Flowlines, Umbilicals and Riser Systems

IFP - Drilling & Production

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IFP, a world's leading research and development center in the domain of hydrocarbons, has over the years built up a strong in-house expertise in order to address the relevant challenges in the field of drilling and production in ultra-deep water, that has become a major focus for the oil industry.

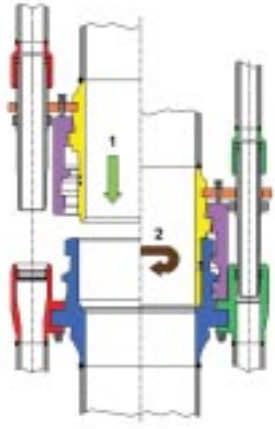
This brochure presents an overview of several innovative technologies, either available through IFP licensees or still under development by IFP and its industrial partners, which cover a wide range of topics, namely drilling and production riser systems, flexible pipes, composite materials, thermal insulation… all dealing with deep offshore. These technologies benefit from the input of highly skilled teams from the Applied Mechanics and Applied Chemistry and Physical Chemistry Divisions of IFP, and rely on the design and use of sophisticated experimental test benches as well as advanced modelling.

EXTENDING THE PRODUCT RANGE AND PERFORMANCE OF CLIP™ DRILLING RISER TECHNOLOGY

The 21" *Clip Riser* was specially developed, through a comprehensive R&D program, for ultra-deep-water drilling. It is distinguished by simple, breechblock type connectors that have been successfully field proven under conditions combining high tensile loads and large bending moments. The *Clip Riser* is manufactured and marketed under license by Kvaerner Oilfield Products. Several *Clip Risers* are currently in operation.

The main advantage of the *Clip* connector over the conventional flange-to-flange connector is a shorter tripping time, with its impact on operating costs and the risks associated with bad weather. The connection itself requires less than one minute.

Ongoing projects are carried out by IFP to extend the *Clip Riser* product line to smaller diameters, workover applications, higher pressures, deeper waters.



The fast make-up of Clip connector is accomplished in two steps: (1) stabbing the long pin member into the box and (2) rotating the ring by one eighth of a turn (45%). Safety devices ensure the locking of the ring in open or closed position.

DeepFlow: ***fluid-structure interaction in an array of five risers, one of them mobile***

MARINE DRILLING RISER INSTRUMENTATION

IFP, working with Principia, has developed an instrumentation system to gather data through testing campaigns on marine drilling risers. The data are expected to yield a better understanding of the behavior of the risers (sources of fatigue, control of riser profile, etc.).

DEEPLINES™

DeepLines is a finite-element program designed to study the behavior of sea-floor-to-surface links. A specific marine environment can be simulated with different types of regular or irregular waves, a time-varying current profile across the water depth and the presence of floating supports.

The sea-floor-to-surface links that can be taken into account are as varied as dynamic flexible risers and umbilicals, steel production and drilling risers, anchor lines, cables and rods. Several types of analyses can be performed: static, quasi-static, and dynamic (frequency or time domain). There are several options for coupling with *Diodore* software.

A graphical user interface makes it possible to define the problem to be solved interactively. This interface subsequently generates an input file that can be processed by *DeepLines*. The interface delivers the results.

Several modules have been added to the *DeepLines* software:

- *DeepVIV*™ for calculation of the fatigue and increased drag coefficient resulting from Vortex Induced Vibrations (VIV),
- *DeepFatig* for calculation of the fatigue of steel risers,
- *DeepDRiser* for the design of drilling risers,
- *DeepFlow,* which couples *DeepLines* with a Reynolds-averaged Navier-Stokes calculation for a more precise calculation of VIV and of fluid/structure interactions in riser arrays.

DeepLines and the first three modules are marketed by Principia.

IFP (Institut Français du Pétrole) is an independent center for research and industrial development, education (IFP School), professional training (IFP Training) and information (IFP Information Center) for the oil, natural gas and automotive industries.

IFP has the dual advantage of covering:

- All sectors of the oil and gas industry – exploration, reservoir engineering, drilling, production, refining, petrochemicals, natural gas processing, automotive engines and fuels, environmental protection;
- From science to industry – basic research, licensing (licenses for processes, products, materials, equipment, software) and advanced services.

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FLEXIBLE PIPES AND REELED PIPELINES

Material

IFP's joint work with Technip on materials used in flexible pipes involves the selection and implementation of new materials to improve performance in terms of permeability, thermal insulation and weight.

The projects include study of the behavior of polymers and composites: investigation of permeability to gases and liquids, aging, identification of blistering damage mechanisms, implementation of the laws of mechanical behavior with allowance for aging.

IFP is also investigating corrosion and fatigue of armors in sour environments.

Flexible pipe test bench with mechanical solicitations and production fluids

Ageing cells for material samples

Structure

The R&D work performed by IFP in co-operation with Technip is aimed at the understanding and calculation of these very complex structures which are both flexible pipes and reeled pipes, and at the development of new structures.
Most of the projects carried out are related to deep sea and ultra-deep sea applications.

IN SITU INSPECTION SYSTEM FOR DYNAMIC FLEXIBLE RISERS

Flexible pipes are complex structures made up of layers of steel and polymer sheaths. They must withstand high pressures and tensile loads while remaining highly flexible. They are used in particular in offshore compliant systems, such as FPSOs and semi-submersible offshore platforms, for production purposes. In response to sustained interest by operators in means of inspecting flexible pipes in service, and to changes of regulations that stiffen inspection requirements for enhanced safety on platforms and vessels, IFP and its partners, the Commissariat à l'énergie atomique (CEA), Bureau Veritas, and Cybernetix, are developing an *in situ* inspection system for dynamic flexible risers.

Bending test bench

This system is based on alternative Magnetic Flux Dispersion, which can detect cracks in the internal pressure vault through a wall thickness of 15mm, and on a special radioscopic device able to inspect the complete pipe wall.

Special concepts have been designed and tested in the laboratory, and shown to provide reliable and fast detection of cracks or breaks in the different resistant layers

(pressure vault, tensile armors, etc.), even inside the stiffener.

In situ *inspection system for dynamic flexible risers*

The system so developed is also expected to detect cracks or breaks in a flexible pipe that has undergone fatigue testing.

OFFSHORE APPLICATIONS OF COMPOSITE MATERIALS

Hybrid lines

Hybrid lines, made by winding carbon fiber strips onto steel tubes, are much lighter (approximately 50%) than conventional steel tubes having the same characteristics. IFP has been developing this concept with EADS Composites Aquitaine and adapting it to cutting the weight of the peripheral lines (kill & choke, booster and hydraulic lines) of drilling risers used in ultra-deep waters. Hybrid lines designed for this drilling application have been extensively tested, both in the lab and in a field offshore Africa.

This product is marketed by EADS Composites Aquitaine.

IFP is currently studying the extension of this concept to other applications, such as production lines.

Composite production risers

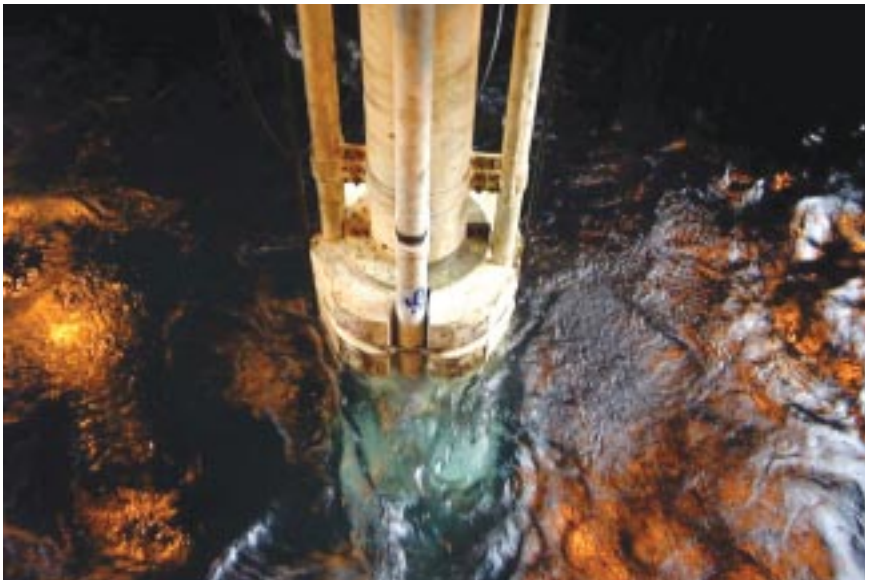
IFP and Aérospatiale pioneered the development of composite materials for seabed-to-surface links in the 1980s, with particular emphasis on riser applications. Based on that experience and recent innovations, IFP, in association with industrial partners, is studying composite risers for applications in ultra-deep water.

Composite materials are well suited to deepwater seabed-to-surface applications because of their light weight, high strength, excellent fatigue resistance, and freedom from corrosion.

The principal applications being considered are risers for TLPs and SPARs. Other promising applications include catenary injection risers, hybrid production risers and mid-depth export lines.

Composite tendons for TLPs

IFP, in cooperation with Freyssinet, Soficar, and Doris has developed a high-strength composite carbon cable for use as TLP tendons. The lightweight and good fatigue behavior of composites are particularly significant for this application.



Hybrid line during field testing

Endurance test of a carbon fiber tether with its anchoring

Composite tendons can be made up of solid rods, and their fatigue behavior is so outstanding that they do not fear damage from "springing" and "ringing". This is not the case of steel tendons which are the present alternative. Steel tendons have to be made hollow (airfilled) to reduce weight, then over-dimensioned both to resist external pressure and to reduce the fatigue effects.

Composite mooring lines

IFP, Doris, Freyssinet, and Soficar are also studying the possibility of using the composite carbon cable mentioned above, for other offshore applications, such as mooring lines for anchoring semi-submersibles and FPSOs in ultra-deep water.

ACTIVE CONTROL

This project is aimed at optimizing the approach of a flexible pipe towards a wellhead for connection. The upper end of the pipe moves with the floating support and the oscillations propagate along the pipe, making connection difficult except under very favorable sea conditions. IFP is developing an advanced control system to make it possible to reach the connection point quickly and smoothly thanks to an assisted remote control.

THERMAL INSULATION

Tideep (Thermal insulation of deep sea flowlines) Joint Industry Program

In their work on a Clarom (Club for research on offshore structures) project, IFP, Ifremer and Bureau Veritas have acquired substantial experience in the evaluation of insulating materials suitable for ultra-deep flowlines.

On the strength of this experience, IFP, Ifremer and Bureau Veritas have launched a JIP to test several thermal insulating materials for ultra-deep waters (up to 3000m) and develop a set of models to predict their long term behavior.

Full-size scale pouring test of bundle gel

Test on prototype ILS

The program of this JIP and the technical specifications of the tests to be performed are based on the requirements of the major oil and engineering companies.

ILS (Solid Liquid Insulation)

New thermal insulation concepts have been investigated jointly with Saipem to develop a new technology using high performance and low cost thermal insulating materials with inherent pressure resistance and capacity to restitute energy to the fluids.

These materials make it possible to significantly increase the cool-down time for flowlines, bundles or risers in deep and ultra-deep submarine environments.

Another development with Saipem concerns more conventional insulating gels suitable for ultra-deep applications. The main interest of these solutions is that they are not sensitive to the pressure.

Pipe in pipe (Hypip JIP)

Pipe in pipe is a classical solution to transport oil in deep sea environment. One of the limitations of the technology pertains to the durability of the thermal behavior of the structure affected by the pressure inside the annulus. Hydrogen due to the internal corrosion of the pipes can reach the annulus and drastically increase the pressure. IFP has built a loop to address this major issue. The objectives of the Hypip JIP are to control the acid gas corrosion in metallic pipe in pipe structures and monitor the hydrogen diffusion towards the annulus of the pipe in pipe structures.

HP/HT applications

New insulating organic materials for HP/HT applications are under development at IFP to control the internal corrosion by acid gases or to ensure external protection against the wet corrosion of the pipe in conjunction with cathodic protection.
The specific knowledge on the chemistry of high temperature resins is also used to optimize syntactic foams with higher thermal resistance in wet environments or composite pipes for risers applications.

More generally in-house expertise, experimental means, and methodologies are available within IFP covering a large range of materials such as concrete, polymer, resin, rubber, composite, metallic,… and more specific ones as membranes or catalysts.

The chemistry of these materials, their mechanical or physical properties and their long term behavior are of prime importance in the development of new technologies. Laboratory tests, but also large benches working under mechanical and physico-chemical stresses, have been developed by IFP to test true structures in representative petroleum environments (acid gases, water, brine, oil under pressure and temperature).

Experimental set-up for H_2 permeation through steel

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