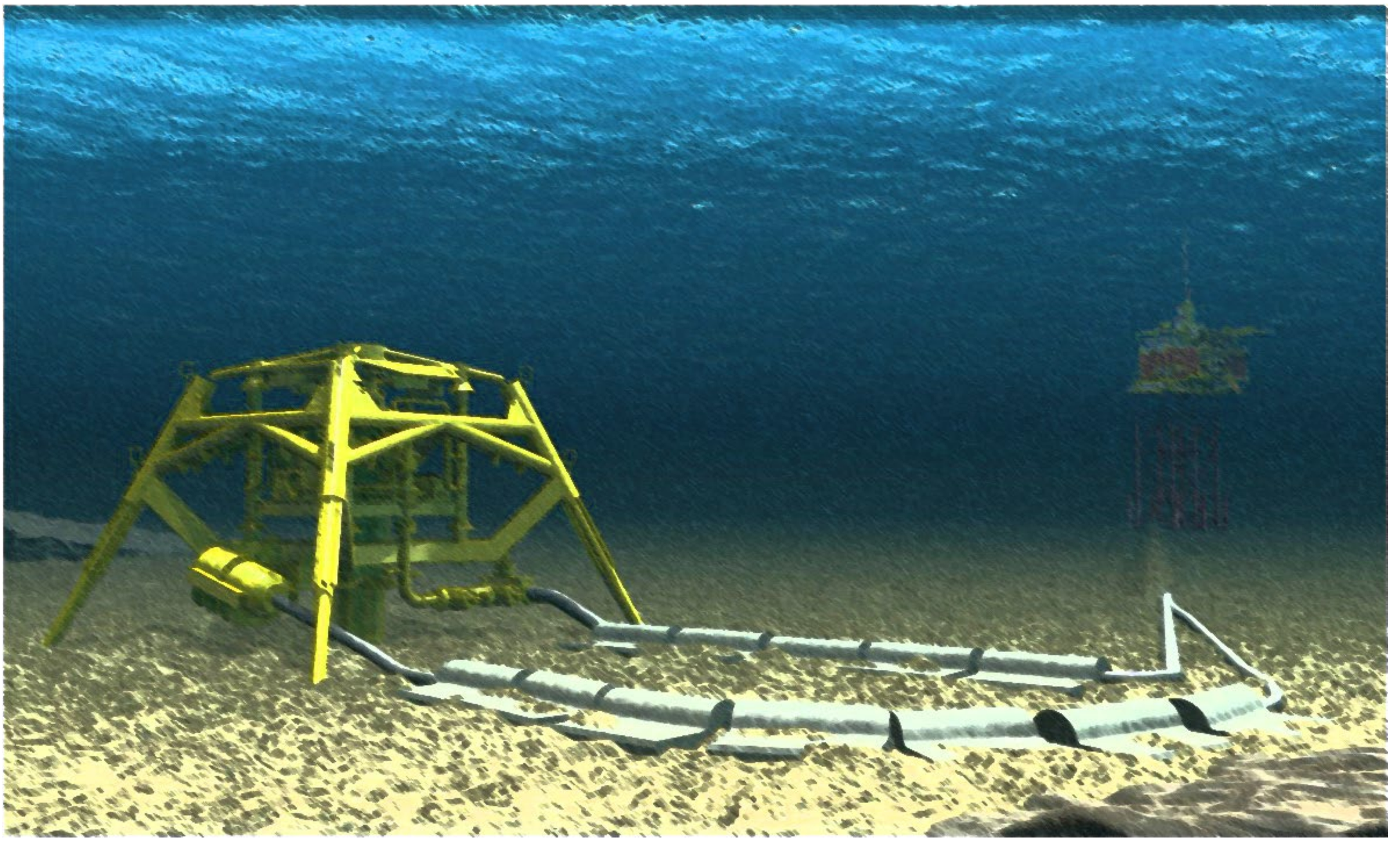
Prospectus

New Large Diameter High Pressure Conductor and Subterranean Separation Technology



Improving the Economics of Stranded Hydrocarbon Tie-backs for Wet or Dry Trees

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Prospectus Large Diameter High Pressure Conductor Technology

by Clint Smith[a] and Bruce Tunget[b]

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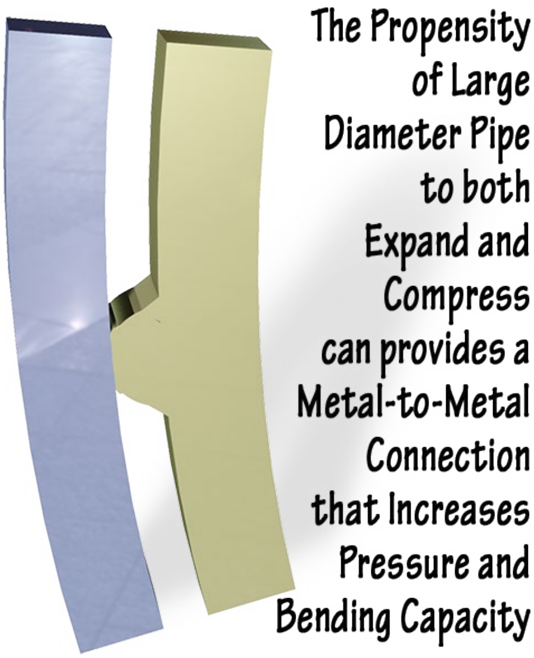


Figure 1 - Increasing Conductor Strength

Abstract: Well architecture has evolved over the years, wherein the sizes of casing and conductor have been standardised for yesterday's hydrocarbons. Since then, industry has tweaked everything to work around conventional conductor and casing sizes using hole opening, under-reaming, bi-centre bits, decreasing coupling diameters, improving flush joint connects and using higher grades of steel. All of these work-arounds relate to standardised well architecture sizes, but the next generation of oil and gas development will be more challenging and may need additional adaptions. Oilfield Innovations' have patented a new tweak to standardised well architecture that retains conventional casing size standards while providing downhole processing and reducing the need to size-the-hole-down when casing off multiple geologic zones. The pressure bearing capacity of large diameter pipe is limited because its large diameter walls are more easily expanded or compressed. As shown in Figure 1, the natural properties of steel in large diameter conduits can be strengthen with and intermediate rib when two or more concentric conductor casings are used. In an offshore environment, shallow geology is easily drilled and larger diameter conductors can be placed. A substantially larger diameter conventional low pressure conductor can be cemented in place. Using the weight of the next conductor casing, a smaller large diameter pipe with the ribs shown in Figure 1 can be slide into and cemented within the lower bearing capacity larger conventional conductor to, effectively, double its wall thickness, bending capacity and pressure rating. Higher pressure surface casing can then be hung within the higher pressure conductor to maintain a larger diameter well architecture. Additionally, large diameter double and triple walled conductor can be used as a subterranean vertical separator, wherein water production and disposal is a significant issue that prevents development or reduces the life of many marginal offshore fields. Large and heavy above sea level fluid separation equipment requires a relatively large offshore jacket for support, while above sea bed subsea separation is very expensive. High pressure and bending capacity large diameter conductor-in-conductor arrangements can be used as a vertical subterranean separator and/or a jacket for a monopod that supports low cost disposal of water downhole. The cost of subsea separation is presently only applicable to prolific offshore fields, whereas a vertical multi-walled well conductor subterranean separator requires only a subsea pump to inject produced water. Low cost downhole separation could make marginal discoveries economic. Accordingly, the simple additional of a ribs to a conductor, which slides into and can be cemented within another conductor, can provide the significant benefits of higher pressure and load bearing compacity needed for development of the next generation well architectures.

Introduction

Single wall large diameter conductors are capable of limited pressure bearing capacity, whereas single wall small diameter casings are capable of significantly higher pressure bearing capacity. The diameter, wall thickness and steel grade dictate the bearing strength of the casing.

Oilfield Innovations propose placing one conductor, with Figure 1 ribs, within another conductor to double conductor pressure bearing and bending strength capacities.

Adding the Figure 1 rib to a conductor reduces the span of the conductor wall to, effectively, double the wall thickness and, thus, pressure bearing and bending capacity.

The importance of increasing the pressure bearing capacity of large diameter conduits becomes evident when considering maximum production tubing sizes, downhole separation and/or use of a conductor as an offshore mono-pod jacket.

Double or triple wall ribbed conductors can be used to withstand high pressure and bending loads to provide a step change in well architecture, subsea processing and monopod jacket design.

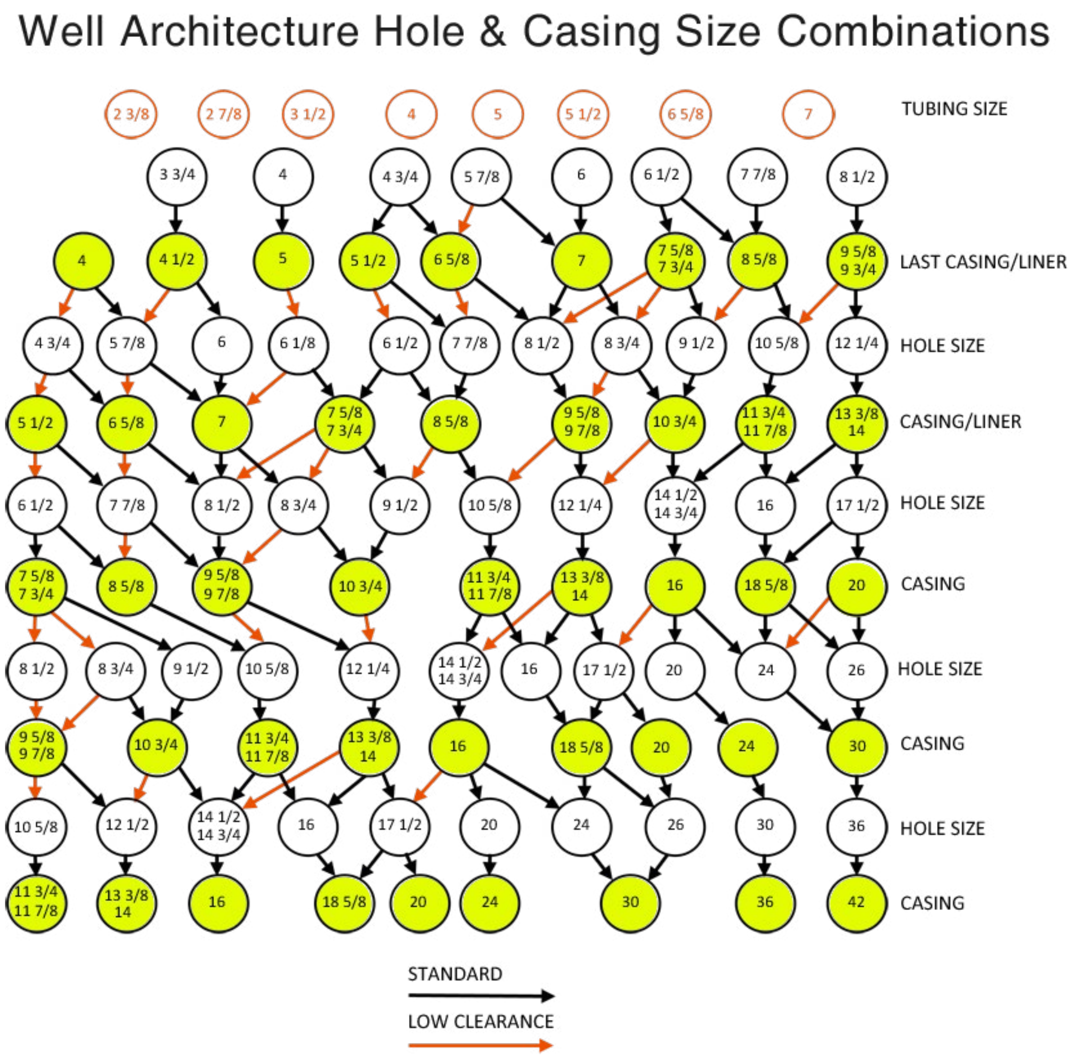


Figure 2 - Hole and Casing Size Combintations

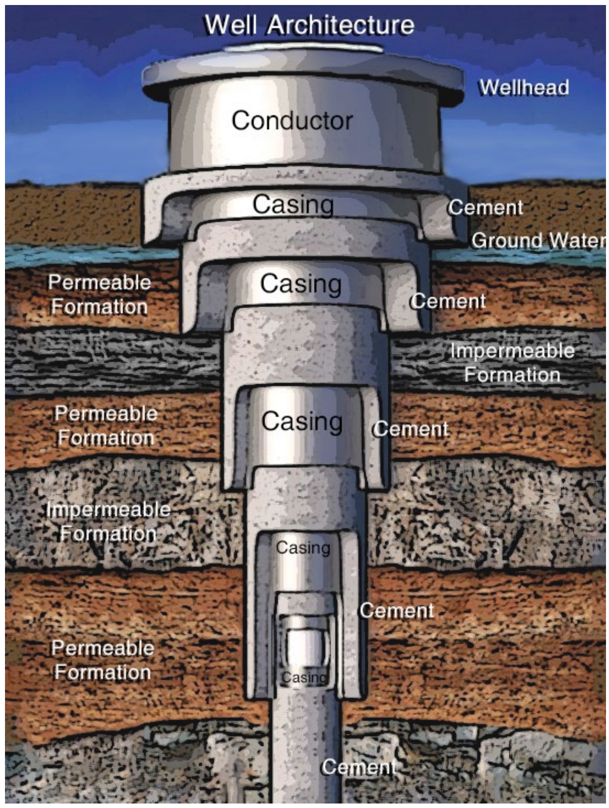
Well Architecture

During construction, well architecture isolates permeable geologic formations and begins with a large diameter conductor with limited pressure capacity and progresses to small diameter casings with significantly higher pressure bearing capacity as shown in Figure 3.

When designing well architecture the reverse occurs. As shown in Figure 2, engineers design from smallest diameter hole size and casing at the deepest part of the well and work backwards to the conductor at seabed. If the conductor or surface casing requires higher pressure capacity, engineers increase tubular wall thickness or add more casing strings with smaller tolerances between casings and higher pressure bearing capacities.

Conventionally, increasing the diameter of the surface conductor occurs in deep water exploration and development where numerous casing strings are required to isolate multiple geologic zones capable of flow and/or provide a pore pressure to fracture gradient window across downhole.

Figure 3 - Well Architecture



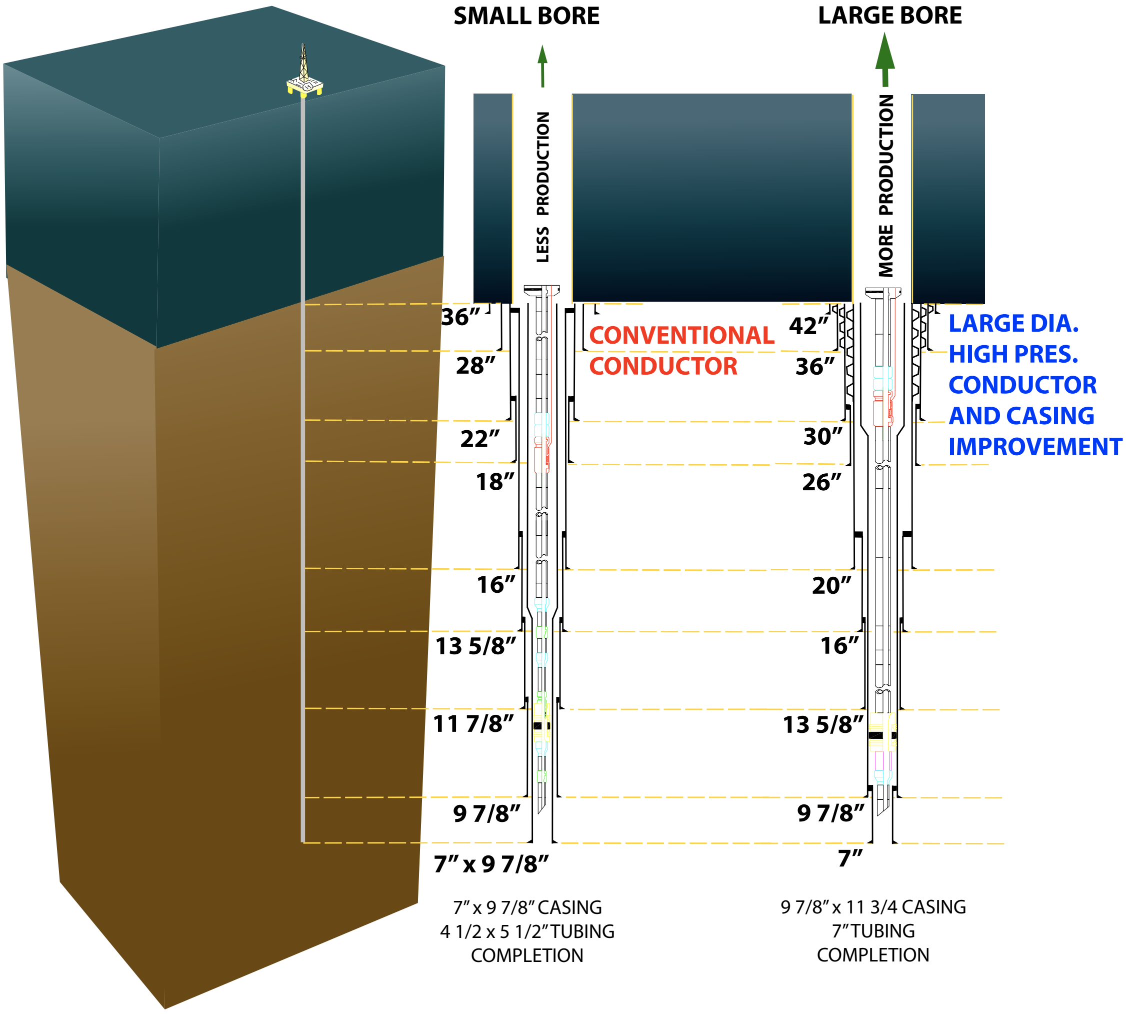


Figure 4 - Example Larger Diameter Well Architecture Enhancement

Development and exploration in conventional water depths can have fewer pore-fracture-window challenges and typically uses 30 inch or 36 inch environment conductor for subsea trees where potential fishing net side bending loads may occur.

For most North Sea wells, the Figure 3 well architecture design starts with the Figure 2 desired final hole size and works downward until the surface casing or conductor size is defined.

Design challenges occur when pressure ramps, depletion or faulting in the overburden require smaller diameter casing and/or additional casing strings and prevent use of the desired completion size, for example 4 ½ inch, 5 ½ inch or 7 inch production tubing. In such cases, more expensive drilling techniques like hole opening, under-reaming with specialised casing may be required and/or a smaller sub-optimal production string may be used. Specialised drilling techniques, non-standard casing and smaller production strings can significantly affect the economics of a development.

Oilfield Innovations propose using conventional well design procedures working downward on Figure 2 to a 30 inch, 36 inch or 42 inch "*ribbed inner conductor*" within a larger diameter "*outer conductor(s)*", for example 36, 42, 48, 52 and/or 56 inch, to provide sufficient bending and pressure bearing capacity to reach the final well depth using lower cost conventional casing sizes without resorting to more costly specialized drilling techniques as shown in the Figure 4 example.

Figure 4 illustrates the effect of replacing smaller diameter conductors and casing shown on the left well schematic with multiple large diameter ribbed conductors and conventional casing on the right well schematic. Setting larger diameter conductors shallower where it is easier to drill geology facilitates a 7" mono-bore completion, whereas the example conventional well architecture required a 4 ½" x 5 ½" completion string.

A larger 7" diameter reduces friction to provide higher production values. Additionally, Oilfield Innovations' Magic Crossover , explained in an accompanying submittal, can be used to access differently pressured formations or, alternatively, as a pre-installed velocity string smart completion that can be used during later stages of well life and depletion.

Figure 5 - Troll Subsea Separation Pilot (Tveter, 2015)[24]

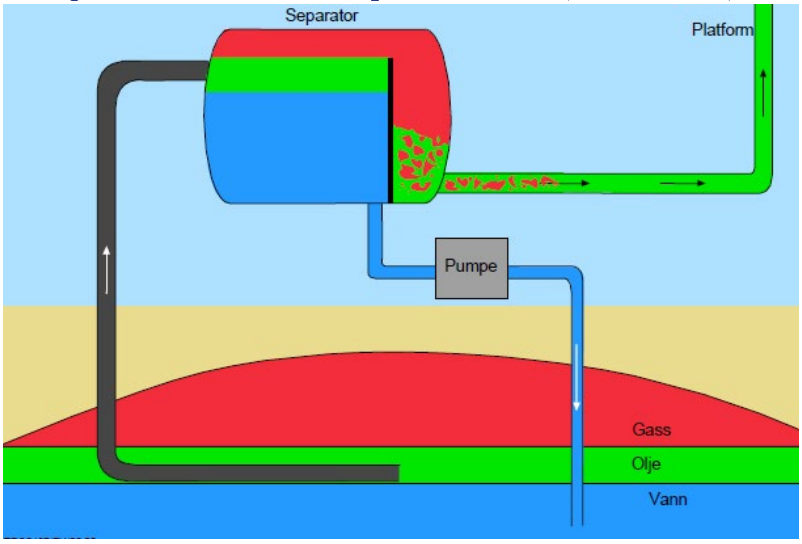


Figure 6- Troll Subsea Separation Pilot Water Disposal (Tveter, 2015)[24]

Downhole Subsea Separation

Another significant advantage associated with Oilfield Innovations' proposed ribbed conductor-in-conductor arrangement, compared to conventional well architecture, is the creation of Large Diameter High Pressure Conductors that are able to provide double or triple walled downhole subsea separation for minimum production facilities and subsea wells.

Multiple independent walls provide the barriers necessary for creating a downhole high pressure vertical production separator that can knock out and dispose of water before it enters the tie-back pipeline.

Tveter (2015)[24] and Figure 5 show Statoil's Troll pilot project for subsea separation. The scale of the Figure 5 Troll subsea separator is evident from the people standing upon it. Troll's subsea horizontal separator volume is comparable to, or smaller than, the downhole vertical separator volume Oilfield Innovations is suggesting, when the height of the vertical separator and the doubled wall environmental barriers are considered.

Tveter's Figure 6 diagram of Troll's horizontal separator depicts hydrocarbon gravity separation with heavier water sinking to the bottom of the separator being pumped downhole.

Subsea/Subterranean Separator

Oilfield Innovations' vertical separator, shown in Figure 7, resides within double or triple walled high pressure large diameter conductor to a depth of, for example, 330 foot (100m) below the mudline with one or more well casings passing through its centre like heat exchanger's tubes.

The vertical separator can be hundreds of metres or feet in height, with a significant volume and residence time for gravity separation of water, which is taken from the bottom of the separator and pumped into a disposal annulus or well while hydrocarbons are taken from a shallower depth and exported to the tie-back pipeline.

Numerous examples of cutting disposal through annuli exist and conventional well architecture is capable of water disposal through an annulus provided the injection horizon is capable of accepting the volume of produced water.

Alternatively, as shown by Tveter in Figure 6, a disposal well can be placed for injecting water below the production zone for re-pressurization of the reservoir in a pseudo waterflood or water-sweep scenario, albeit an extra well may be beyond the economics of most marginal developments.

Should suitable annulus water disposal be impractical or an extra disposal well be economically unviable, Oilfield Innovations' Magic Crossover (see separate submittal) can be used to convert a single well into two (2) wells so as to inject water below a production zone at minimal cost.

Oilfield Innovations' Large Diameter High Pressure Conductor and Casing innovation provides the extremely simple and low cost innovation of ribbing that can provide the necessary barriers with sufficient pressure and bending capacity to be used for either subsea wells with wet production trees or dry trees on conventional or minimal facility jackets.

Water production and disposal cost is a primary problem preventing development of marginal fields and decreasing profits or shorting the life of hydrocarbons fields that are economically viable.

A low cost vertical separator, insulated by the subterranean strata, forming part of a well architecture where water disposal and production through heat-exchanger-like casings passing through the separator to maintain hydrocarbon exports at near reservoir temperatures could provide a dramatic step-change in offshore development.

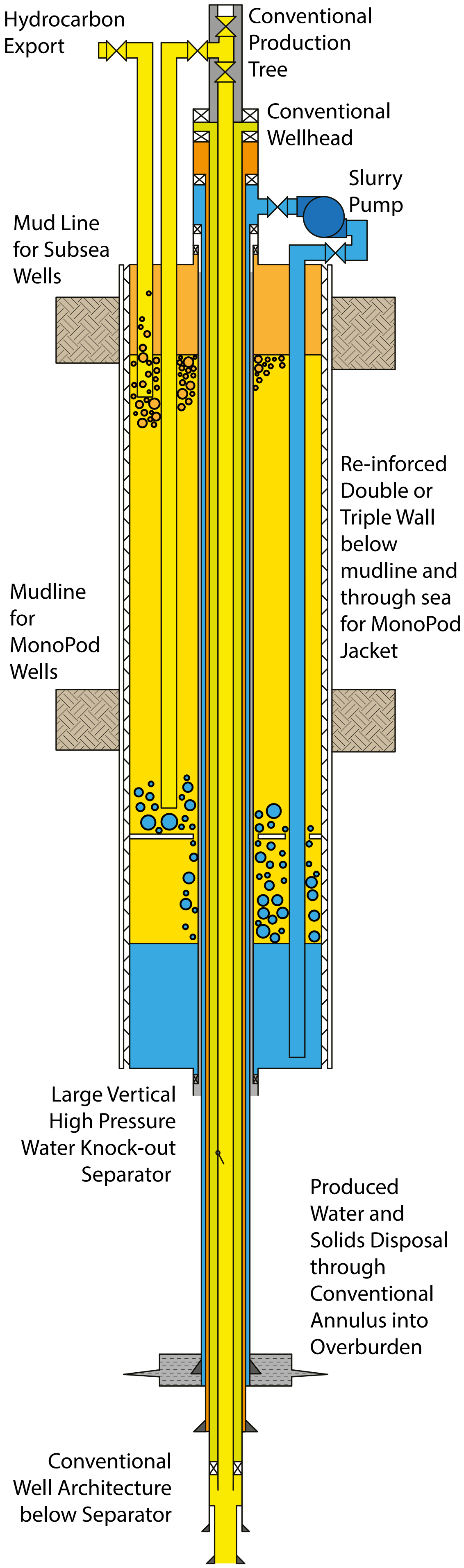


Figure 7 - Single Well Vertical Separator

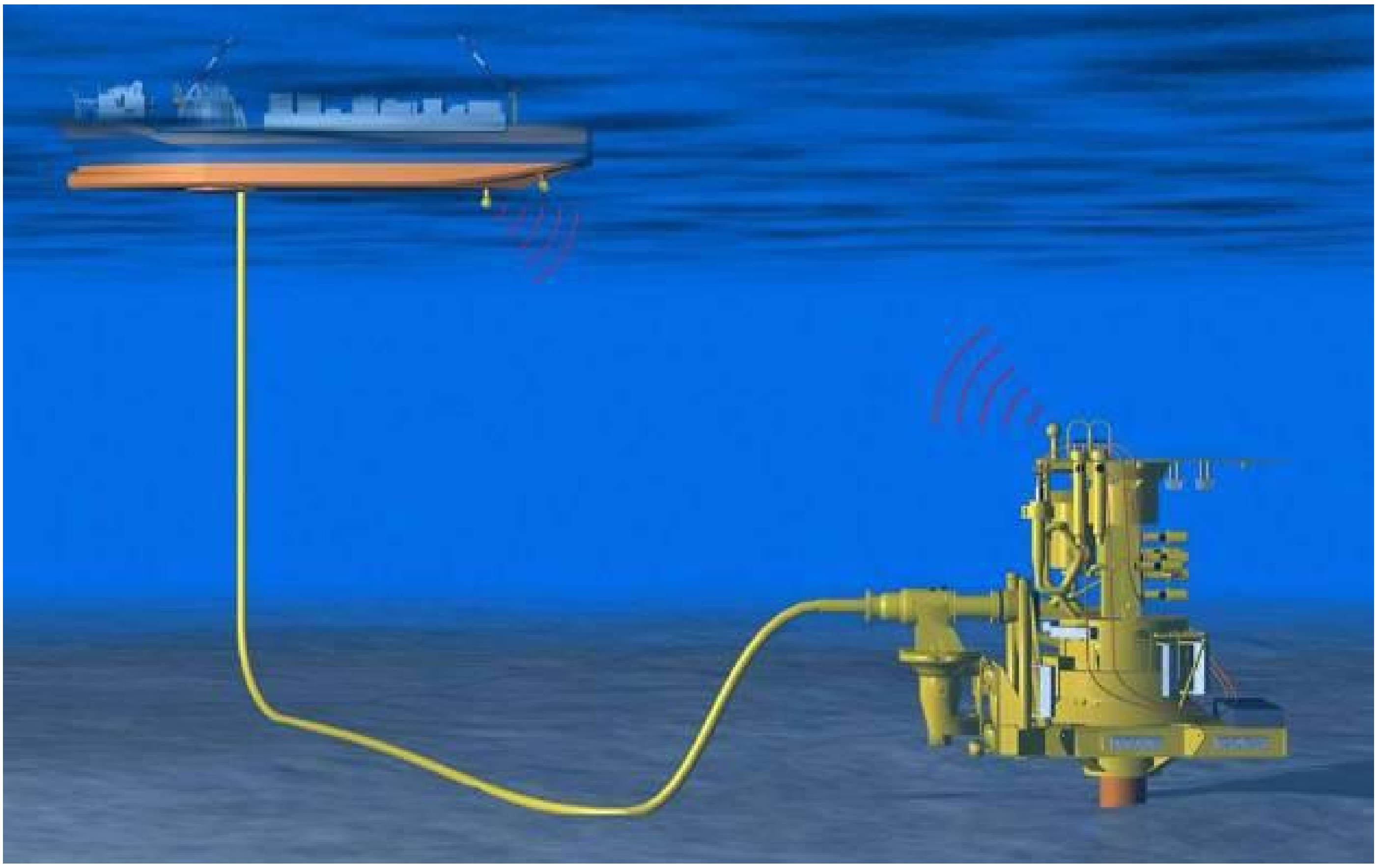


Figure 8 - Subsea Well Tied-Back to Mini-FPSO Facility with Beacon Control (Halforsen, FMC)[33]

Production Facility Size Reductions

Removing water separation and disposal from platform and floating storage and production operations (FPSO) facilities can reduce their size dramatically and, when combined with other innovations, significantly improve the economics of offshore hydrocarbon production.

For example, in Figure 8 Halforsen[33] depicts the cost reducing innovation of replacing an expensive control umbilical with through-water beacon signals, wherein a nearby FPSO facility processes hydrocarbons from a subsea well.

Using Oilfield Innovations subterranean separator to remove water separation and disposal equipment from the FPSO facility can significantly reduce its size and, therefore, its construction and operating costs, wherein power generation on the FPSO, using produced gas, can be easily cabled to a subsea pump that disposes of water downhole before it enters the flexible riser tie-back. Alternatively, if the FPSO is positioned close to the well the water disposal pump could be located on the floating vessel with two additional flexible risers used to extract water from the subterranean separator and dispose of it downhole.

Plug and Play Opportunities

Smaller FPSO vessels, unburdened by water production and disposal, can accommodate export equipment and be reused in various plug-and-play arrangements that could, for example, produce oil and re-inject gas into the reservoir to sweep further hydrocarbon liquids.

When Oilfield Innovations high pressure water knockout separator is combined with well annulus water disposal (see Figure 7) and Oilfield Innovations Magic Crossover dual flow stream tool (see separate submittal) can be used to inject separated hydrocarbon gas into the reservoir below the producing zone to sweep the reservoir and, thus, increase hydrocarbon recovery, wherein gas is separated from liquids, compressed and reinjected from an FPSO facility.

Also, inclusion of gas lift valves within Oilfield Innovations' Magic Crossover dual concentric flow completion can be used to stimulate production by reducing the hydrostatic head of

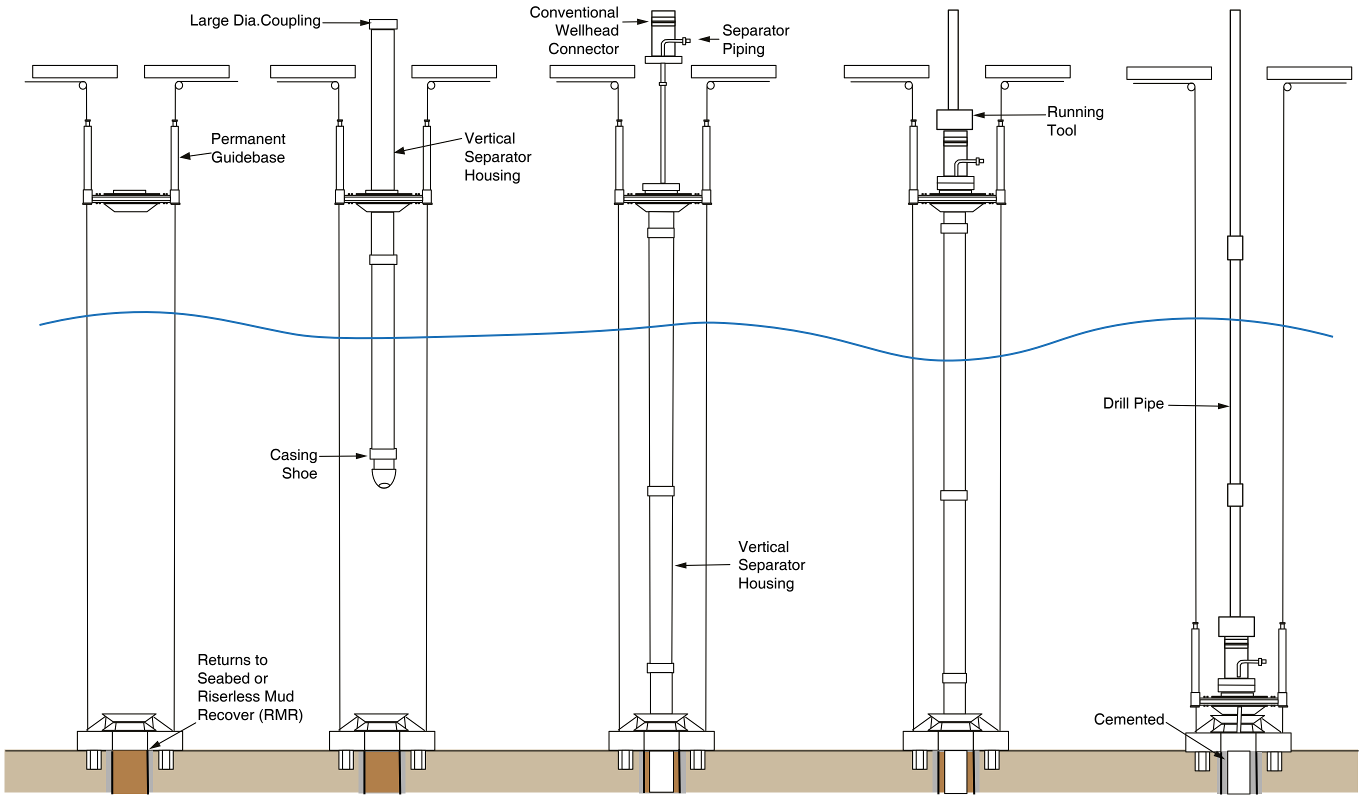


Figure 9 - Assembling Conductor Vertical Separator

produced fluids.

Accordingly, excessive flaring can be avoided and oil alone can be produced while the cost of a tie-back pipeline can be avoided by offloading to another vessel at frequent intervals with downhole water disposal and hydrocarbon gas production stimulation.

Assembling Subterranean Separator

A conventional or standardised wellhead system and production tree can be used within and above a large diameter high pressure conductor.

For subsea wells the guide base is modified to accept a larger diameter conductor and to facilitate piping into and out of the high pressure conductor as illustrated in Figures 9 and 10.

For example, a large 46” diameter conductor can be run with the temporary guide base and jetted in place or landed and cemented within the temporary guide base after drilling. The vertical separator ribbed conductor can then be run on the permanent guide base, as shown in Figure 9, using high pressure connections comprising, for example, a 38 inch pipe body with XL Systems Viper™ Connections (see similar XLW™ connector in Figure 16).

As illustrated in Figure 9, the large diameter ribbed vertical separator pipe is screwed together as it is run with additional ribs clamped over the connection upsets with the weight of the 2 inch thick wall 38 inch outside diameter inner pipe swaged into the outer pipe to create a metal-to-metal connection within the 46 inch outer diameter conductor.

With the long 38 inch diameter separator conductor suspended at the rotary table of the drilling rig, the internal piping is run into the separator conductor using a false rotary table and connected to the final joint of the separator conductor, which has an integral sealed top with clamp connections to the internal piping suspended from the false rotary table.

After connecting the separator piping, the false rotary table is removed and the 38 inch separator top is clamped to the separator body and landed in the temporary guide base which is run on drill pipe as illustrated in Figure 9.

Once the separator is landed it can be cemented in place or, alternatively, a secondary cap can be added with intermediate conductor-to-conductor annulus monitoring capabilities.

Subsequent to landing the wellhead and separator, normal drilling continues with casings passing through the separator, wherein the pack-off seals for the first casing string are landed at the bottom of the separator with the remaining casing hangers and seals at the top of the separator.

Accordingly, a drilling rig can construct and install hundreds of feet or metres of subterranean separator capable of removing produced water for disposal down the same well without significantly changing conventional well construction practices.

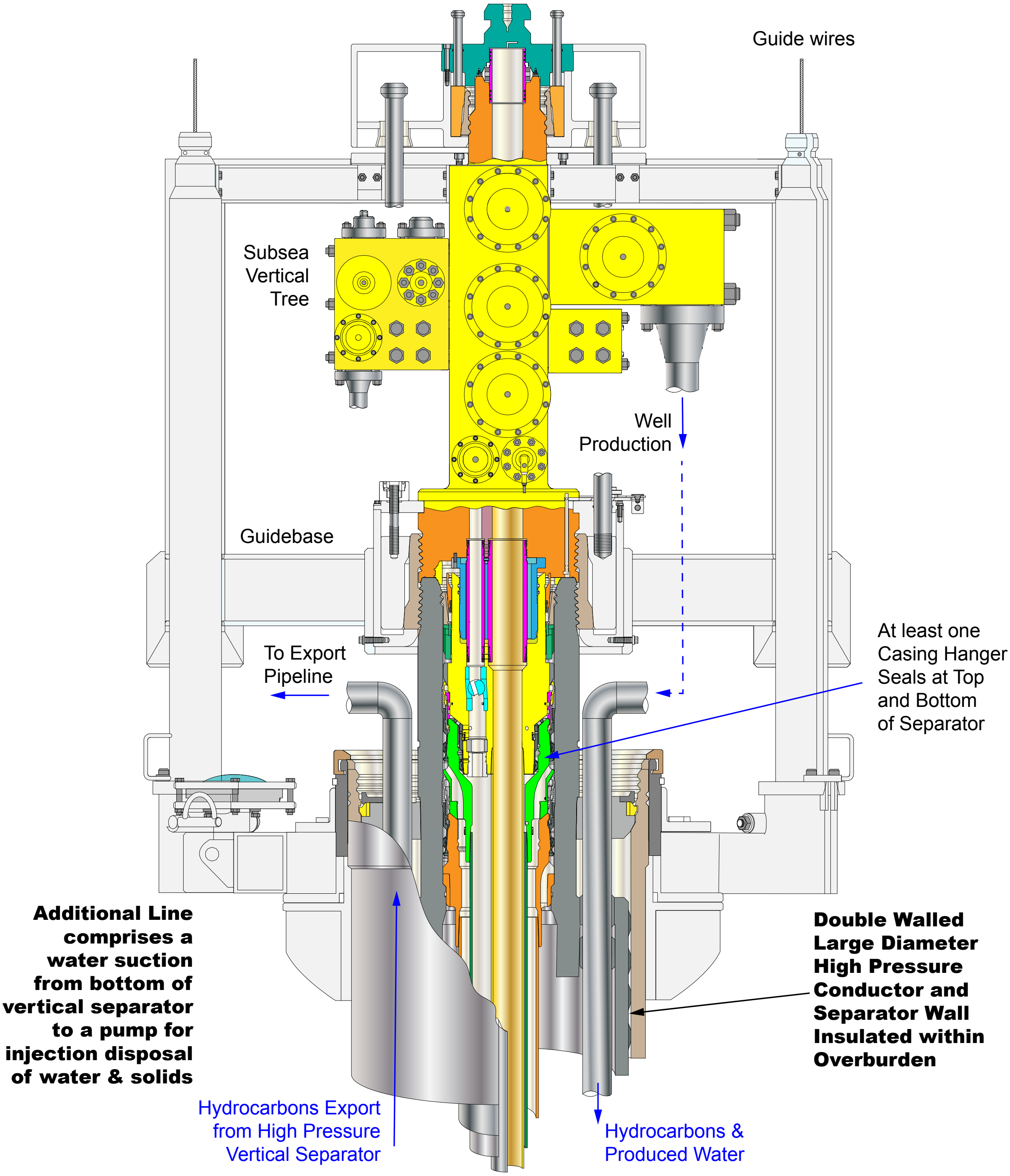


Figure 10 - Example Subsea Vertical Tree with Subterranean Insulated Vertical Separator

Subsea Tree and Subterranean Separator

As depicted in Figure 10, any convention wellhead and subsea tree can be used above the proposed subterranean separator.

The Figure 9 installed separator piping is positioned around the wellhead and its internal components, whereby the separator's large diameter and metal-to-metal connection with the exterior conductor provide suitable trolling net bending strength.

At least the last casing string passes through the separator, wherein at least the first surface casing is hung and sealed at the bottom of the separated. The separator is then cleaned and the remaining casings can be hung and sealed at the top or bottom of the separator to seal the separator, create the desired volume and provide a heat exchanger tube arrangement through the centre of the separator.

Flow from the production wing valve can be directed to the separator via a flexible jumper hose while another flexible jumper hose may be attached from the separator to the hydrocarbon export line.

Figure 11 - Example Monopod Jacket usable with Dry Surface Trees

Monopod Jackets

Large Diameter High Pressure Conductors can also be used as monopod jackets, wherein the jacket can have a subterranean separator below the jacket or the jacket itself can form a vertical separator.

Figure 11 shows the “Cutter” monopod jacket with wind turbines and solar panels on its weather deck with external stair access on the outside of its circular jacket using, for example, a motion compensated gangway from a boat.

Presently, monopod structures are restricted to water depths and areas where bending forces exerted by waves and weather are relatively low such that use in the North Sea is limited.

Improved bending strength can be achieved by driving a large diameter environmental conductor and then driving a second ribbed conductor within the first conductor. As shown in Figure 12, a further third conductor can be driven within the second ribbed conductor to further strengthen the jacket.

Driving ribbed conductors within other conductors causes the outer conductor to expand and the inner conductor to compress with the ribs causing a metal-to-metal connection between the conductors.

Metal-to-metal connections along the diameter of multiple conductors effectively increases the wall thickness of the jacket and, therefore, increases the bending loads that may be applied from waves and weather.

Increased bending capacity increases the applicable water depths and environmental loads that can be applied to allow monopod jacket use within the North Sea.

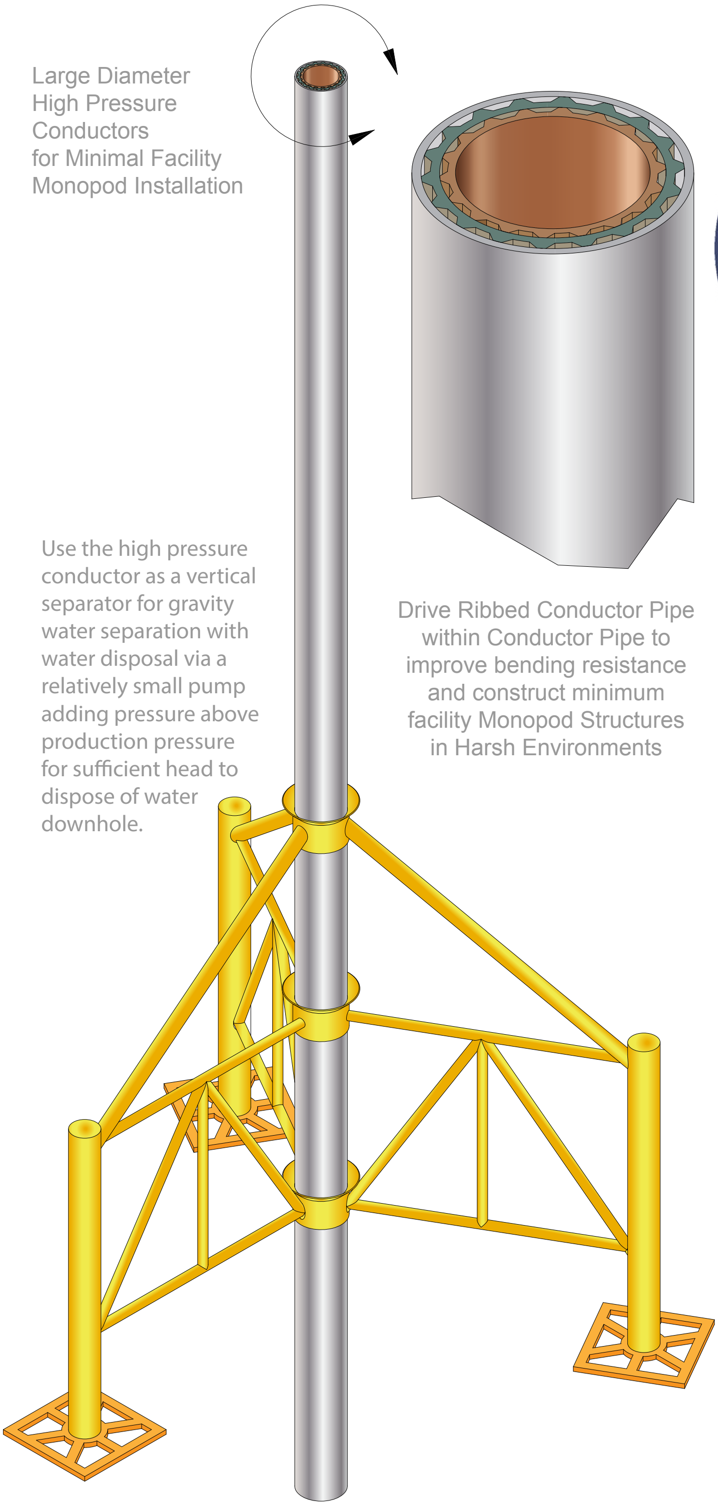


Figure 12- Monopod Jacket Bendng Support

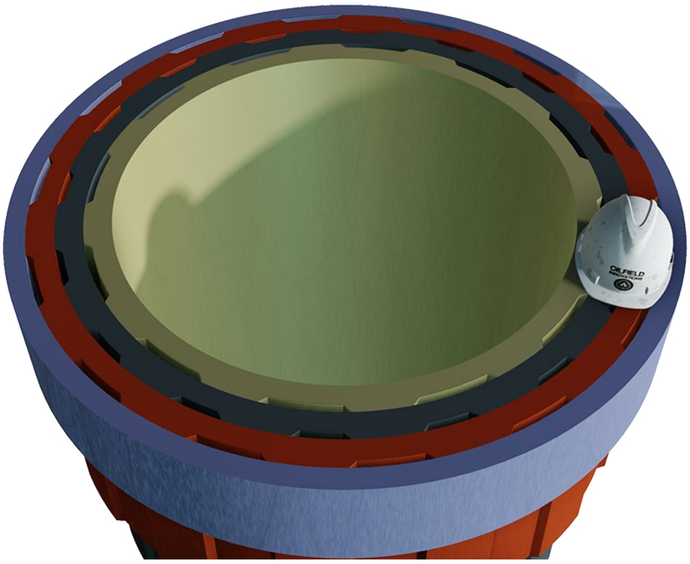


Figure 13- Example of Relative Scale

Subsea Jacket Support

Subsea bracing shown in Figure 12 is commonly used to strengthen monopod jackets and is equally applicable to the proposed metal-to-metal ribbing arrangements shown in Figures 13 and 14.

The height of conventional Figure 12 monopod tri-pod support can be increased to accommodate the water depth in, for example, the Central North Sea.

A lift vessel can place and pile a lighter 200 foot (61 m.) high tri-pod bracing structure in deeper water prior to driving the large diameter conductors.

With the bracing structure in place, larger diameter ribbed conductors can be driven into the shallow overburden in sequence to provide a relatively low cost jacket. The topsides can then be lifted onto the jacket prior to drilling wells through the slots of the jacket and topsides.

Conductor Sharing

As described in the accompanying submittal, many examples of conductor sharing wells exist and the technology is proven.

Proven technology used in conductor sharing can also be applied to a ribbed conductor monopod jacket arrangement to facilitate the Figure 14 multiple well slots through the jacket.

Application of a monopod jacket and topsides to Central North Sea marginal discoveries could further reduce cost and improve development economics.

For instances where water disposal is necessary, a mo-

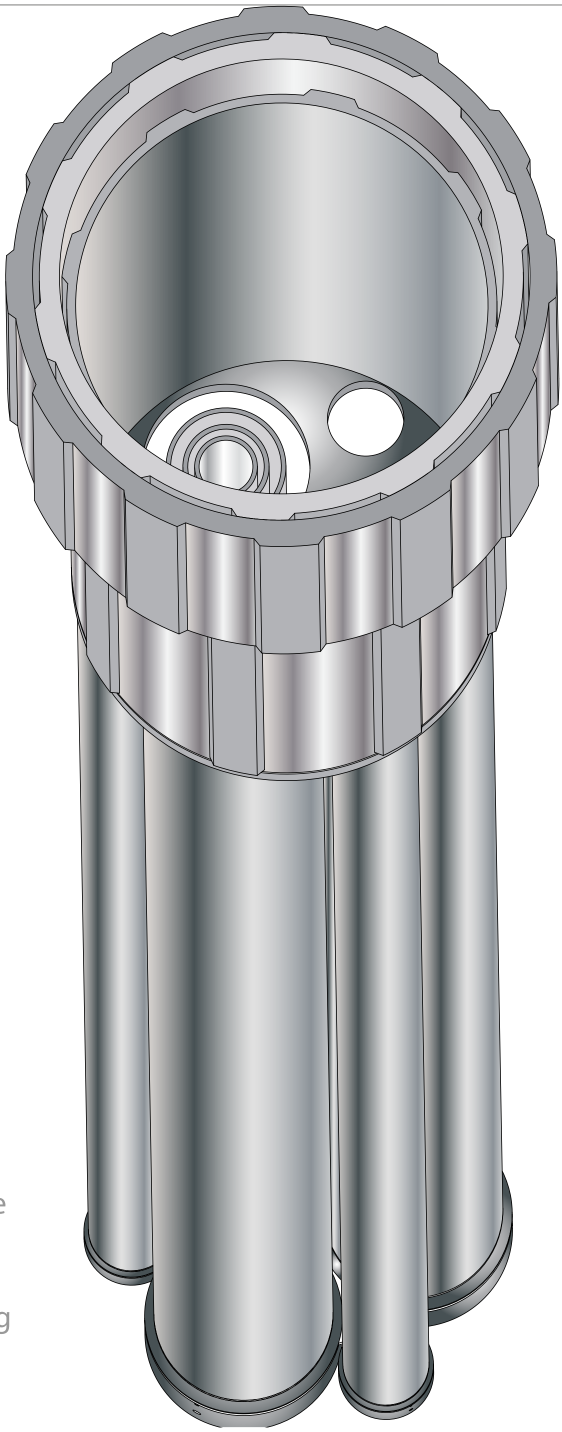


Figure 14- Example of Multiple Ribbed Conductor used for Monopod Jacket

nopod jacket can also function as a vertical separator to avoid additional drilling costs associated with placing it within the overburden.

Additionally, the high cost of subsea equipment and infrastructure can be avoided with a minimal facility monopod using dry trees with solar and wind driven satellite monitoring power.

For instances requiring more power to dispose of water or reinject gas, an accompanying mini-FPSO can be used with a motion compensated gangway to facilitate monopod access to water and gas injection equipment placed on the topsides and powered by the FPSO.

Oilfield Innovations multi-well "Cloverleaf" and dual concentric flow "Magic Crossover" technologies can also be applied to further reduce the costs of marginal developments using batch drilling and simultaneous concentric productions and/or injection flow through the slots within the jacket.

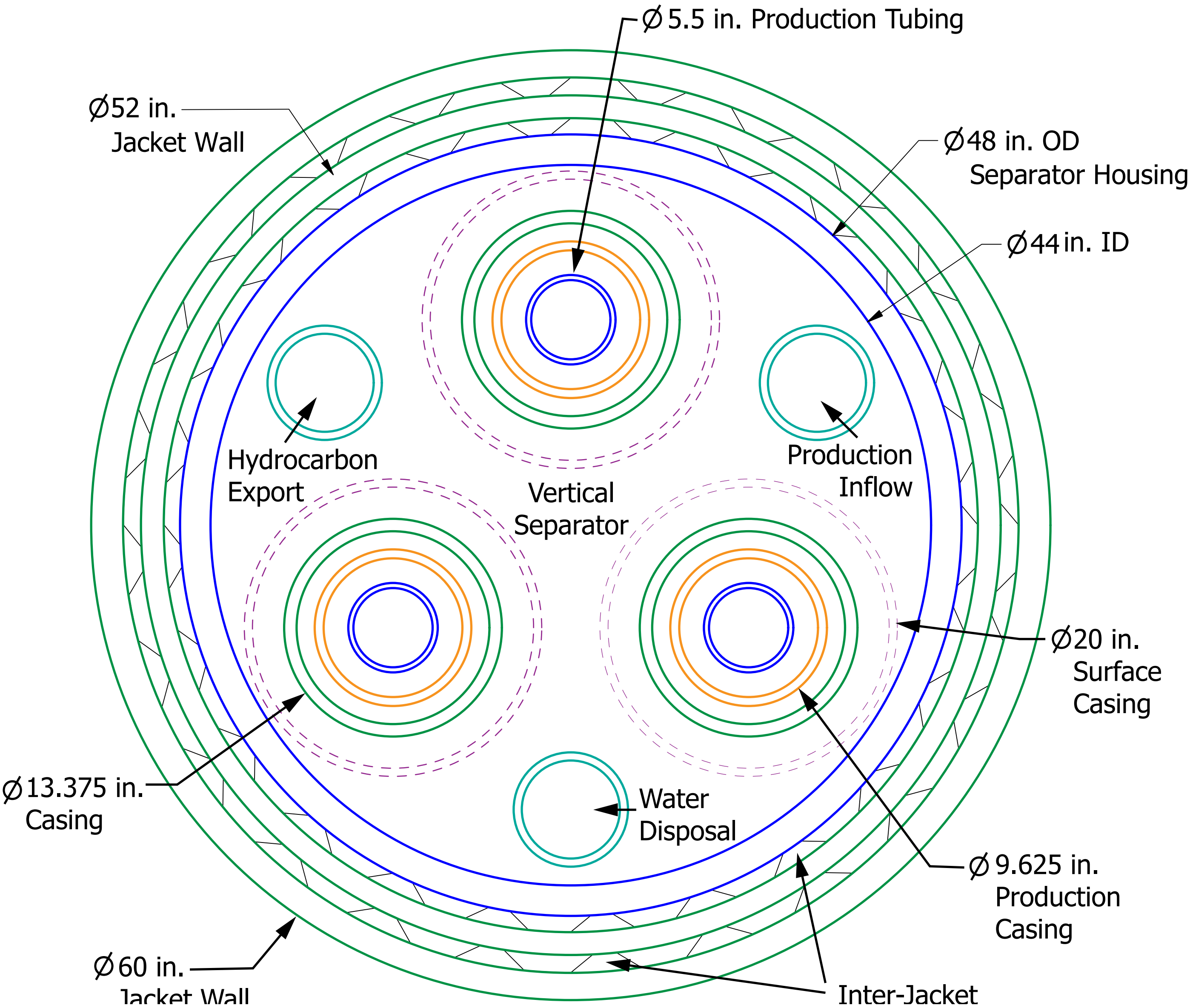


Figure 15 - Example Monopod Multi-Well-Slot Arrangement

Well Slots

Figure 15 illustrates a plan view of three conductor sharing well slots within a 48 inch separator housing that was driven within 52 inch and 60 inch external conductors.

Figure 15 can be used for monopod platform jackets requiring high bending strength and conventional conductor sharing arrangements and the use of the conductor as a vertical separator is optional.

Conventional piling equipment can be used to driver the 60 inch jacket conductor within the shallow overburden and can be followed by driving a 52 inch ribbed conductor within the 60 inch outer jacket pipe.

Finally, a 48 inch conductor, optionally usable as a vertical separation, is driven within the 52 inch jacket casing, wherein couplings like that in Figure 16 can be used.

Ribbing may be welded to the pipe body with thinner short ribbing sections clamped over the couplings, as shown in Figure 16, wherein the couplings are suitable for driving (hammering) of the conductor into the overburden.

Conventional casing sizes can be used through the conductor housing and ample room exists for production, water disposal and export piping.

The conductor jacket can be installed before the arrival of the rig when the optional separator portion of the conductor is above seabed, otherwise a drilling rig can drill and install the conductor and optional separator section significantly below seabed with the topsides lifted onto the monopod jacket after the rig leaves.

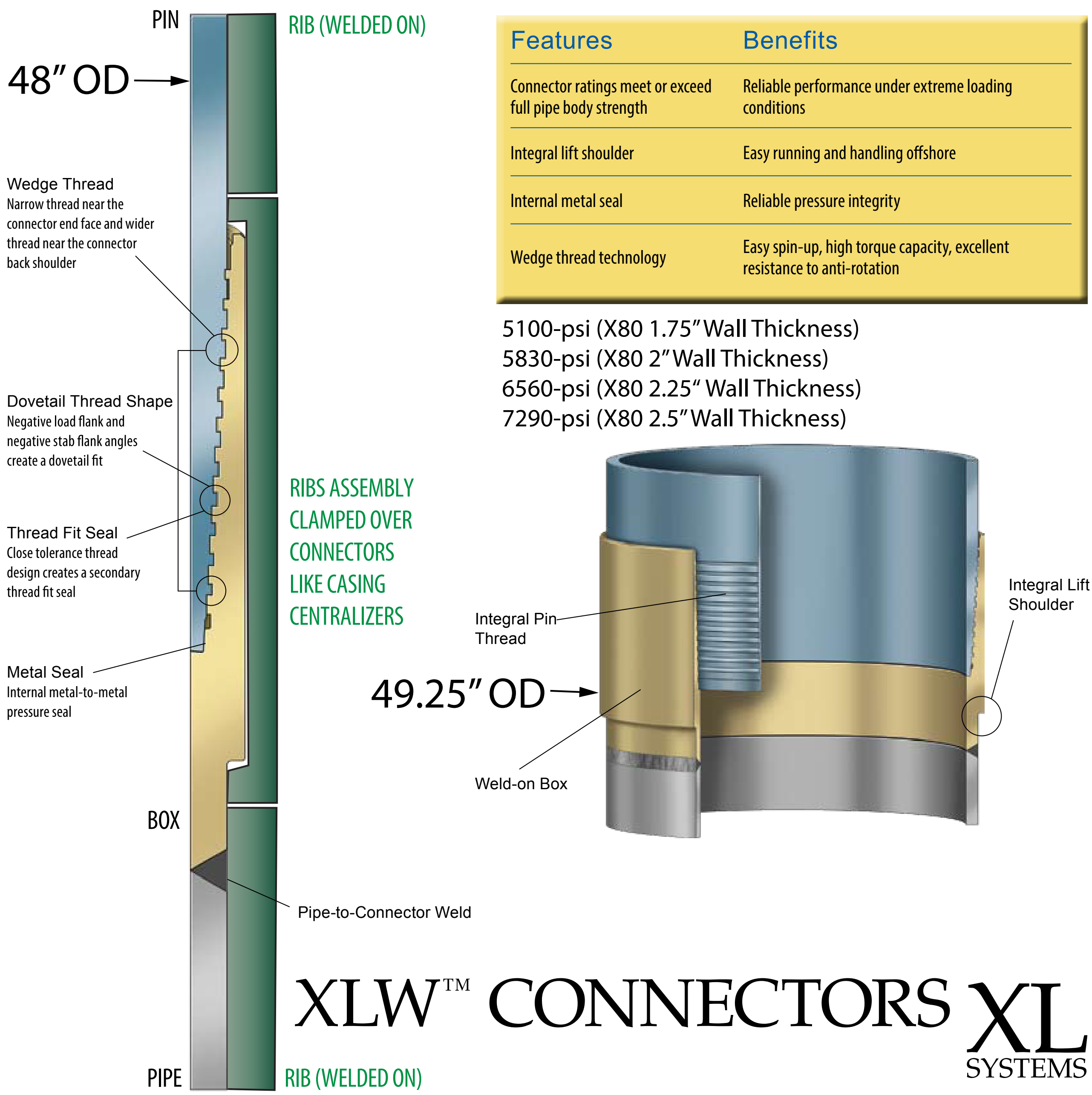


Figure 16 - Example Large Diameter High Pressure Connector

Ribs, Pipe and Connections

Large conductors with thick walls are very heavy but quickly assembled during installation. The heavy weight of the conductor is to drive one conductor within another.

Figure 16 XL Systems™ and other manufacturers, like Oil States™, have drivable connections with sufficient bending and pressure bearing capacity to be used with Oilfield Innovations' rib conductor strengthening.

Ribs are welded to the body of the pipe sufficiently away from the couplings to facilitate make-up. Once the connection is made-up, an assembly of short ribs are clamped over the connection profile to ensure continuous metal-to-metal conductor connections.

Figure 17 - Britannia Triple Wellhead Arrangement (Matheson, 2008)[11]

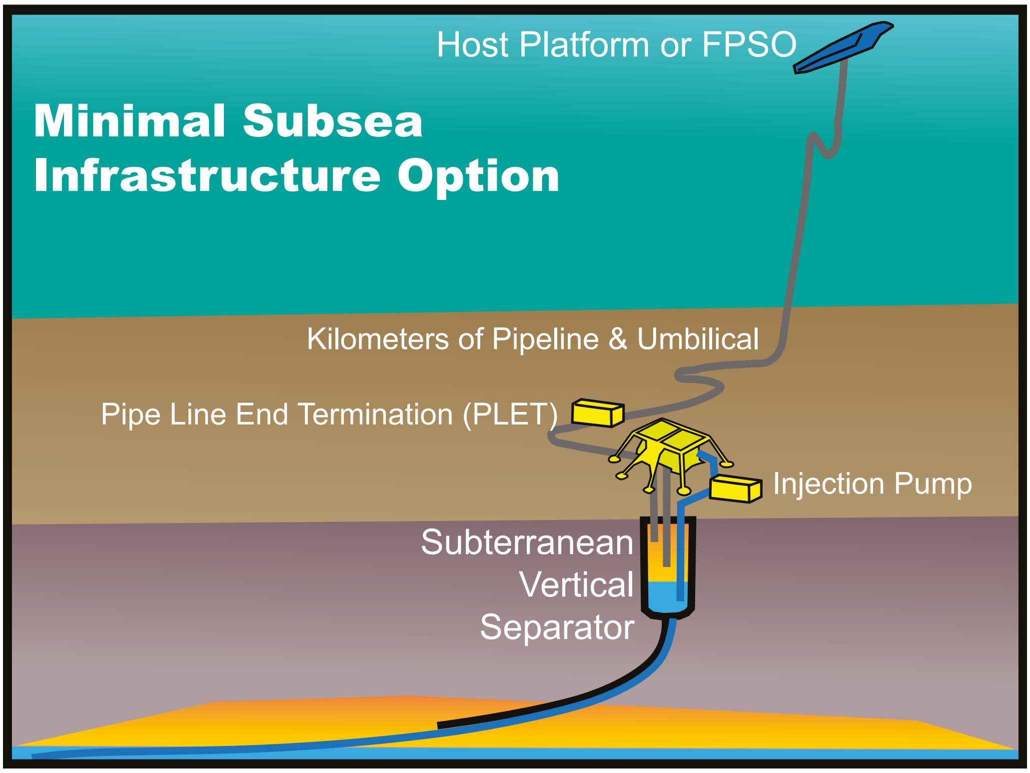


Figure 18- Subsea Vertical Separator

Conclusion

The purpose of plug-and-play standardisation is to minimise variation and maximise interoperability and, therefore, requires minimal deviations from the norm.

Oilfield Innovations' Figure 1 conductor ribbing is a minimalistic change that is compatible within any plug-and-play application to improve the economics of stranded small hydrocarbon pools by minimising infrastructure needs.

Driving a ribbed conductor within another conductor increases bending strength to facilitate low cost monopod jackets in deeper water depths and harsher weather conditions with conventional conductor sharing wells and dry trees like those shown in Figure 17.

Also, driving a ribbed conductor within another also provides double reinforced high pressure walls for a vertical separator that can be placed below a subsea tree or within the monopod jacket.

Water production and disposal is one of the most critical issues facing the development of marginal stranded hydrocarbon discoveries. Removing the water before it enters the tie-back pipeline to the host facility could significantly improve the economics of any tie-back.

Finally, driving a ribbed conductor within another conductor increases burst and collapse ratings for surface conductors and casings to allow larger hole sizes to be drilled in shallow geology which can be used to increase the diameter of the reservoir hole section.

Generally speaking, based on the physical space needed, reservoir drilling and completion equipment is optimal within an 8 ½ inch diameter hole through the reservoir.

Oilfield Innovations' conductor strengthening technology can be used to design backwards from an 8 ½ inch hole section through the reservoir back to mudline so as to optimise the well architecture for maximum production and operational efficiency to improve the economics of any well.

Accordingly, the simplistic addition of ribs between nested large diameter conductors and casing can improve well architecture, provide double walls for subsea water separation and improve minimum facilities designs to maximise the value of small pools of hydrocarbons.

If a potential investor is interested in further discussing a development path for this new technology, Oilfield Innovations would be happy to discuss it further and answer any further queries you may have.

Further Information

Addition detailed information on the Oilfield Innovations' Large Diameter High Pressure Conductor Technology, described above, can be found in the accompanying submittal of Oilfield Innovations' Conductor Sharing Technology. Please provide this document to your engineers and we would be happy to answer any further queries. For additional information or further queries please contact Clint Smith or Bruce Tunget at the below email addresses.

Notes and references

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† Various photograph have been taken from the following cited references.

‡ Footnotes: See accompanying Conductor Sharing Technology submittal for References.