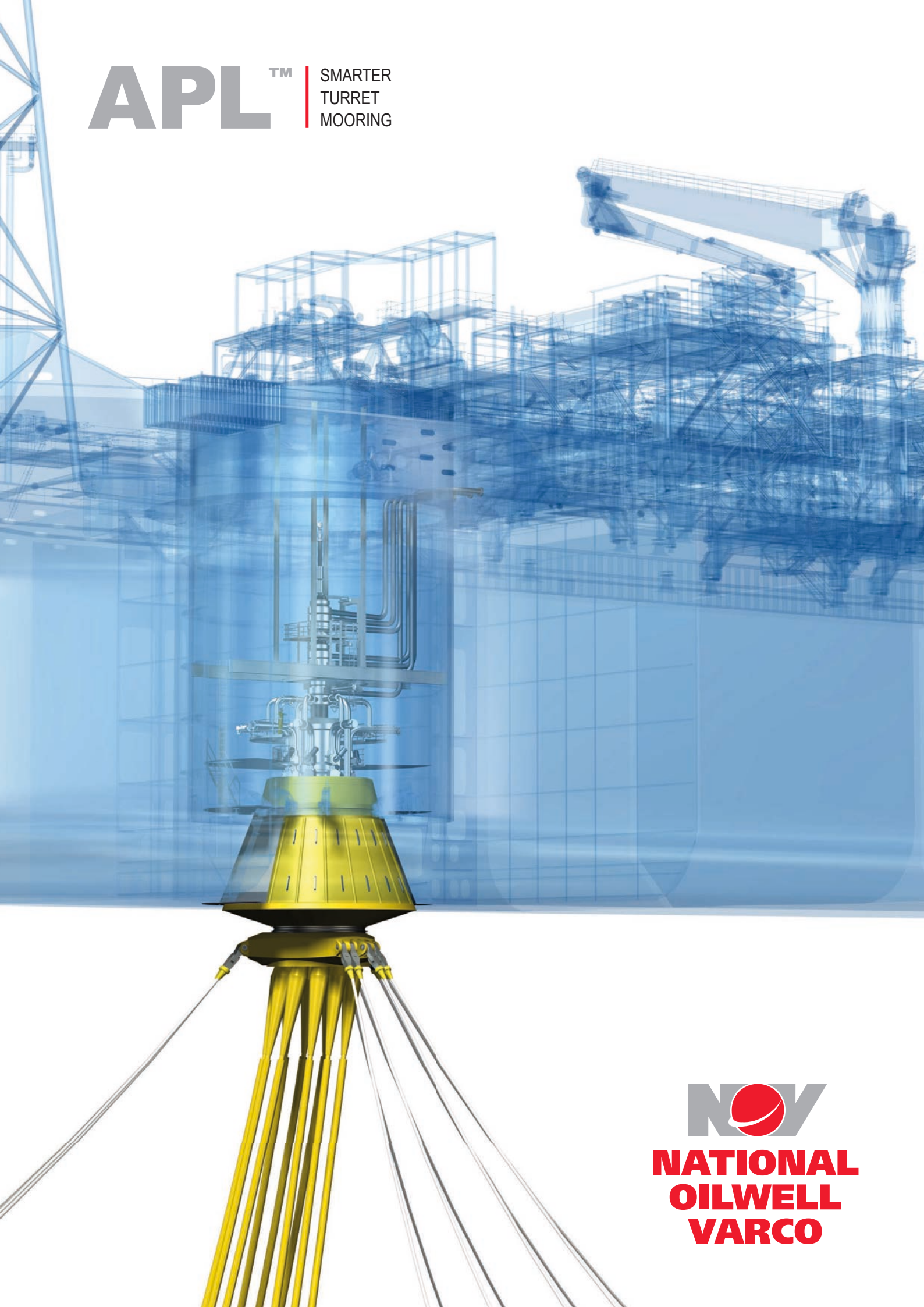
APL™

SMARTER
TURRET
MOORING



NATIONAL
OILWELL
VARCO

APL™

Building on 20 years' experience in the Floating Production Business, APL technology is ready to face new challenges. Since its foundation in 1993, Advanced Production and Loading (APL™) has become one of the world's leading mooring providers for offshore oil and gas production and transfer.

ADVANCED PRODUCTION AND LOADING

NOV Floating Production Solutions offers a unique value to the market and a strong center of drive and innovation, directed at all operators in the Floating Production and SURF markets. NOV Floating Production Solutions is your independent advisory partner and provider of integrated, tailor-made solutions, based on unique combination of existing and customary designs, which are often ground breaking.

By mastering the design and fabrication, NOV obtains smart and robust solutions. Solutions that will drive cost reduction and increase your profit in a long term perspective.

Our capabilities extend beyond the design and supply of project resources, equipment, and systems. But also leverage planning, purchasing, and project management services along with numerous manufacturing and fabrication facilities to provide the customer with turnkey solutions that will improve your overall revenue and profits.
The goal is simple: Create the best and most innovative solutions combined with life-cycle commitment. The reward therein lies in sharing your success.

Advanced Production and Loading (APL) was established with the objective of developing and exploiting the Submerged Turret Loading (STL™) and Submerged Turret Production (STP™) mooring system. These technologies are still an essential part of APL's product offerings, yet have been extended to moor customer units in any situation.

We have also acquired a solid naval architecture expertise. APL are thus able to best manage typhoons in the South China Sea or offshore Australia and to protect the unit.

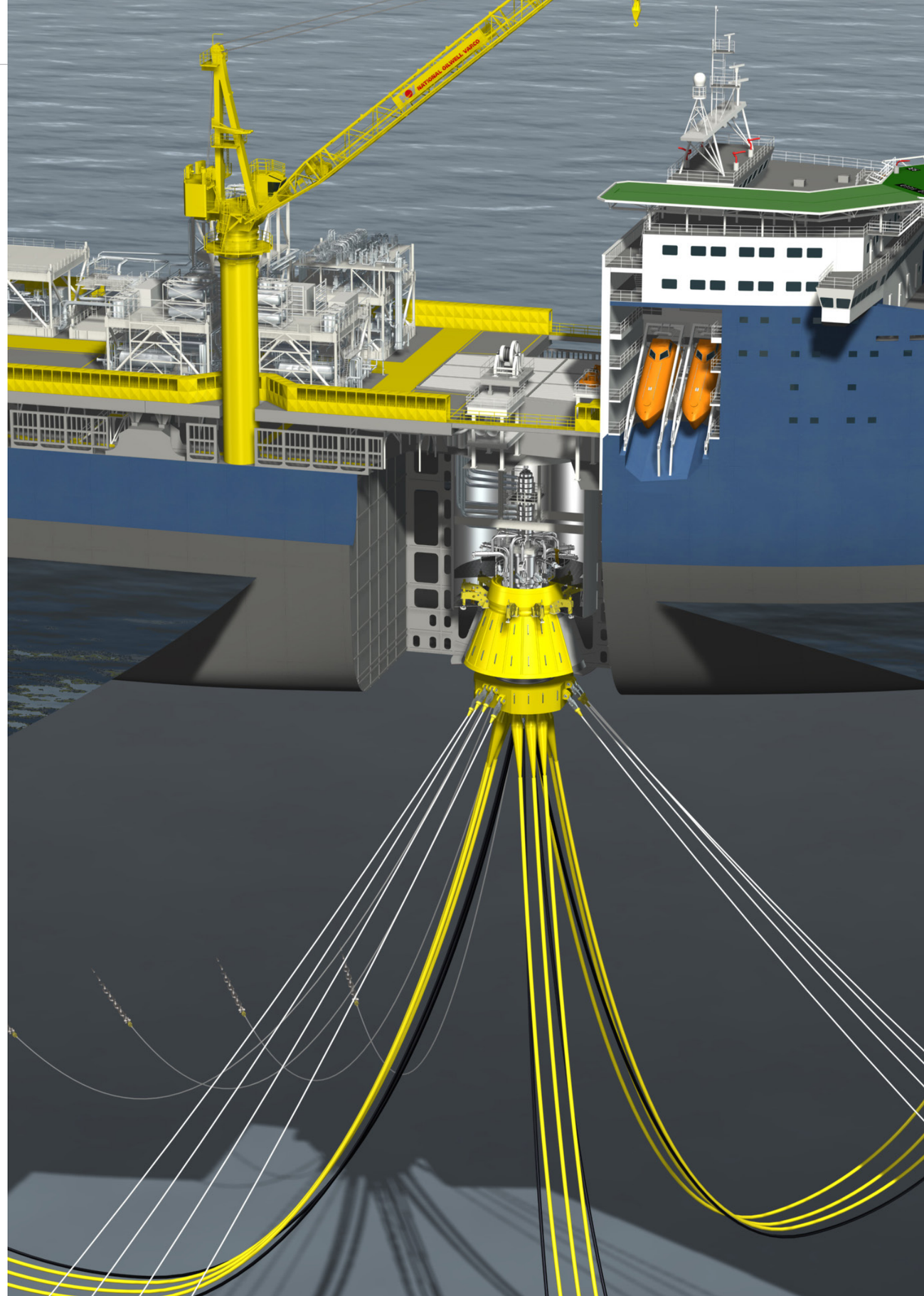
The APL technology is now serving specially built LNG Carriers with on-board regasification to transfer gas directly into the pipe-line and on to the consumers thanks to the APL Buoy.
National Oilwell Varco (NOV) acquired APL in December 2010 and allowed *APL* technology to benefit from an even larger pool of expertise and know how.

> **"THE GOAL IS SIMPLE: CREATE THE BEST AND MOST INNOVATIVE SOLUTIONS COMBINED WITH LIFE-CYCLE COMMITMENT"**

World´s first Offshore LNG Receiving Terminal based on STL, Gulf Gateway – US GoM 110 miles offshore Louisiana

"YÙUM K'AK' NÁAB", the first FPSO in the Gulf of Mexico. Moored on the APL STP System.

STL moored FSO "Nordic Apollo" off- loading crude oil at the Banff field, UK sector North Sea.



STL™

The Submerged Turret Loading (STL™) system represents the state-of-the-art technology within offshore loading. The STL technology offers a flexible, safe and cost-effective solution for Oil Loading Tankers (OLT) and Floating Storage and Offloading (FSO). STL technology has a high availability in harsh environments and is well proven since 1993.

SUBMERGED TURRET LOADING

STL Basics
- A buoy moored to the seabed is pulled into and secured in a mating cone into the vessel.
- The buoy incorporates a turret connected to the mooring and the riser(s).
- All STLs are based on standardized mating cone geometry in the vessel.

Permanent or Disconnect Mooring
- The STL system can be designed for disconnect service (OLT or Shuttles) or for permanent mooring throughout the field life (FSO).
- Disconnection takes only a couple of minutes and can be performed in any weather condition.
- The buoy drops clear of the vessel, and floats in an equilibrium position approximately 30-50 meters below sea level.

Advantages
- The STL system allows for schedule decoupling between the offshore and the shipyard work. STL, mooring and riser can be completed independently from the OLT or FSO. The STL system is installed on site prior to the FSO or OLT arrival at the field. Upon arrival, the vessel hooks up onto the STL on its own.
- Unplanned repair, upgrading, inspections and replacement of the FSO, as well as abandonment of the field, is simplified by the disconnect feature of the buoy based STL system.
- Connection in sea states between 5 and 7 m Hs (Significant Wave Height). Weather independent offshore loading.
- Disconnect regardless of weather conditions.
- High level of safety.

STL Integration
- With bearing structures integrated in the STL buoy, as opposed to bearings integrated directly in the hull, the turret integration in vessel is simplified. Vessel modifications are limited to standard steelwork.
- The STL compartment is a cylinder extending from bottom to upper deck with the receiving cone as the lower part. With a diameter of 10 to 12 meters, the impact on the hull is minimal.

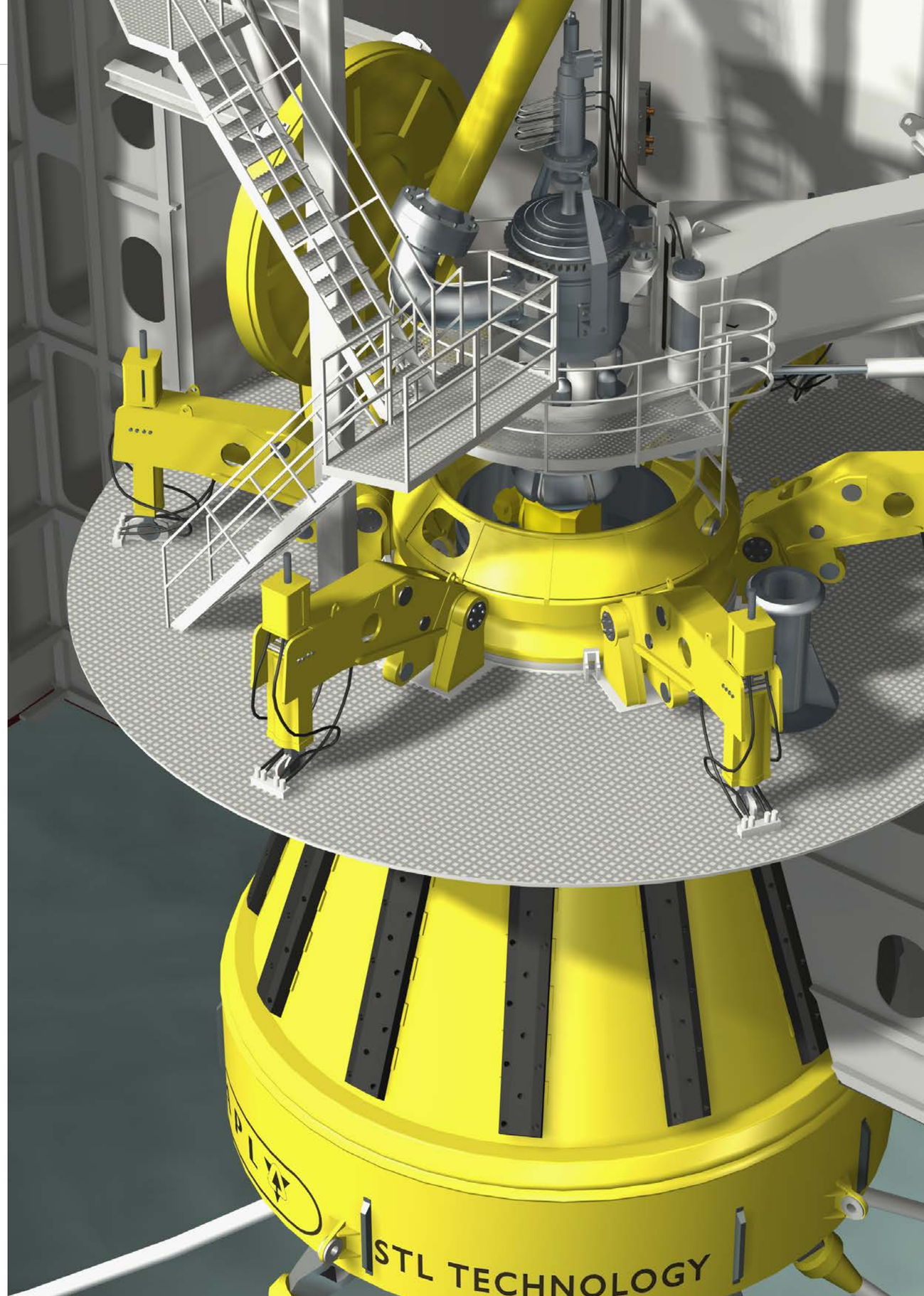
STL System References
STL systems in service cover a wide range of application from the harsh North Sea environment to cyclone prone areas such as China or Australia, mooring caters for sea as high as 19 m Hs (Significant Wave Height), water depth up to 2500 m, vessel sizes up to ULCCs, throughput up to 600,000 BOPD.etc.

STL for High Pressure LNG Re-Gas
- The STL is widely used to moor LNG carriers either FSRUs or Regas Vessels (RV).

STL in ice
- Icebergs and ice ridges in arctic environments are better addressed with the quick disconnect features provided by the STL system.
- STL systems are verified in ice environments.
- Model tests have documented survival of a vessel moored in 1.6 m level ice with drift speed of 0.75 m/s.

STL Buoy lifted to outrigger for wire connection. Neptun project -Massachusetts Bay.

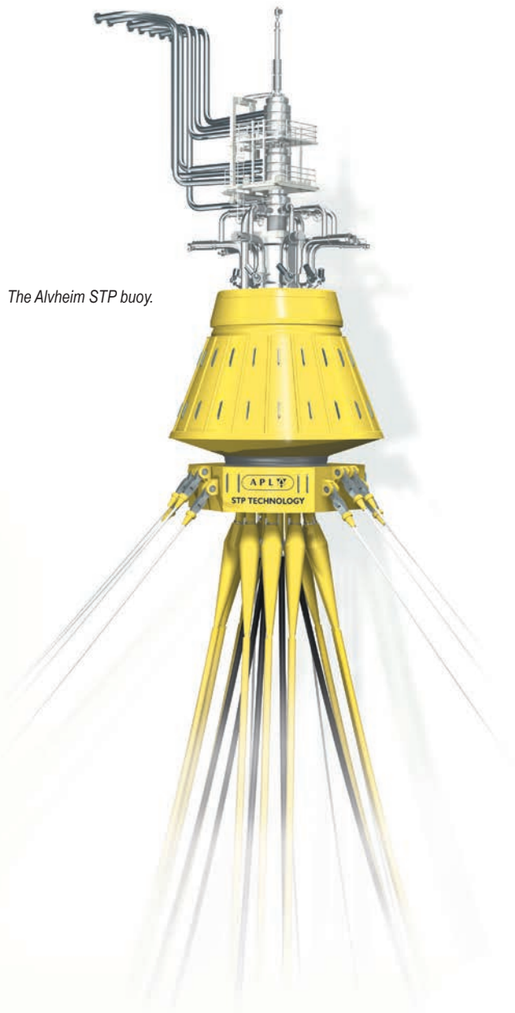
Excelsior, World's First Regas Vessel.



STP™

The Submerged Turret Production (STP) is a unique, innovative and flexible turret mooring system for Floating Production, Storage and Offloading vessels (FPSO) making it suitable for a wide range of applications. As a further development of the STL system, STP is combined with a high pressure multi-path swivel to create a complete turret and swivel package.

SUBMERGED TURRET PRODUCTION



The Alvheim STP buoy.

STP™ Basics

- STP for FPSO mooring is developed from the basis of the proven STL system
- The STP swivel mounted on top of the turret buoy transfers oil, water, gas, signals and power from the geo-stationary riser system to the piping and cabling system of the freely weather vaning production vessel.

Permanent or Disconnect Mooring

- As for STL, the STP system can be designed for disconnect service or for permanent mooring throughout the field life.

Advantages

- As for STL, the STP system allows for schedule decoupling between the offshore and the shipyard work.
- As for STL, yet far more importantly for an FPSO Process Plant, unplanned repair, upgrading, inspections and replacement is dramatically simplified by the disconnect feature of the buoy based STP system.

STP Integration

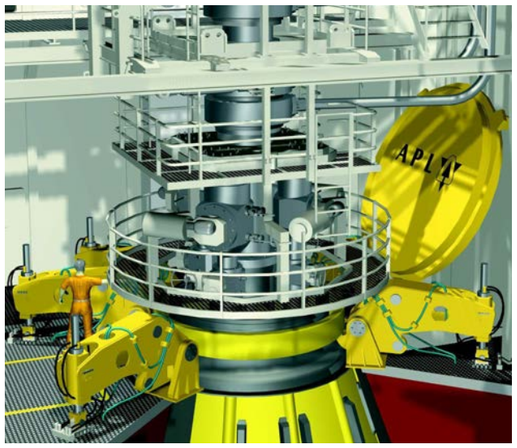
- The STP compartment in the FPSO is a cylinder extending from bottom to upper deck with the receiving cone as the lower part.
- With a diameter of 10 to 18 meters, the impact on the hull is minimal.
- Only local reinforcements of standard steelwork are required.
- With bearing structures integrated in the STP buoy as opposed to bearings integrated with FPSO hull, the turret integration in the FPSO hull is simplified.

STP System References

STP systems in service cover a wide range of application from harsh North Sea environment to cyclone prone areas such as China or Australia, mooring caters for sea as high as 16 m Hs (Significant Wave Height), water depth up to 2600 m, vessel sizes up to VLCCs, through-put up to 600,000 BOPD.etc.

STP in ice

- Icebergs and ice ridges in arctic environments are better addressed with the quick disconnect features provided by the STP system.
- STP systems are verified in ice environments.
- Model tests have documented survival of a vessel moored in 1.6 m level ice with drift speed of 0.75 m/s.



STL compartment, Bayu Undan - Timor Sea

Preparing the Cascade / Chinook STP buoy for transportation to the US GoM.

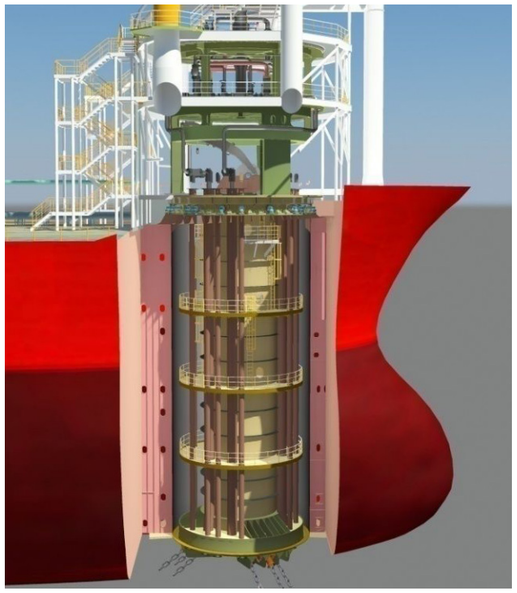
SIT

The Ship Integrated Turret (SIT) is an innovative and flexible turret mooring system for Floating Production, Storage and Offloading vessels (FPSO). Modular design allows for upgrades or modifications to suit different field requirements. Developed from a unique modularized design, these units are available in various sizes and with varying riser capacities to suit the client's requirements.

SHIP INTEGRATED TURRET

The units are comprised of a number of standard components and feature a combination of roller and journal type bearings, thus providing adequate load capacity for use in all areas and water depths. The units are available with multiple decks on the turret shaft thereby allowing for manifolding, pigging equipment, subsea control and chemical injection equipment and safe riser handling.

Winches are provided for riser handling and chain tensioning which can be performed from the turret shaft assembly.
Interfaces with the vessel are well defined and the units can be integrated into all vessel types.



SIT gantry and compartment

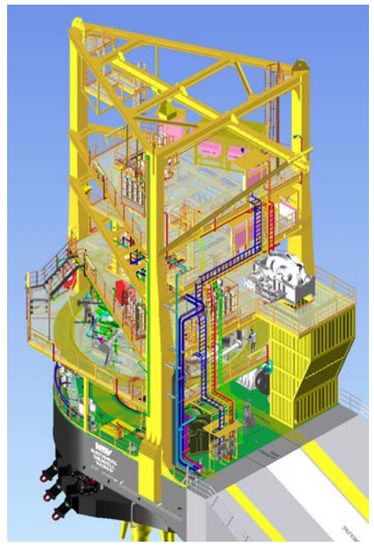
The SIT moored FPSO Polvo offshore Brasil

ETP

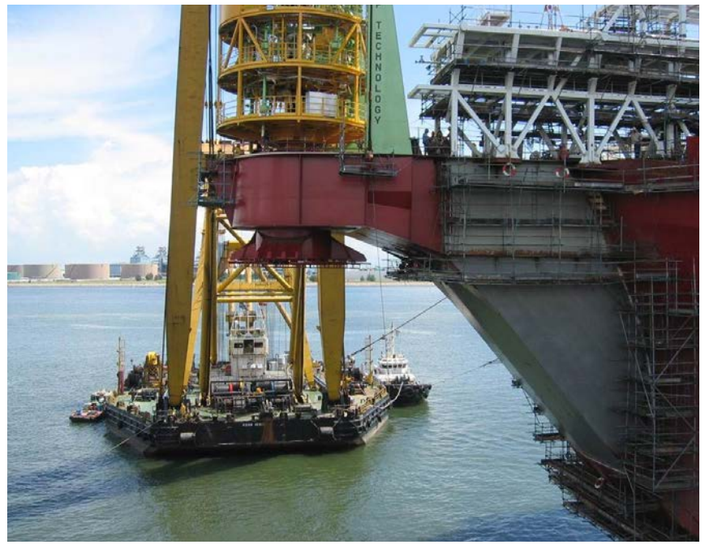
The External Turret Production (ETP) is mounted forward on the bow of the Floating Production, Storage and Offloading vessels (FPSO) with the turret, swivel and main parts of the transfer system above the main deck level. The turret is supported in a ring-shaped turret support structure, which is mounted onto the vessel's bow by a cantilever structure.

EXTERNAL TURRET PRODUCTION

ETP moored FPSO Berge Helene at the Chinguetti field offshore Mauritania.



ETP for the Thang Long field offshore Vietnam.



Assembly of the ETP module to the hull, FPSO Berge Helene.

SYS

The SAL Yoke System (SYS) is a cost-effective solution for Floating Production, Storage and Offloading vessels (FPSO's) in shallow waters. SYS is based on APL's proven technological components and is designed for long-term unattended service. All critical components are designed for lifetime yet with inspection and maintenance access.

SAL YOKE SYSTEM

SYS Basics

- A SYS Base anchored into the seabed integrates the PLEM (Pipeline End Manifold) and a mooring yoke with chain connection to the FPSO at her bow. The yoke weight and heights are adjusted to cater for any vessel size and high sea states.
- A column transfers the torque and supports the topsides inclusive of the swivel stack and associated piping and valves.
- Flexible jumpers transfer oil, gas, water and utilities to and from the FPSO in a U shaped catinary.

Advantages

- The SYS allows for schedule decoupling between the offshore and the shipyard work. Initial installation of SYS can be completed independently from the FPSO conversion or new build at shipyard. The SYS system is installed offshore prior to the FPSO arrival at the field. Upon arrival, the vessel hooks up onto the SYS with the help of tugs but no construction vessel is required to assist.
- The SYS provides for reduced bending moment onto the structure as opposed to traditional Jacket Soft Yoke. In turn, reduced bending moments allow for a more cost efficient structure less prone to fatigue issues.
- The SYS allows for high sea states in very shallow waters. Up to 10 m Hs in water depths of 42 m and 5 m Hs in depths of 18 m.
- During offshore installation, the SYS chain connection to the FPSO is decoupled from the yoke. The yoke is controlled by a RAM winch and the chains are load free while the connection is performed.

SYS Integration

- Vessel modifications are in the bow area and limited to chain connecting arms, gutters and equipment lay out as opposed to bow integration of a yoke.

SYS System References

- SYS systems have been installed in the Bohai Bay in China.

SYS in ice

- The SYS has a minimum sea surface interface. Its column diameter can further be equipped with a conical shaped ice breaker allow the SYS to sustain up to 50 cm of ice sheet.

SYS for High Pressure LNG Re-Gas

- The SYS can be used to moor FSRUs.

SYS located at the Bohai Bay, China

SYS is developed for water depths ranging from vessels minimum to 50 metres.

SMS

Spread Mooring System is commonly used in either benign area of the world such as Africa or South East Asia or in very deep waters as found in Africa or Brazil. Many engineering contractors are providing SMS arrangements, yet APL is providing for a complete system and for an optimized one.

SPREAD MOORING SYSTEM

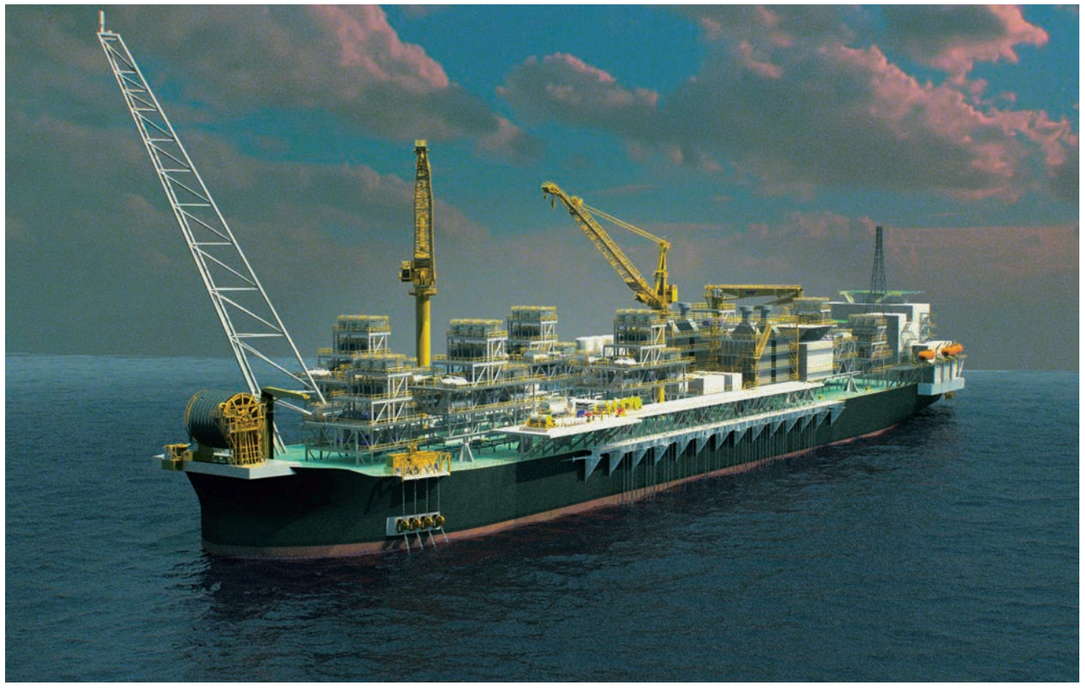
Indeed, APL looks at the complete arrangement with interaction inclusive of the following:

- Naval Architecture with hull global strength (ULS & Fatigue), hull local analysis, stability (stability book, inclination tests), accelerations and model scale testing.
- Spread Mooring: anchors, mooring legs
- Riser Arrangement / Riser Balcony
- Deck Equipment: Fairleads, Winches, etc

And as APL supplies "all of the above", APL is in a position to optimize the SMS based on its wide experience and intimate knowledge of components.

With a recent reference, a VLCC was moored with an APL SMS in 1200 m of water, with exposure to a 100 years significant wave Hs as of 9.1 m and the riser arrangement catered for 53 risers.

Spread moored FPSO P63 for the Papaterra field offshore Brasil



Complete and optimized Spread Moored System.

SAL™

The Single Ancahor Loading (SAL) was developed as a low-cost alternative to the STL system for use in situations where traditional CALM Buoys cannot be used. The SAL system design is based on the technology of the proven STL system and as the STL it is meant for Oil Loading Tankers (OLTs) or Floating Storage and Offloading vessels (FSOs).

SINGLE ANCAHOR LOADING

SAL™ Basics

- A SAL Base anchored into the seabed integrates the PLEM (Pipeline End Manifold), a mooring turret and in-line swivel. The OLT or FSO freely weather vane around the SAL subsea turret via a mooring polyester rope.
- The mooring includes a Clump Weight that provides damping.
- Oil is transferred through an in-line swivel and a hose string assembly up to the vessel piping at the bow.
- OLTs may gain efficiency with the addition of a complete Bow Loading System (BLS) while FSO simply require minor bow piping manifold addition.
- A quick connect/disconnect coupler provides safety against oil spill risk while a weak link in the chaffing chain provides for mooring release beyond a set threshold.

Permanent or Disconnect Mooring

- The SAL system can be designed for disconnect service (OLT or Shuttles) or for permanent mooring throughout the field life (FSO).

Advantages

- Connection and disconnection takes only a couple of hours and can be performed in seas as high as Hs 4,5 m for connection and 7 m for disconnection.
- As the SAL is subsea, the risk of collision between the tanker and traditional CALM buoy is eliminated.
- The SAL mooring and hose string assembly is abandoned clear of the vessel and lies on the seabed well protected.

SAL Integration

- Vessel modifications are limited to either bow piping manifold addition or to the addition of a standard North Sea BLS.
- All equipment used to operate the SAL system are remotely controlled and monitored.

SAL System References

- SAL systems in service cover a wide range of application from harsh North Sea environment to ice covered areas such as Arctic Russia.

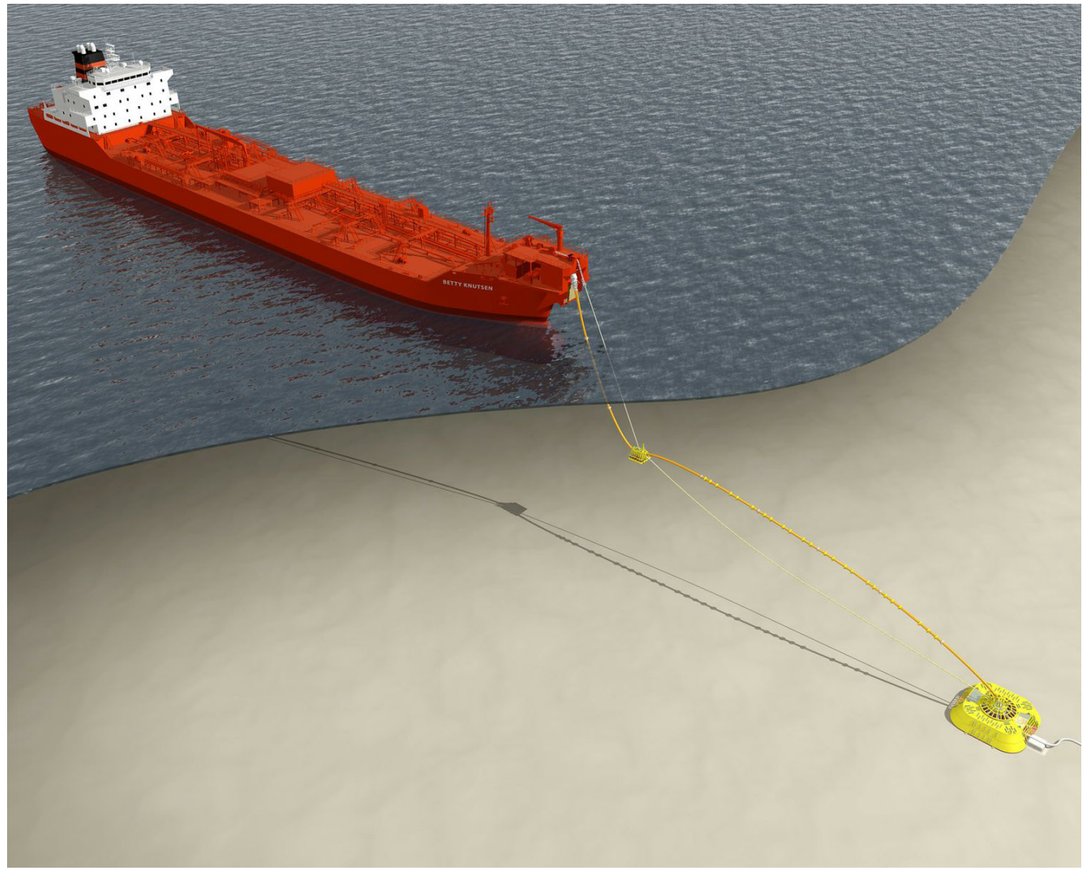
SAL in ice

- Ice bergs and ice ridges in arctic environments are better addressed with the quick disconnect features provided by the SAL system.
- The SAL is naturally protected subsea under the ice sheet.

SAL for High Pressure LNG Re-Gas

- The SAL can accommodate a flexible riser (instead of a hose string assembly) and a high pressure swivel to moor LNG carriers either FSRUs or Regas Vessels (RV).

Tow out of the SAL anchor to Hanze and Ardmore fields



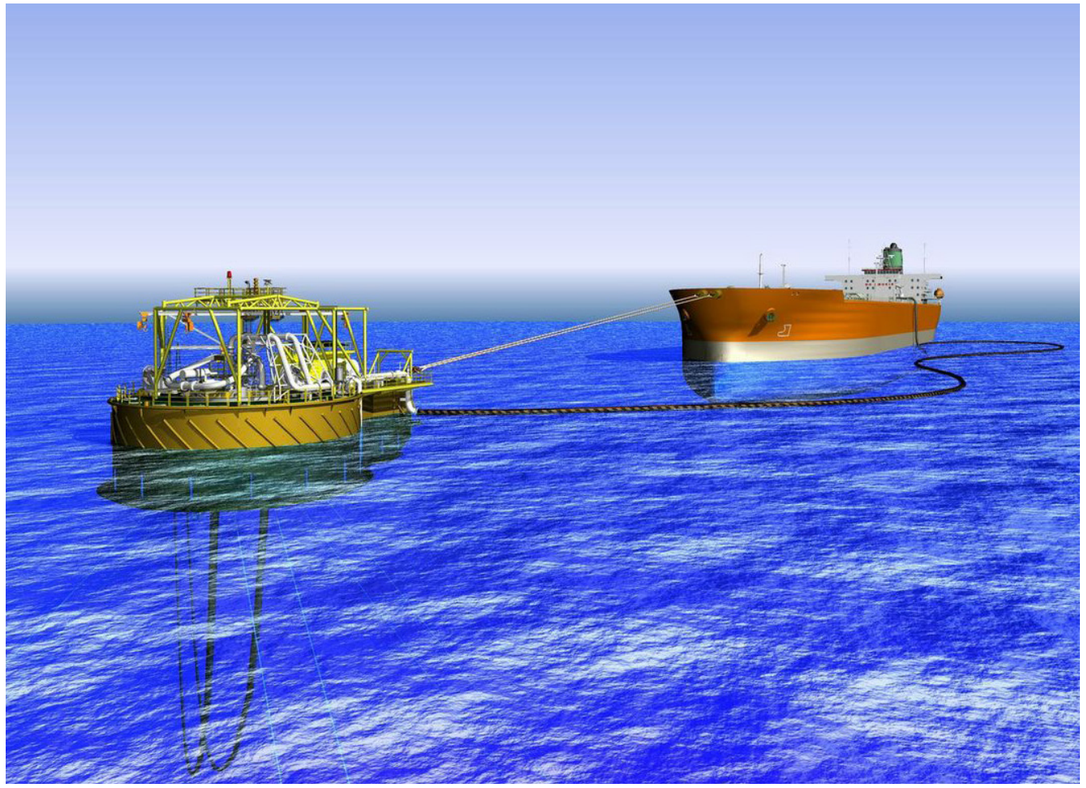
Shuttle tanker connected to the SAL System

Shuttle tanker connecting to the SAL system - Ardmore field in the UK North Sea sector.

BTL

The Buoy Turret Loading (BTL) is a turret CALM Buoy aimed at deepwater application and at large and frequent offloading operations. Its deck offers wide space for operation, inspection and maintenance of equipment. Its keyhole shape provides for improved weather vaning. The BTL is fabrication friendly allowing for high local content.

BUOY TURRET LOADING



Shuttle tanker with mid-ship connection loading crude via the BTL calm buoy.

Buoy Turret Loading at the Dalia field offshore Angola.

BLS

The Bow Loading System (BLS) is providing efficient means for offshore loading required by Oil Loading Tankers (OLTs) or FSOs. The BLS is compatible with standardized equipment on Oil Loading Tankers (OLTs) and Floating Storage and Offloading vessels (FSOs) as well as APL's SAL™ and OLS system.

BOW LOADING SYSTEM

The BLS is based on years of operational experience in the harsh North Sea. The BLS also incorporates optimized versions for Brazil and for the Arctic.

The BLS incorporates a ball joint at the Loading Manifold, which provides a "moment free" connection between the loading hose and the vessel. This enhances the durability and service life of both the loading hose, hose end piece and coupling. The system may also incorporate a sliding chain stopper (SPM Auto), which minimises manual operations during the mooring and unmooring sequences.

The first BLS was delivered in 1992, and since then a significant number of BLS systems have been supplied to ship owners and yards worldwide.

Shuttle Tanker "Scott Spirit" loading crude oil in the North Sea.

SDS

The Stern Discharge System (SDS) is installed in the aft end of Floating Storage and Offloading vessels (FSOs) and Floating Production, Storage and Offloading units (FPSOs) and it provides for offloading to shuttle tankers or standard trading tankers.

STERN DISCHARGE SYSTEM

The SDS incorporate the following features:

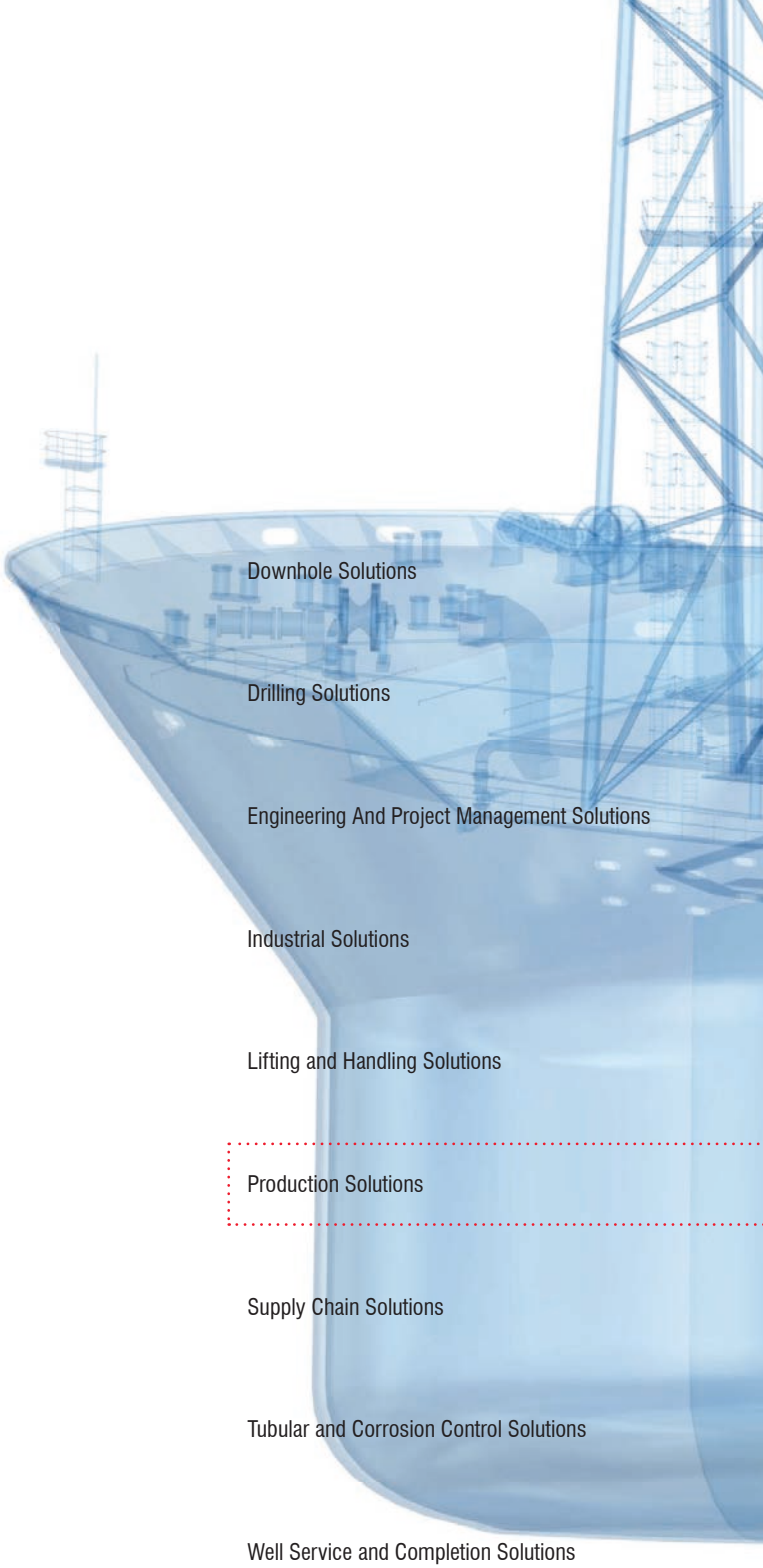
- The hose assembly is stored from a dedicated hose reel providing for rapid and safe deployment.

- A vertical drum mooring & hawser handling winch, which is specifically designed for tandem mooring. The mooring operation is significantly simplified as the winch stores chain and rope on the same drum. To avoid wear on the soft mooring hawser both chafing chains are stored in a special recess at the bottom flange. The vertical drum construction also prevents chain fall-off, which is a common problem for horizontal drum winches

- A ball joint (optional) for "moment free" termination of the loading hose, thus protecting it from excessive strain.

- The winch can also be equipped (optional) with tension monitoring and quick release of the mooring hawser.
The first SDS was delivered in 1993 for M/T «Vinga», operating as an FSO on the Shell/Esso Fulmar Field in the North Sea. Since then, a significant number of SDS Systems have been delivered worldwide.

Aasgaard C FSO, North Sea



NATIONAL OILWELL VARCO

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Drilling Solutions

Engineering And Project Management Solutions

Industrial Solutions

Lifting and Handling Solutions

Production Solutions

Supply Chain Solutions

Tubular and Corrosion Control Solutions

Well Service and Completion Solutions

MAIN OFFICES

Corporate Headquarter
7909 Parkwood Circle Drive
Houston, Texas, 77036
United states
Phone: + 1 713 375 3700
Fax: +1 713 346 7687

APL Norway AS
Vikaveien 85, N-4816 Kolbjørnsvik
Arendal, Norway
Phone + 47 45 29 70 00
Fax: + 47 37 02 41 28

APL do Brasil Ltda
Rua Lauro Muller 116, sala 4202
22.290.160 Botafogo, Rio de Janeiro RJ, Brazil
Phone/Fax: +55 213575-0661

Advanced Production and Loading Inc.
2000 Dairy Ashford, Suite 600
Houston, Texas 77077, USA
Phone: +1 281 293 7711
Fax: +1 281 293 7707

APL Management Pte Ltd
3A International Business Park
ICON@IBP, Tower A, 12-06/09, Singapore 609935
Phone: +65 6659 5505
Fax: +65 6659 5575

www.nov.com/fps
Prospects and General Information: APLTechnology@nov.com
Aftersales, Spareparts and Service: APLService@nov.com

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