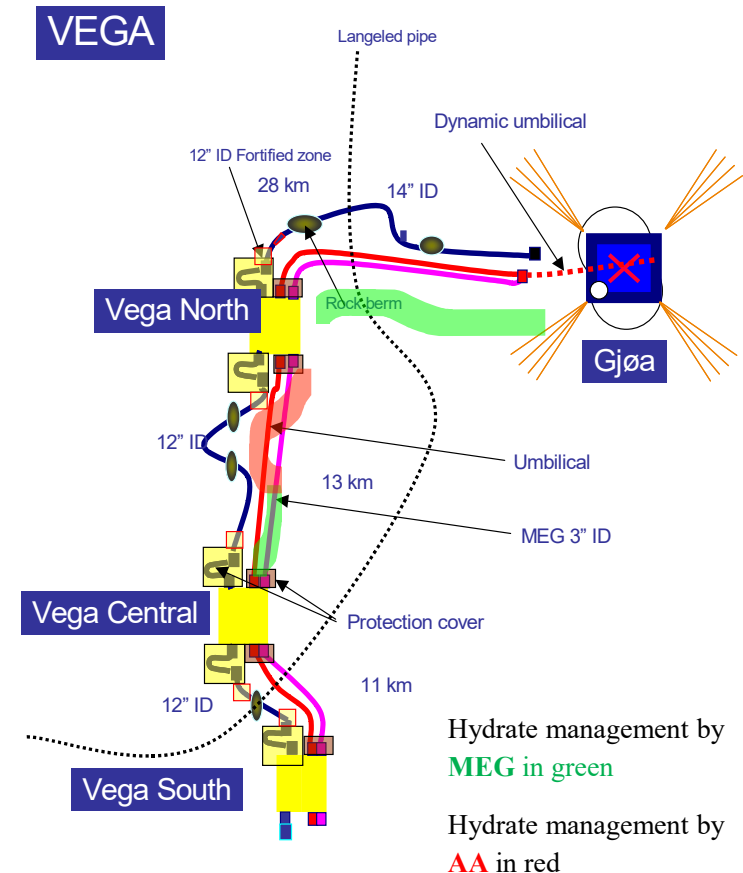
Product Laboratory Performance

- Application envelope aimed for
 - Subcooling 14 K
 - Working over large range of salinity
 - Subsea applicable
 - Various tests run in different setups to assess performance
 - Variation of AA concentration, salinity, pH, gas phase composition, liquid hydrocarbon phase, ...
 - Rocking Cell Tests
 - Constant Volume
 - Constant Pressure
 - Autoclave Tests
 - Rheology Tests
 - Depflux testing
- **Grade 1 (Pass):** finely dispersed hydrates particles, no hydrate deposits, ball rolls across the entire cell, low liquid viscosity.
 - **Grade 2 (Pass-Intermediate):** coarse hydrate particles with some affinity for walls, weak hydrate association, ball rolls across the entire cell, viscous liquid.
 - **Grade 3 (Fail):** extensive hydrate agglomeration and/or deposition, ball could be stuck, full or low liquid level, viscous liquid.

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Subsea Qualification Test

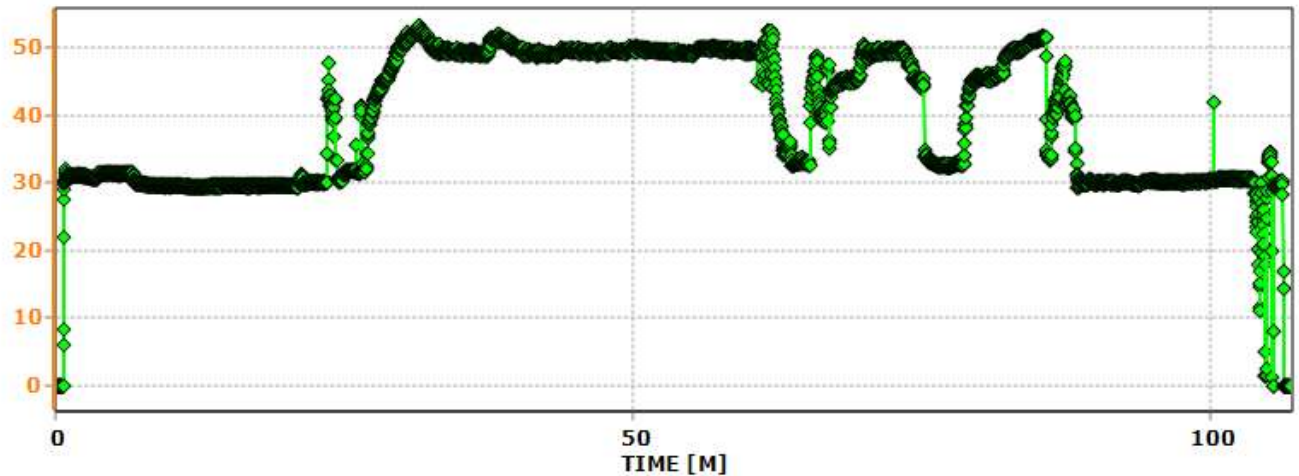
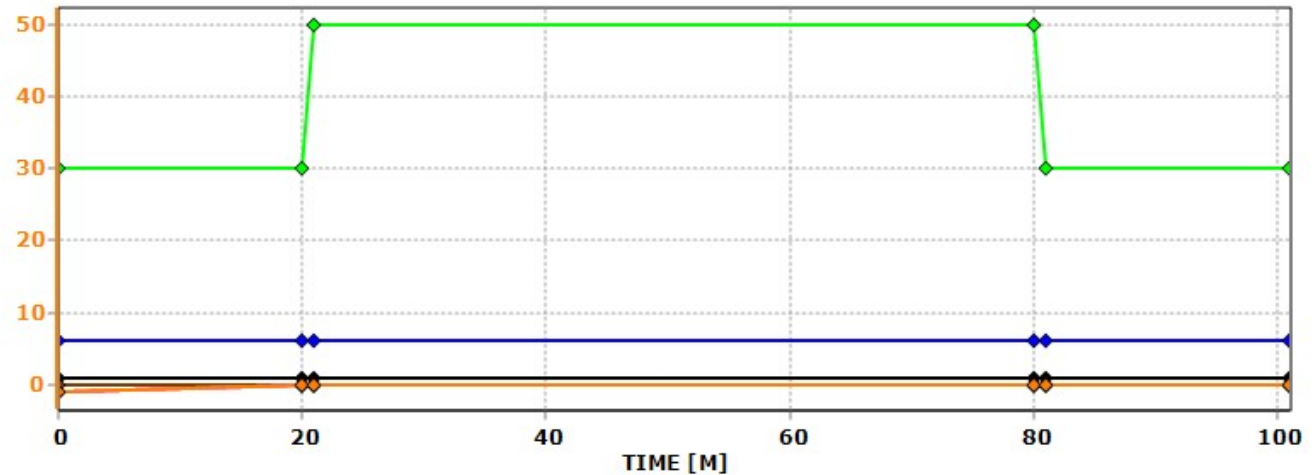
- Step 0: Preparation
 - Cleaned MEG unit, low level in MEG tanks
 - IMR connection to Vega Central
- Step 1: Injection of water package to Central, sufficient to cause a hydrate plug
 - Stop MEG injection to Central whilst producing
 - Add 70 m³ of KCl water with AA to the flowline through the downline of the vessel
 - Continue producing until water package at right location
- Step 2: Shut-in step
 - Minimum MEG usage for shut-in to protect template
 - 32 hours of cool-down
- Step 3: Restart Central to see if AA worked
- Contingent step: Hydrate Plug Remediation



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Operations overview

- Pumped Saturday evening 05 July
 - Some slight hick-ups towards the end of the larger water package injection due to pump fluctuations
 - Total water delivery volume in line with expectations
- Restart Monday morning 07 July
 - No indication of added pressure drop
 - No specific observations on GjØa (apart from slugs / added water)



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Technology qualification

- According to CSM:
 - A plug was expected according to the simulations for the given pumping schedule
 - The fact that no plug formed during the operations shows that the AA was effective as planned
- Review by Wood
 - AA works fine based on laboratory tests
 - “Results from the field trial indicate successful performance with no sign of plugging”. The “AA performed as expected and is suitable for deployment as a” life of “field solution in operational environments”
 - TRL 5 / early stage TRL 6
- According to internal review (FA, PC, PE), CSM, and Wood, the technology was successfully qualified subsea

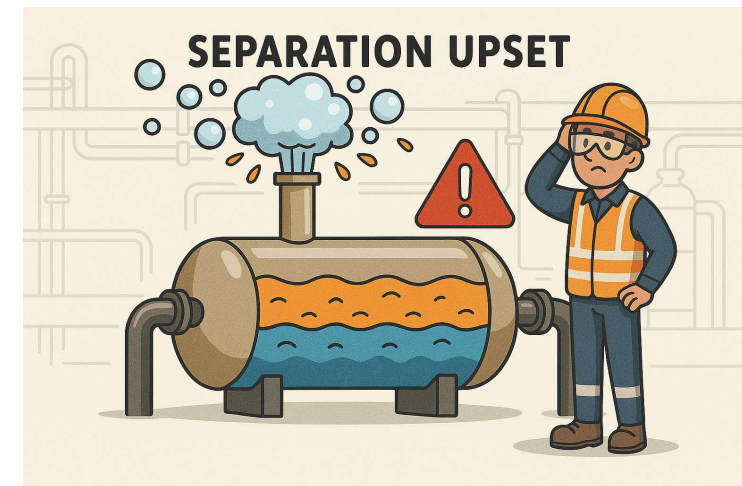
Readiness Level	Definitions for AA LDHI Strategy Readiness	
	TRL Technology Development	ERL Engineering Activities
0 Unproven Concept	Paper concept. No analysis performed.	
1 Proven Concept	Preliminary analysis shows promising AA performance and HSEQ properties.	Concept is scientifically sound but has little or no track-record in the industry.
2 Validated Concept	Lab testing or field experience shows that NCS performance requirements can be achieved.	Concept has received support from industry as a valid solution.
3 Prototype Tested	Lab testing is completed with industry methods for a small number of operating conditions, using field fluids and selected AA chemical; OR, extensive industry experience has been documented and the completion of lab testing (limited) and gap analysis indicates that chemical qualification will be possible with further testing, analysis or research. HSEQ rating meets typical industry requirements but not yet confirmed to meet regional standards.	Concept has been validated extensively using a prototype system or lab test. Successful testing has been performed with a similar system and at similar operating conditions, but not using specific field fluids or chemicals. Industry standard analysis methods* exist.
4 Environment Tested	Lab testing has assessed an extensive range of operating conditions. Where lab testing is not practical, qualification is achieved by a combination of literature review, expert view and case study experience. HSEQ rating meets regional standards.	Actual system has been qualified using lab testing or industry standard analysis methods* for a full range of operating conditions with the field fluids.
5 System Tested	Lab testing has assessed the full operating envelope. Chemical properties and integration test have benchmarked well against lab performance and HSEQ measurements.	Actual system has been tested in the field for the full range of operating conditions.
6 System Installed	Successful implementation of AA strategy for hydrate mitigation. Processes / Procedures / Strategies are in place and routinely used in offshore operations. No performance, HSEQ or export issues reported but limited experience with challenging operating conditions (e.g. limited extended shutdowns).	Actual system is used in the field. Processes / Procedures / Strategies are in place and routinely used in offshore operations. Inspection programme is in place and integrity / reliability are routinely monitored.
7 Field Proven	Extensive field experience including several prolonged shutdown/start-up operations. Chemical performance is well aligned with lab predictions. No performance, HSEQ or export issues reported.	Extensive field experience. System performance meets expected requirements. No HSEQ, integrity or reliability issues identified.

* DNV GL RP A203 (s9.2) lists that acceptable analytical methods include handbook solutions, methods from existing standards, empirical correlations, mathematical formulas, process simulation models, CFD, FEM, corrosion models, experiments, engineering judgement (documented). This is not an exhaustive list.

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Topside test

- Goal
 - Evaluate impact of AA on topside separation during regular production
 - Take samples for partitioning
 - Both aspects could be taken care through a dedicated “squirt test” (no IMR scope, topside only)
- Executed end October offshore Gjøa
 - Injected AA chemical into the first stage separator in three different concentrations
 - Monitoring effect on separation in Vega and Gjøa, OiW, WiO
 - Taking samples to check on partitioning
- Results
 - Good results without any optimization of treatment chemical package
 - OiW and WiO values increased by within specifications
 - No identified showstoppers (but short duration test)
 - Partitioning data gathered (+95% of active in oil)



Graphic: Co-Pilot

Conclusions and way forward

- New AA chemical is available, compliant with North Sea regulations
 - Performance has been tested extensively in the laboratory
 - Very good performance even at high subcoolings
 - Some dependence on salinity for very low saline brines
 - Some pH dependency
- Vega field tests to confirm performance seen in the lab
 - Subsea test indicated re-start-ability after >32 hours deep in subcooling (>10 K)
 - Topside test indicated limited impact on product specifications on short term testing
 - Appetite for pilot production period in 2027
- New opportunity for mature fields!
- New opportunity for marginal fields!

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Thanks!

- Harbour Energy, Clariant, Colorado School of Mines
- Vega license partners
 - DNO Norge AS
 - Harbour Energy Norge AS
 - INPEX Idemitsu Norge AS
 - Petoro AS, Vår Energi ASA
- Operational teams in Harbour Energy and Vår Energi
- SODIR
- You, the audience

- Any questions?

VEGA HYDRATE SLURRY CHEERS!

