

Flexible pipe

A broad range of flexible pipe systems with advanced integrated solutions.





Flexible pipe

TechnipFMC offers a broad range of services in engineering, manufacturing, installation and retrieval of flexible pipe systems with the most advanced integrated solutions for any field developments.

TechnipFMC is the most experienced provider of integrated solutions for subsea field developments based on a broad range of field-proven products and services. In the early 1970s, TechnipFMC pioneered flexible pipe technology and used it to provide our clients with ever-higher levels of reliability and quality in the world's harshest and deepest offshore environments.

Now more than 40 years later, our high pressure flexible products have provided offshore operators with reliable and efficient subsea solutions worldwide. To date, more than 12,000 kilometers of our high-pressure flexible pipe has been installed.

Our products are versatile, corrosion resistant and compliant and are easy to install, retrieve and reuse for marginal or evolutive field architectures, making them environmentally friendly.

Flexible pipes have carved out their place not only in floating facilities but also in the shallow and medium water markets once the exclusive domain of rigid steel flowlines. With internal diameters ranging from 2" to 22", flexible pipes are the product of choice for infield lines.

At the same time, the flexible pipe's versatility and ability to evolve with the industry will continue to ensure its place in the deepwater and ultra-deepwater markets that characterize new offshore field developments.

What is flexible pipe?

A fit-for-purpose structure

A flexible pipe is a configurable product made up of several layers. The main components are leakproof thermoplastic barriers and corrosion-resistant steel wires. The helically wound steel wires give the structure its high-pressure resistance and excellent bending characteristics, providing flexibility and superior dynamic behavior. This modular construction, where the layers are independent but designed to interact with one another, means each layer can be made fit-for-purpose and independently adjusted to meet specific field development requirements.

Main characteristics

Flexibility

Flexibility is the distinctive property of a flexible pipe. A typical 8" internal diameter (ID) flexible pipe can safely be bent to a radius of two meters or less. This is the reason why flexible dynamic risers have been the enabling technology for floating production systems. This flexibility is also important for flowlines laid on uneven seabed conditions. Flexibility makes it possible to spool the pipe on a reel or in a carousel for efficient and quick transportation and installation.

Installability

Because the flexible pipe comes in a continuous length, laying speed commonly averages 500 meters per hour. Separate sections are connected on deck during installation, eliminating the need for intermediate riser base structures or subsea connections. This reduces risk in operation.

In 1971, the first TechnipFMC flexible pipe was installed in the Congo. It took 1.5 hours to lay the 650-meter flowline, including connections.

Modularity

The independent layers of a flexible structure enable it to be tailored to the precise needs of a specific development. Simple flexible pipes for medium pressure water transport comprise only four layers. The most complex flexible pipes may have up to 19 layers.

Beyond the basic fluid barriers and stress-resistant wires, additional layers can be included to prevent wear between steel layers in dynamic applications or to provide improved thermal insulation (standard flexible pipe already has a much better insulation coefficient than steel pipe).

Besides including new thermoplastic or steel layers within the product, it is also possible to assemble thermoplastic hoses, electrical cables or optical fibers around a flexible pipe to produce an Integrated Service Umbilical (ISU[®]), or include active heating for flow assurance in deepwater to produce an Integrated Production Bundle* (IPB), or with heating cables replacing armour wires technology (ETH-HCRAW).

In 2001-2002, TechnipFMC participated in the DEMO 2000 JIP and demonstrated our ability to supply heat traced flexible pipe, including gas lift tubes and temperature monitoring optical fibers within the same line (Integrated Production Bundle). Heat tracing and monitoring allow temperatures to be perfectly tuned within the core production flexible pipe to meet flowing or cool down requirements. This type of flexible pipe provides an "all-in-one" solution for deepwater applications. It has been used several times in West Africa deepwater fields and offshore Brazil.

Corrosion resistance

Since the steel wires are not in direct contact with the conveyed fluid, they do not require the same corrosion resistance as steel pipe. This means that our design experience and knowledge of gas diffusion through thermoplastic materials enable us to use carbon steel where the equivalent rigid pipe application would require more expensive corrosion resistant alloys.

Standard TechnipFMC flexible structure



IPB* (Integrated Production Bundle)



Flexible pipe: a cost-effective solution

High pressure resistance

Flexible pipes resist all fluid pressures encountered in the most severe subsea applications. The modularity of the flexible pipe manufacturing process enables us to adjust thickness, shape and the number of steel wire layers to meet the specific requirements of our clients.

Modularity enables flexible technology to cover different applications:

- ▶ Production flexible products already installed in waters up to 2,300 meters
- ▶ Kill and choke line for drilling (up to 20,000 psi)
- ▶ Drain pipes and foam lines for onshore refinery applications

It also means that the flexible pipe structure is constantly evolving to meet stringent field specifications:

- ▶ Higher pressures (up to 17,500 psi for a 6" ID, up to 13,125 psi for an 8" ID, and up to 10,500 psi for a 10" ID) on dynamic riser applications
- ▶ Higher temperatures (up to 170°C)
- ▶ Enhanced flow assurance: Active heating, gas lift and temperature monitoring
- ▶ Ultra deepwater and up to 3,000 mwd

The combination of flexibility, installability and modularity, along with corrosion and high-pressure resistance, reusability and versatility show why flexible pipe is a cost-effective solution.

Versatility and reusability

Environmentally friendly, flexible pipe can be recovered and reinstalled several times to be used in marginal or evolving fields.

A worldwide reference

In the early 1970s, TechnipFMC pioneered flexible pipe design, manufacture and installation, and now has accumulated more than 40 years of field-related experience worldwide. Our strategy is to base our leadership on technological differentiation. In that respect, flexible pipe is our historical reference.

TechnipFMC is committed to researching new solutions to better serve our clients' needs. We introduced Coflon®, Crossflex®, TP35, Gamma-Flex®, CoflonXD, various types of Cofoam® insulation materials, both Zeta, Teta and Psi vault profiles, the Vertical Laying System®, Steep Wave and Pliant Wave riser configurations, midwater arch configurations and buoyancy modules, Integrated Service Umbilicals (ISU®) and multibore risers.

TechnipFMC also has pioneered the development of most of the analytical and numerical tools used to design flexible flowlines and riser systems. Today, this drives us to find the most reliable and client-focused solutions for the ultra deepwater and heavy oil production challenges that lie ahead.

Providing the best suited solutions for field developments

The widest range of services

TechnipFMC is the only offshore contractor that seamlessly integrates design, engineering, manufacturing and installation services through its unique integrated Engineering, Production, Construction and Installation (iEPCI) capability and Subsea 2.0 products. Our regional staff regularly interfaces with clients worldwide. Our Flexibles Technology centers coordinate flexible pipe related engineering within our regional business units.

Flexible Pipe Plants

TechnipFMC currently operates four flexible pipe plants:

- ▶ Flexi France (Le Trait, France) was upgraded in 2017.
- ▶ Flexibras (Vitória, Brazil)
- ▶ Asiaflex Products (Tanjung Langsat, Malaysia) was inaugurated in 2010 to serve the Asia Pacific and Middle East subsea markets
- ▶ Flexibras Açú (Port of Acu, Brazil)

Based on a normalized 8" ID pipe, the current yearly capacity of our plants exceeded 1,000 kilometers of product.

Pipelay

TechnipFMC owns and operates a large fleet of dynamically positioned vessels, four of which are dedicated to flexible pipelay. Skandi Africa, the flagship of the TechnipFMC fleet, can lay flexible pipes to water depths of 3,000m. The vessel is fully equipped with a 900 Te active-heave compensated main crane and 650 Te Tilt-lay System. TechnipFMC also is a leading supplier of reeled rigid pipe solutions. These assets and capabilities are integrated by our project management organization, enabling us to optimize the solutions we offer and provide the optimum flowline and riser systems, rigid or flexible, for any offshore development.



Coflon®, Crossflex® and Gamma-Flex® are registered trademarks of TechnipFMC. * patented technology

Field experience and milestones

- | | |
|---|--|
| 1971 First flexible pipe installed in Congo for Elf Emeraude | 2004 First qualification for 2,100mwd (DIP test offshore Brazil, 7" and 9" ID flowlines) |
| 1974 First flexible flowline in the North Sea on Mobil Beryl | 2005 Installation of the deepest riser (7.5" ID - 10,000psi for water injection) in 1,890m for BP Thunder Horse in the Gulf of Mexico |
| 1976 First dynamic flexible riser in Brazil on Petrobras Garoupa | Extension of BV certification to 15,000 psi |
| 1978 First flexible riser with heat tracing in Indonesia on Conoco Udang | 2006 First supply and installation of 8 x 11" Integrated Production Bundle (IPB)* dynamic risers in 1,400mwd for Total Dalia, offshore Angola |
| 1982 First flexible riser with thermal insulation | 2007 Supply and installation of the world's first smooth bore 14" ID dynamic riser for gas export on Statoil Åsgard, Norway |
| 1986 First dynamic flexible riser system installed in the North Sea on Balmoral Sun Oil; First flexible pipe with a Coflon® pressure sheath in the North Sea and Spain | 2007 Installation of the deepest single section riser for an 8" HP/HT sour service production application in 1,500mwd for Chevron Agbami in Nigeria |
| 1987 Largest diameter of flexible riser (19" ID) on Statoil Statfjord C | 2010 Supply and installation of 6" and 10" flowlines in 2,100mwd, offshore West Africa |
| 1988 New depth record for flexible riser (567m) in the Gulf of Mexico on Conoco Jolliet | 2010 Supply and installation of 2 x 10" IPB* risers in 800mwd for Total Pazflor, offshore Angola |
| 1989 First flexible pipe with a Crossflex® pressure sheath | 2010 Deep Immersion Test and qualification for 3,000mwd |
| 1992 First installation using the VLS (Vertical Laying System)* on Saga Snorre | 2011 Supply and installation of 6", 8" in 2,300mWD for Libra project and supply of 9.13" risers in 2,240mwd on Iracema Norte project |
| 1994 First flowline (16" ID, 3.5 km) manufactured in carousel First ISU® (Integrated Service Umbilical) on Norsk Hydro Troll | 2012 Qualification of 9" carbon fiber armours for presalt ultra deepwater applications |
| 1997 New world depth records for flowline (1,709m) and riser (1,390m) in Brazil on Petrobras Marlim Sul | 2013 IPB Papa Terra |
| 1998 First flexible riser with a Teta pressure armor on Norsk Hydro Visund and Enterprise Oil Pierce | 2016 First high temperature PE delivered 2,300m WD 8" |
| 2000 New depth record for flowline (1,877m) on Petrobras Roncador | 2017 >100km of high temperature dynamic monolayer manufactured (Coflon XD) |
| 2001 Implementation of the first Product Integrity Management System (PIM) on the Åsgard field, Norway | 2018 Heat traced, ETH-HCRAW, flexible pipe on Alta Gotha |
| 2002 Installation of the deepest flowline (1,886m) on Petrobras Roncador | 2018 i-Connector on Trestakk |
| 2003 First Oil Offloading Lines (OOL) 2 x 2,240m long installed on Shell Bonga | 2018 1,000+ km delivered for presalt field |
| | 2019 First >140°C flexible pipe project for BP |



Skandi Africa

Since 1972, the highly respected Offshore Technology Conference in Houston, Texas, USA has been honoring companies that have significantly contributed to the offshore oil and gas industry. In 1995, TechnipFMC won the award for the design, manufacture and installation of flexible steel pipe used in floating production systems, deepwater developments and high-pressure pipes for drilling and well servicing.

Excellence

In addition to manufacturing and supply activities, TechnipFMC offers solutions tailored to clients' needs. With our extensive offshore field experience and our intimate knowledge of the technical challenges faced by flexible pipes, we deliver the highest quality flexible products available.

All TechnipFMC activities are placed within an integrated Quality System that ensures our organization, manufacturing process, product solutions and services are reliable and efficient. We are certified ISO 9001 and our flexible pipe plants have received the API 17J certification for the design and manufacture of unbonded flexible pipe.

* Proprietary technology.





Flexibles Technology France
- the R&D center dedicated
to flexible pipes located in
Le Trait

A client focused organization

A client oriented company dedicated to cost reduction and technology

Research and development

TechnipFMC's Flexible Technology Division is equipped with a full range of test facilities, including a state-of-the-art laboratory for advanced material testing and analysis, making it possible to simulate realistic service conditions on actual pipe samples.

The R&D activity is oriented towards extending the current product range by introducing new products and materials. Cost reduction and manufacturing quality are two of our top goals.

Performance

- ▶ Largest internal diameter: 19" ID export riser on Statfjord C (Norway) and Bonga Offloading lines (Nigeria)
- ▶ Deepest risers in Brazil: 8" ID 2300 WD for Libra and 2240mWD for 9.13" for Iracaema norte project
- ▶ Deepest and highest value of diameter times pressure: 7.5" ID 10,000 psi, water injection risers and flowlines, Thunder Horse (Gulf of Mexico) in 1,890mwd. Highest value of diameter times pressure (for a flowline): BP Raven, 10 000psi, 9" ID.
- ▶ Innovative proprietary technology: flexible Integrated Production Bundle (IPB)*, 1,400m Dalia, Angola and 800mwd Pazflor, Angola and offshore Brazil

- ▶ Since 2006, delivery of a 14 off smooth bore gas export risers, patented technology to avoid flow induced pulsation issue. Internal diameter going from 9 to 14"
- ▶ Successfully tested to a max. flow of 48MSm³/d
- ▶ Highest pressure ever reached (4"; 20,000 psi) in service for the offshore well stimulation industry
- ▶ Deep Immersion Performance test in the Gulf of Mexico: 9" at 3,000 mwd
- ▶ Development of carbon fiber armour wires (corrosion free, ultra deepwater and oil offloading applications)
- ▶ HP riser tested up to 105,000 psi.inch (6" at 17,500 psi)
- ▶ Next generation: Hybrid flexible pipe under qualification
- ▶ Smooth carcass for better flow assurance or gas field
- ▶ Heating cables replacing armor wires (ETH-HCRAW)
- ▶ Anti-H₂S sheath for an H₂S free flexible pipe annulus
- ▶ High temperature (170°C) with thermal screen
- ▶ Monolayer PVDF solution at 150°C

* Proprietary technology

Research and development

Engineering

Our engineering group meets two main objectives: Being close to our clients to answer their needs while ensuring a sustained level of engineering excellence. This is achieved through Local engineering departments in each of our business units performing most project engineering tasks within the project teams;

- ▶ A center of excellence in Le Trait sharing the same site as the main flexible pipe manufacturing technology and
- ▶ All engineering and manufacturing centers sharing the same design rules.

Integrity management

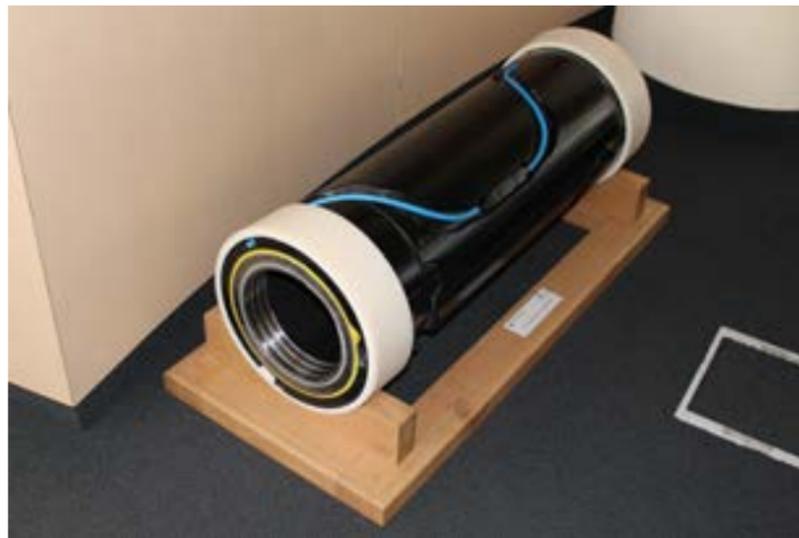
TechnipFMC Subsea Services offers a dedicated suite of services and technologies for asset surveillance to improve subsea operations in terms of uptime, production and OPEX throughout the asset lifecycle.

A specific offer is available relating to flexible risers

Dedicated solutions can be tailored to suit any needs, from integrity management planning to maintenance or service life extension assessment, including specialized inspection, repair, storage and preservation, integrity and production monitoring, as well as data management services.

We have developed differentiated technologies to address flexible pipe integrity and performance specificities like annulus condition or fatigue life assessment and extension, using optical fiber, acoustic emission detection, microelectronic or ultrasonic/electromagnetic imaging devices. Thanks to these technologies, we can offer monitoring solutions through condition and performance monitoring software.

The morphopipe - invention by the riser integrity management



Manufacturing

Manufacturing is organized under a global factory policy whereby our four flexible pipe factories are managed similarly by applying common quality and safety group standards. Our Malaysian plant also operates following our worldwide QHSE standards. As our manufacturing center of excellence, Flexi France has the facilities and capabilities to produce the widest range of flexible pipes. The center is where all our innovative pipe designs are first manufactured and tested. Flexibrás Vitória has been established primarily to supply the local market but can also supply flexible pipe internationally.

Flexibras Vitoria and Acu supply mainly the local markets, whereas AsiaFLex Products serves mainly the Asian and Middle East markets and Le Trait the rest of the world.

Installation

Because of our integrated approach to flexible pipe technology, we ensure that our vessels and equipment are designed to install the flexible products we develop and manufacture.

Regarding equipment, we have developed and patented several laying systems, including VLS* - Vertical Laying System, PPS* - Portable Pipelay System and flexible pipe laying towers.

These systems allow for the efficient installation of flexible flowlines and risers in deepwater and harsh environments. They make it safer to lay flexible lines especially when equipped with intermediate connections, buoyancy modules or other ancillaries for a 650-tonne capacity.



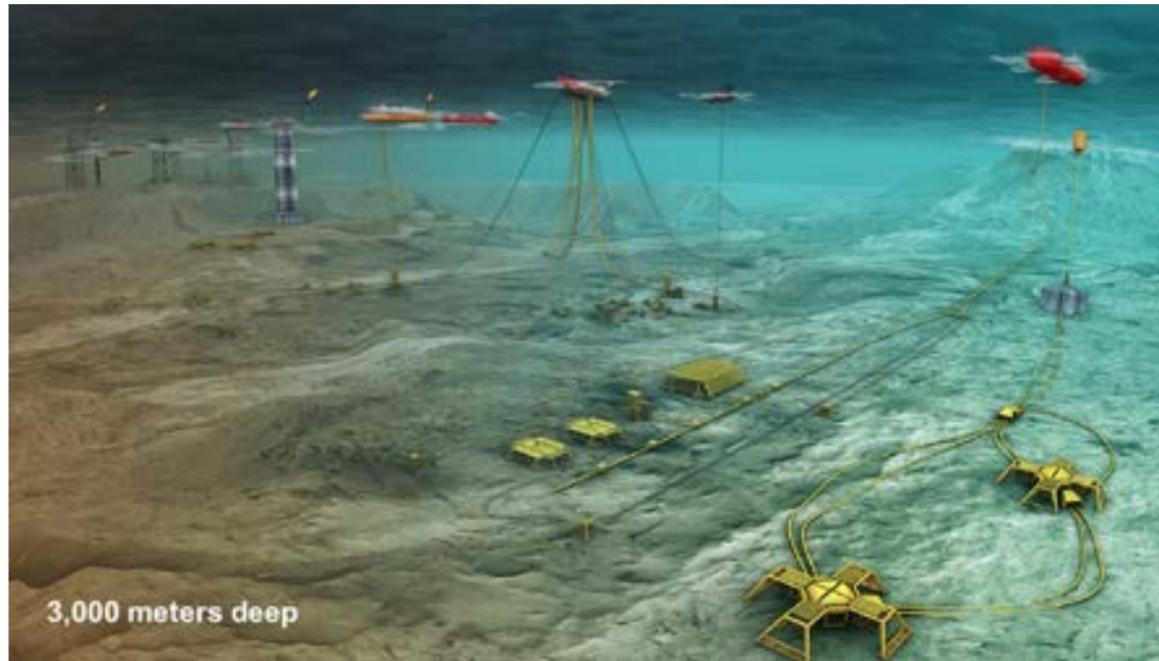
Installation



Installaton

Ultra-deepwater performance

We offer an extensive qualification range in the flexible pipe industry.



Our ultra-deepwater performance range extends from 1,000 to 3,000 meters.

Deep Immersion Performance (DIP) full scale tests were conducted in the Gulf of Mexico in 2010 with 7" and 9" ID tested at 3,000 meters water depth.

- ▶ 2010: 6" and 10" for sour service in 2,100m water depth
- ▶ 2011: Supply and installation of 6", 8" in 2300mWD for Libra project and supply of 9.13" risers in 2,240mwd on Iracema Norte project

We are making full use of our capacity to efficiently and effectively evolve the configurability of flexible pipes. In ultra-deepwater developments, the steel layers

are most affected, with each improvement answering a specific client-led challenge:

- ▶ Internal carcass for collapse resistance
- ▶ Pressure vault for collapse and weight reduction
- ▶ Tensile armors for weight reduction

Also available for deepwater use is active heated flexible pipe (IPB or ETH-HCRAW) necessary to develop some offshore fields and guarantee optimal flow assurance and smooth carcass.

In deep and shallow waters, our flexible pipe technology is a core component supporting the evolution of the subsea industry, allowing us to offer clients high quality and cost-effective solutions tailored to their needs.



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