Gas Lift Using the Concentric Offset Riser

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Abstract

The production of heavy oil presents a number of problems to deep water operators. A combination of high fluid density, therefore high hydrostatic head in deepwater, and viscosity in the risers tied back to the floating production vessel limits the oil production rate. The Concentric Offset Riser (COR) offers a solution for convenient provision of production and riser base gas lift within a single riser. The injection of gas at the riser base mixes with and lightens the oil and hence enhances the production rate from heavy oil reservoirs.

The COR is a free standing, thermally efficient pipe-in-pipe hybrid riser system suitable for subsea developments tied back to a floating vessel. The annular space has many potential uses, one of which is gas lift. The vertical steel pipe is tensioned at the top with a buoyancy tank, and tied back to the production vessel with a flexible jumper. Such systems are being implemented in West Africa.

This paper describes the COR configuration and benefits of implementing the COR design for deepwater heavy oil developments.

Introduction

The COR is suitable for heavy oil developments in both mild and harsh environments and for a range of production facility types. Conventionally, one riser for import production and one riser for gas lift are employed. The COR reduces the number of riser strings by allowing gas lift using the annulus.

A key feature of the COR is the ability to install them quickly from any deep water drilling vessel using standard rig equipment and procedures.

The COR is a flexible riser type that can be adapted to suit a range of construction methods (welded or threaded couplings for the steel pipe) and installation methods, J-Lay, tow, reel lay or from a Mobile Offshore Drilling Unit (MODU). In addition, riser components such as the foundation and top assembly can be tailored to suit project requirements, operator preferences or the chosen installation method.

Hybrid Riser Types

Free standing hybrid risers can either be configured in a single pipe arrangement (Single Line Offset Riser – SLOR), or a pipe in pipe arrangement (Concentric Offset Riser – COR) or as a bundle arrangement with the individual pipes arranged around a central carrier pipe, either internally or externally of the buoyancy modules, Figure 1.

Installed and Future Hybrid Risers

A summary of the existing and planned future hybrid risers is given in Figure 2 and are briefly described in the following sections.

Placid/Enserch Hybrid Riser Bundle. This non offset bundled hybrid riser was originally installed at Placid's Green Canyon development in 469m water depth in the Gulf of Mexico. The riser was subsequently retrieved, stored and then later reused for Enserch's Garden Banks development in the Gulf of Mexico in 670m water depth. With the non-offset arrangement the riser relied on a tension contribution from the vessel.

Total Girassol Bundled Hybrid Risers. The Girassol freestanding risers consist of 3 internal bundle hybrid riser towers. The Girassol field, operated by Total is located offshore Angola in a water depth of 1350m. Each bundle consists of 14 peripheral lines of varying diameter, including 4 for production and 4 for gas lift, arranged around a 22inch carrier pipe.

ExxonMobil Kizomba A and Kizomba B. The ExxonMobil Kizomba A and B developments are located offshore Angola in a water depth of approximately 1000 to 1200m. The Kizomba A development used 5 SLOR risers for water and gas injection duties, with risers attached to the bow and side of the FPSO.

For Kizomba B a further 5 hybrid risers have been employed with 2 SLOR risers, as for Kizomba A, and an additional 3 COR or Pipe-in-Pipe risers used for production and test duties. These are the first COR risers and are of welded steel construction, installed from the Saibos Field Development Ship (FDS). The annulus of the COR risers is used for gas lift, with two flexible jumpers, for production and gas lift, connecting the top of each riser to the Kizomba B FPSO.

Total Rosa Hybrid Riser Bundle. Currently in development is an additional internal bundle hybrid riser to tie-back the Rosa field to the existing Girassol FPSO.

BP Block 18 Hybrid Riser Bundle. The Block 18 hybrid riser bundle is planned to go onstream in 2007. The bundle is the external type with the peripheral lines arranged around the outside of the buoyancy modules.

Petrobras P-52 Single Line Hybrid Riser. The Petrobras P-52 SLOR, due to be installed in early 2007 is a large diameter 18inch riser, to be used for oil export. The P-52 semi-submersible platform is in 1800m water depth in the Roncador field in the Campos Basin, offshore Brazil.

Configuration

There are a number of variations to the COR design, one of them is described below and shown in Figure 3.

The COR consists of two concentric vertical steel pipes connected to a foundation pile at the seabed. A buoyancy can assembly near the water surface, but located below the wave and high current zone, is used to tension the steel pipe. The riser pipes run through the bore of the buoyancy can where centralisers maintain concentricity of the outer riser pipe within the buoyancy can stem. The COR is tied back to the vessel with two flexible jumpers for access to both the riser annulus and bore. The flexible jumpers are attached to the gooseneck assembly at the top of the buoyancy tank, and the flexible jumpers help to decouple the vessel motions from the riser.

Depending on water depth, vessel excursions, and number of risers to be accommodated, the riser foundation is typically 200m or more from the vessel. The flexible jumper lengths are chosen to provide comfortable hang-off angles and bend radii at the sag bend whilst accommodating vessel excursions. Typical base tension for the COR is in the range 100 to 200Tonnes, and is chosen to optimise the riser response.

Foundation. The foundation consists of a drilled and grouted pile to which the riser is connected with a high integrity connector. The foundation diameter and penetration depth is dependent on the riser base tension and the soil conditions at the site. The riser has a rigid base connection.

Lower Riser Assembly. The lower riser assembly consists of the lower off-take spool, gas lift injection system, and the lower taper joint. The off-take spool is a component with an internal flow path which is open at the side of the spool. Attached to the side of the spool is an induction bend, and a riser base jumper is connected to the end of the induction bend by either a horizontal or vertical connection system. The opposite end of the riser base jumper is connected to the flowline via a Pipeline End Termination (PLET).

The gas lift injection system is attached to the off-take spool top. This component completes the gas injection flow path from the annulus to the riser bore.

The lower taper joint is connected to the top of the gas lift injection system. This component is designed to control the bending at the base of the riser where it connects to the stiff lower riser assembly.

Riser String. The majority of the riser string consists of two concentric riser pipes manufactured from high strength steel and constructed from threaded and coupled steel joints. Alternatively, a welded construction is possible using a lower strength steel. Centralisers maintain pipe-in-pipe concentricity at required locations along the riser to aid even distribution of bending between the two pipe strings and avoid contact between the inner and outer pipes.

Buoyancy Can. The COR is tensioned by a single nitrogen filled buoyancy can or an assembly of smaller cans. Internal bulkheads are used to divide the can into compartments to limit buoyancy tank flooding in the event of localised damage.

The riser pipe is attached to a load shoulder at the top of the buoyancy can, and thus the upthrust generated by the buoyancy can is transmitted directly to provide tension in the riser string.

Keel Joint. At the base of the buoyancy can, where the riser exits from the central structural pipe, a keel joint arrangement is used to control the bending moment transferred to the riser string due to vessel excursion and riser motion. The keel joint arrangement is similar to that used for dry tree production risers, except that there is no relative stroke between the buoyancy can and riser string.

Gooseneck Assembly. The gooseneck assembly provides fluid off-take from the free standing riser to the flexible jumpers. It consists of two induction bends to accommodate access to the riser bore and annulus, which are structurally braced back to a gooseneck support spool at the base of the assembly to react the loads generated on the assembly by the flexible jumpers.

The bends in the gooseneck, off-take spool and base jumper are typically configured as 3D or 5D radius bends. These can allow the passage of pigs and prevent flow restrictions.

Flexible Jumper. Flexible jumpers are used to transfer the fluid between the riser and the vessel. Bend stiffeners are used to control the bend radius of the jumper at the vessel and gooseneck termination points. The gas lift flexible jumper typically has a different length from the production jumper in order to avoid interference.

Alternative Configuration

COR configurations may depend upon project specific requirements, contract strategy and installation method. The COR described below has been implemented for riser base gas lift offshore West Africa. An illustration of this configuration is provided in Figure 4.

There are two main differences in the West African COR configurations:

- Gooseneck location
- Foundation

The gooseneck for the West African COR is located below the buoyancy can. This configuration simplifies the interface between riser and buoyancy can as the riser pipe does not pass through the buoyancy can. However, advantages exist in placing the gooseneck at the top of the buoyancy can as the flexible jumper can be installed after the riser is free standing by a smaller, cheaper installation vessel. Also, the gooseneck is diver accessible when located at the top of the buoyancy tank. This allows for easier repair and replacement of the flexible jumper in the event of damage.

The West African COR has a gravity assisted suction pile foundation, which can be easily installed from many different vessel types and fabricated locally. In addition, a flexible joint at the riser base mitigates bending moment in this region. This differs from the other configuration, which uses a tapered joint to distribute the high bending at the riser base.

Gas Lift Arrangement

A typical lower riser assembly complete with gas lift injection system is shown in Figure 5.

The inner production pipe has multiple holes equally spaced around the circumference for the distribution of gas to the production bore. As gas flows through these holes, which vary in diameter depending upon the specific fluid requirements, the production and gas lift flow streams will impinge on each other and mix. This reduces the effective density of the oil and increases the production rate.

There is a small annulus at the base of the COR, which may collect water during some modes of operation. Whilst the locations of the gas lift injection holes are selected to minimise this volume, the area may be overlaid with corrosion resistant material to prevent corrosion if this is considered an issue. However, during non gas lifting operation, a back pressure will be maintained in the annulus and small influxes of oil with small volumes of water are expected to constantly flush this area as opposed to having just stagnant water. During gas lift, the warm gas will maintain a positive back pressure preventing influx of production fluids and also evaporating any moisture that collects in this area. On this basis, corrosion is not considered a problem. In addition, the riser pipes are designed with thick sections at these locations.

Key Design Drivers

The key design drivers for the COR riser, which are also applicable for single line hybrid risers are summarised below.

Buoyancy Tank Size. The buoyancy tank upthrust required is dictated by the total weight of the riser string, including contribution from the flexible jumpers and internal fluids. The weight of internal fluids during hydrotest and installation may be the governing condition.

The diameter of the buoyancy tank is dictated by construction and installation limitations, with possible restrictions on the length from offshore handling (height below crane).

Buoyancy Tank Depth. The depth of the buoyancy tank below the mean water level is dictated by access requirements and the desire to place it below the wave loading region and, if possible, below areas of high currents. This must be balanced against the advantages of placing the buoyancy tank near the surface to allow diver access and inspection and shorten the length of required flexible jumper.

Flexible Jumper Length. The flexible jumper length is dictated by the riser offset from the vessel, vessel offset envelope and riser movement under current and wave loading. If the flexible jumper length is insufficient the angle ranges that must be accommodated by the bend stiffeners at the ends of the flexible jumper may be too high and the bend radii in the sag bend of the flexible jumper compromised. As this is a high cost item it is desirable to keep the flexible jumper as short as possible.

Offset From Vessel. The offset distance from the riser is dictated by the extreme vessel offset envelope, the effect of current loading on the riser and field layout clearance requirements.

Tension Overpull at Base. The tension overpull at the base of the riser is driven by the possible range of internal fluid combinations (overpull required for all scenarios), the riser deflection (increasing base tension can decrease deflections and improve clearances between risers) and the required fatigue life of the riser.

Conclusion

Implementation of the COR is an ideal tieback solution for heavy oil developments as the riser base gas lift can be employed using the annulus as the gas injection flow path. Furthermore, the capability of the of the COR to perform riser base gas lift reduces the number of required riser strings as conventional gas lift utilises one riser for import production and one riser for gas lift.

- Moderate dynamic response
- Thermal and process capability
- Common hardware
- Cheap and flexible installation
- Field development and schedule flexibility
- Low maintenance

References

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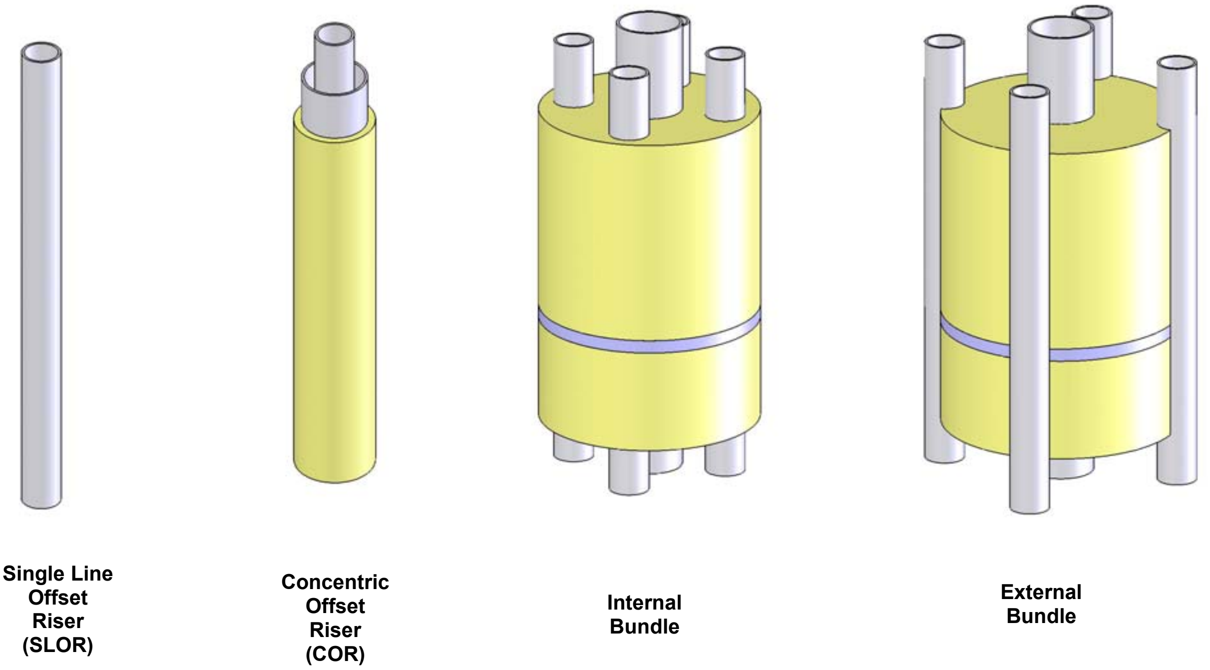

Figure 1 – Hybrid Riser Types

Field Development	Riser Type	Water Depth (m)
Placid Green Canyon	Internal Bundle	469
Enserch Garden Bank	Internal Bundle	670
Total Girassol	Internal Bundle x 3	1350
Exxon Kizomba A	SLOR x 5	1200
Exxon Kizomba B	SLOR x 2 COR x 3	1200
Total Rosa (planned – 2006)	Internal Bundle	1450
BP Block 18 (planned - 2007)	External Bundle	1300
Petrobras P-52 (planned - 2007)	SLOR x 1	1800

Figure 2 – Existing and Planned Hybrid Risers

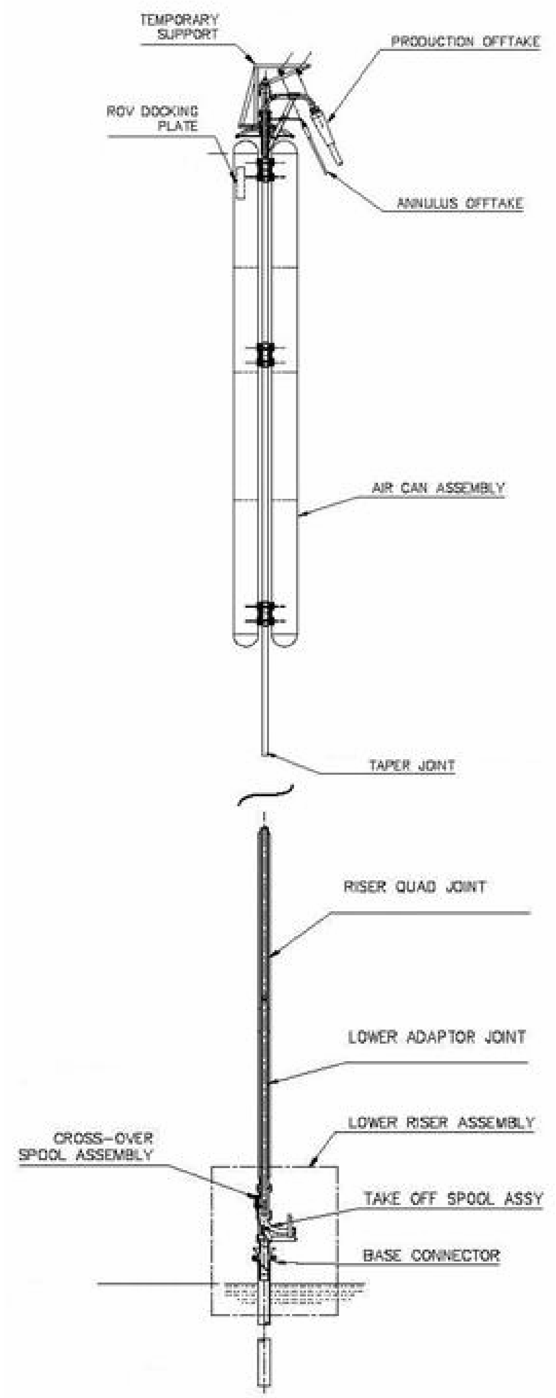

Figure 3 – Typical COR General Arrangement

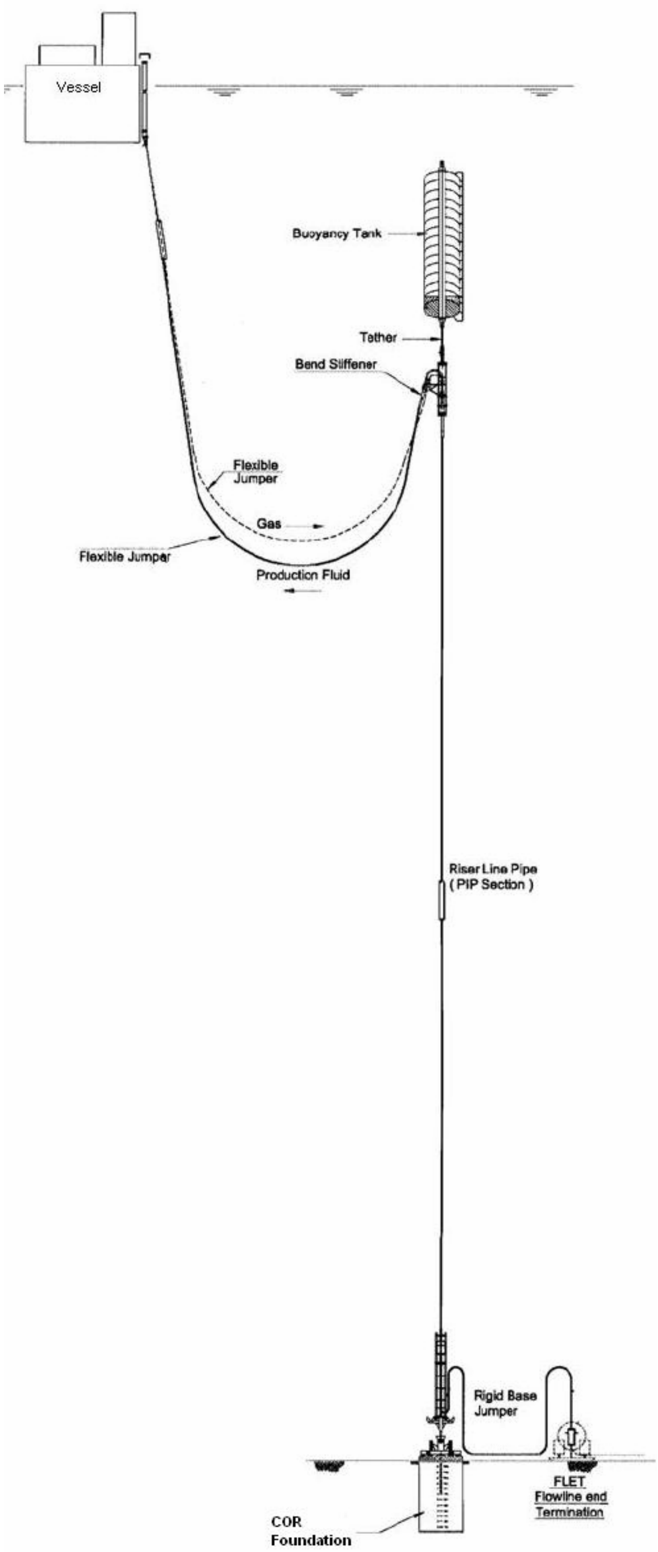

Figure 4 – West Africa COR General Arrangement [2]

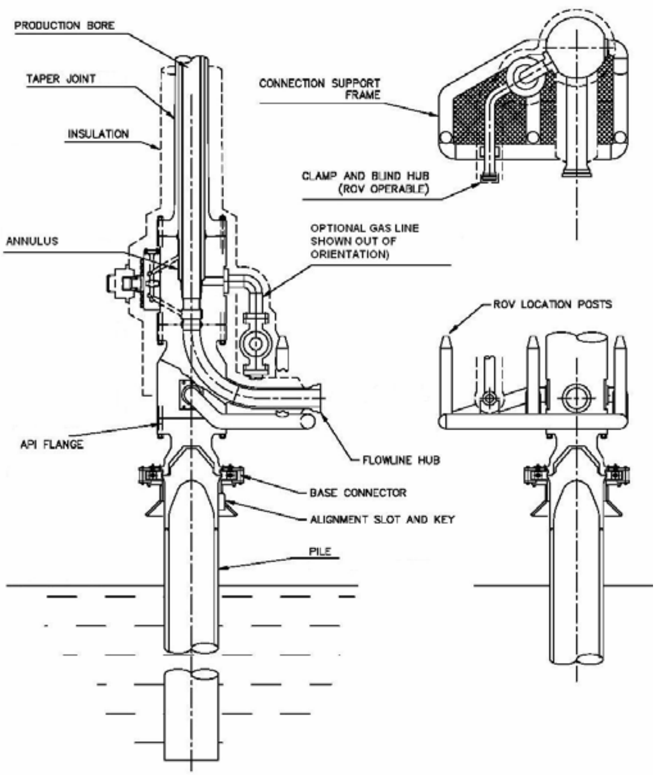

Figure 5 – Lower Riser Assembly