

Subsea storage systems

The subsea storage system is developed based on experiences from existing storage solutions. It is a competitive alternative for field developments requiring temporary or permanent storage.

PRODUCT BENEFITS

Lowering production temperature

- Optimum and predictable cooling performance

Multiple storage solutions

- Robust subsea storage solutions for oil, chemicals and produced water

Health, Safety and Environment

- Low environmental impact (CO₂, NO_x, VOC)
- No toxic settlements to seabed
- No risk for surface vessel collision
- Double barrier against leakage to the sea

Flexibility

- Adjustable in size and overall storage capacity
- The solution can be placed at any location and water depth, including Arctic regions
- Cost reduction
- Flexible and scalable cost during the field lifetime
- Reusable (low CAPEX).
- No personnel/helicopter transfer and low SSU maintenance effort required (low OPEX)

Remoteness

- Spare capacity and sufficient thermal insulation to handle uncertainties in offloading frequency
- Simple-to-use

Efficiency

- Enhances the economics of fields with insufficient reserves to support a full field development

Reduced platform logistics

- Eliminating umbilical for transportation of chemicals from the host to the injection point
- Removes practical challenges with long supply lines.
- Reduced platform weight and size

Flexible bag

- Robust and collapsible bag included
- Featuring optimal separation between stored medium and sea-water
- Adjustable in size, shape and overall storage capacity

Subsea storage systems - Oil

The patented Subsea Storage Unit (SSU) enables storage of crude oil, chemicals and produced water at the seafloor. The SSU is a gravity based storage unit that employs the new concept of a flexible bag protected by a dome. The flexible bag introduces a physical barrier, between the stored medium and the surrounding seawater, ensuring the quality of the stored medium. The dome is open to sea so that the medium stored is at a hydrostatic pressure greater than the vapour pressure, and hence preventing gas separation within the SSU. The SSU can be placed at any water depth and the storage is flexible in size depending on field needs during development, expansion and end of field.

Three different subsea storage concepts:

Oil Storage System | Chemical Storage System (MEG) | Produced Water Storage System.

This technology represent the next generation of subsea storage solutions; flexible, competitive and environmentally friendly.

During a qualification program and previous feasibility studies NOV has assessed the feasibility of replacing existing Floating Storage Units at the Norwegian Continental Shelf with a Subsea Storage Unit (SSU) system. The SSU system consists of one or multiple SSU's connected to a manifold, which are controlled by an Operational Management System. The stored volume is contained within the collapsible bag, eliminating contact between the stored

medium and surrounding seawater, thus preventing formation of an emulsion layer and bacteria growth. Oil is preferably stored at export quality but partially stabilised oil may be stored. Oil at export quality is offloaded to a conventional shuttle tanker while partially stabilised oil is offloaded to a shuttle tanker with capabilities of handling such a vapour pressure.

The SSU has a net negative buoyancy when filled with oil, which is obtained by filling ballast compartments with sand.

The protection structure is open to sea (pressure balanced), and the SSU can be deployed at any water depth. The SSU has a double barrier against leakage to the sea.

The overall storage volume (size and number of SSU's) is optimised based on field specific production data. The SSU system including loading and offloading equipment is preferably analysed in a flow assurance analysis.

FEATURES

- Separation of stored medium and water preventing an emulsion layer and bacteria growth
- Enabling technology for Arctic's, subsea processing and remote fields
- Robust subsea storage in stable environmental conditions, not affected by extreme weather conditions
- Thermal management after Client needs
- The SSU has a double barrier against leakage to the sea
- Integrated leak detection system
- The flexible bag can be replaced through the removable hatch on top of the SSU
- The SSU has a net negative buoyancy when filled with oil, which is obtained by filling ballast compartments with sand
- Field specific soil conditions governs the foundation method (skirts, piles or suction anchors)

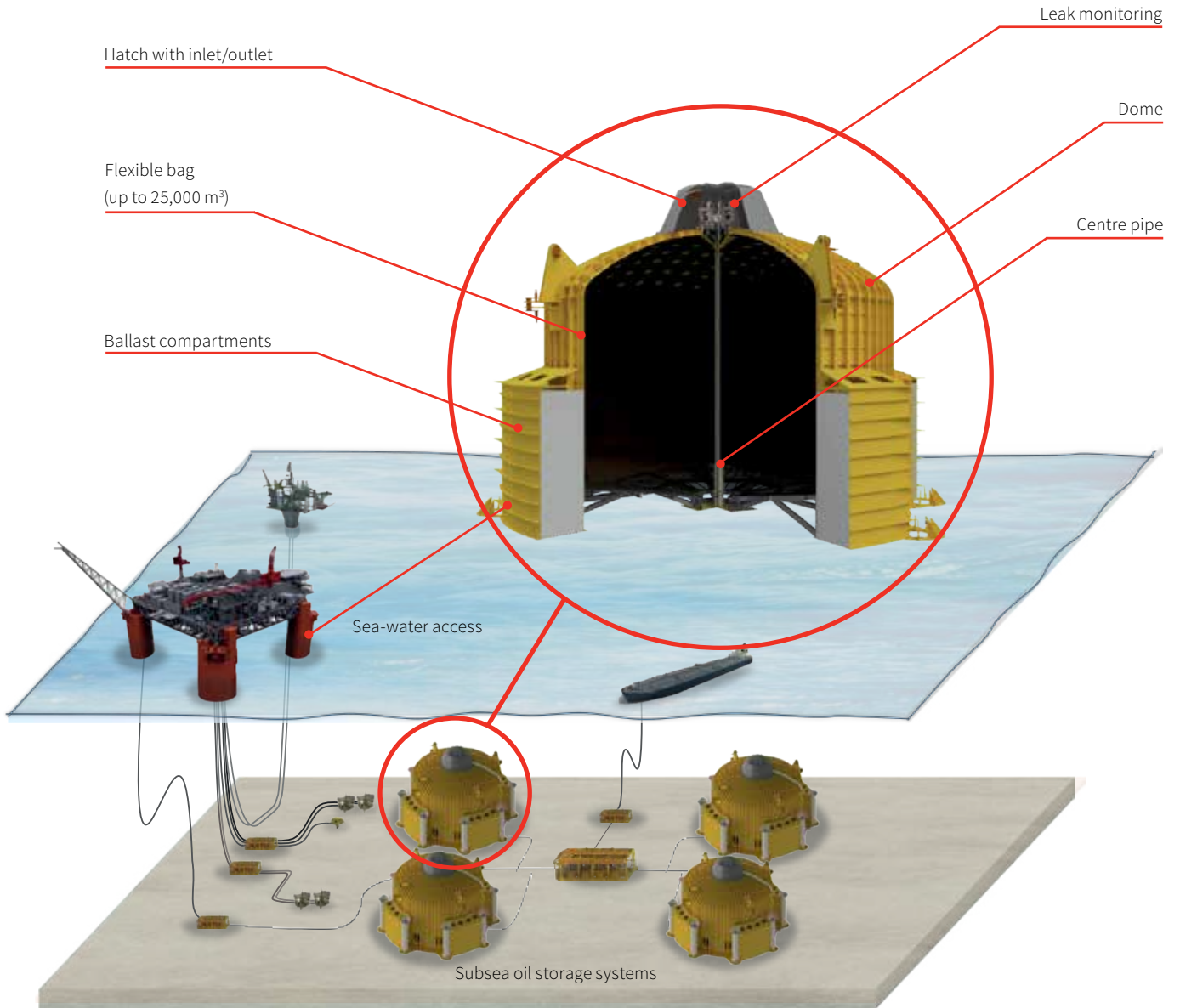
TECHNICAL SPECIFICATIONS

DESIGN LIFE:	25 years
FLEXIBLE BAG DESIGN LIFE:	15 years
STORAGE UNIT SIZE:	10,000 m ³ to 25,000 m ³
WATER DEPTH:	> 100 m
MEDIUM STORED:	Oil/Condensate
VAPOUR PRESSURE:	< 5 bar
DENSITY (OIL/CONDENSATE):	700 kg/m ³ - 850 kg/m ³
INLET TEMPERATURE:	Up to 60 °C
FOUNDATION:	Skirt, piles or suction anchors

SSU demo 2000 scale test



Subsea storage systems - Oil

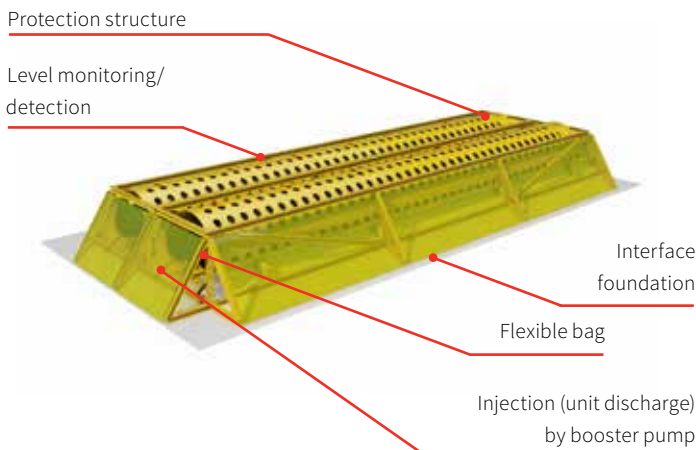


Subsea storage systems - Chemical

During The SSU development has progressed to include seabed storage of a medium more dense than seawater e.g. Mono Ethylene Glycol (MEG). MEG is used to decrease the hydrate formation temperature below the operating temperature as an important part of developing an economic and attractive solution for remote subsea fields. MEG is typically used during start up and shut down (intermittent) or continuously for inhibition of fluids during transport.

Remote storage close to consumer

Local MEG storage close to the injection point is a stepping stone towards elimination of chemical transport in long umbilicals. Introducing a modular and flexible chemical storage design, the Chemical Subsea Storage System allows moving the MEG storage and handling from topside to subsea.



FEATURES

- Separation of stored medium and sea-water
- Collapsible bag offers opportunity for low cost installation of relatively large units
- Enabling technology for Arctic's, subsea processing and remote fields; not affected by extreme weather conditions
- Radical reduction in umbilical complexity decreasing umbilical CAPEX, installation time and cost
- Removes practical and flow assurance challenges with long supply lines
- Local storage close to consumer and thereby avoid sizing the umbilical for solitary events (start/stop inhibits)
- Reduce topside load (space/weight) by moving MEG storage subsea
- Enhances platform safety as it represents a remote subsea storage system that will not inflict on a potential platform fire and explosion

Storage close to platform

This MEG storage system comprises a buffer tank arranged at a seabed for storage of MEG and a plurality of conduits for providing the flow of MEG to and from the surface. Consists of qualified components.

Flexible bag packing test



Storage close to platform



TECHNICAL SPECIFICATIONS

DESIGN LIFE:	25 years
FLEXIBLE BAG DESIGN LIFE:	15 years
STORAGE UNIT SIZE:	50 m ³ to 25,000 m ³
WATER DEPTH:	> 100 m
MEDIUM STORED: (e.g. MEG)	Chemicals (1150 kg/m ³ - 1200 kg/m ³)
INLET TEMPERATURE:	Up to 60 °C
FOUNDATION:	Skirt, piles or suction anchors

Subsea storage systems - Produced water

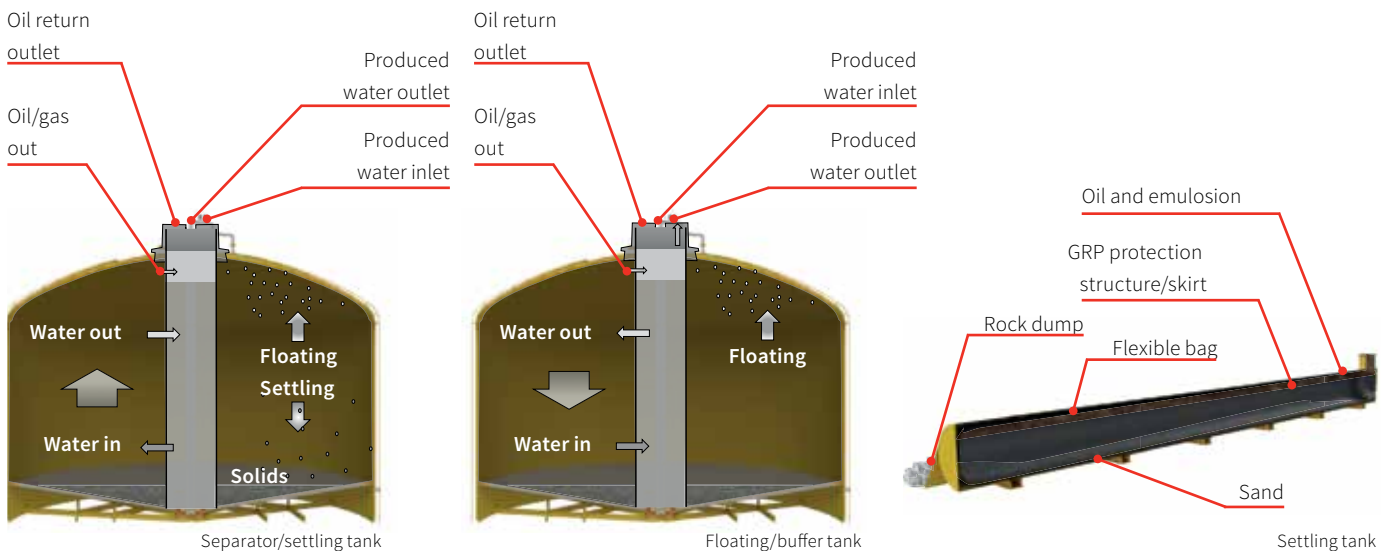
Developing new marginal fields and keeping mature fields with declining production profitable requires meeting several challenges. One challenge is subsea separation of water and oil, and by performing the separation subsea the pressure loss in production flowlines is kept low. This enables a lower wellhead pressure that may lead to increased production. Another challenge is meeting increasingly stricter environmental requirements for discharge of produced water.

The crude oil subsea storage unit is further developed to handle produced water as a large separation module or as a settling tank. Using the SSU as a separation module in a subsea production system allows reducing surface process equipment. Complementing an existing water treatment system with a SSU settling tank for removal of total dissolved solids enables operators to meet environmental requirements for discharged of produced water.

The main purpose of the flexible bag in this application will be to act as a settling tank for solids that need to be removed from the produced water before it is released to sea.

Three different systems for subsea storage of produced water:

1. Separator/settling tank
2. Flotation/buffer tank
3. Settling tank



Subsea Production Systems develops, produces and markets some of the strongest and most advanced subsea systems. Subsea Production Systems is a Business Unit in National Oilwell Varco (NYSE:NOV) which supplies customer-focused solutions that best meet the quality, productivity, and environmental requirements of the energy industry.

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FEATURES

- Meeting flow assurance challenges by providing subsea separation of water and oil, and thereby enabling increased production
- Offering subsea separation of water and oil to a degree allowing reinjection of water
- Providing a settling tank with sufficient retention time for particle settlement and separation of the oil phase so that discharged water meets environmental requirements
- Controlled handling of the separated particles

TECHNICAL SPECIFICATIONS

DESIGN LIFE:	25 years
WATER DEPTH:	> 100 m
MEDIUM STORED:	Produced water
FOUNDATION:	Skirt, piles or suction anchors