InField Liner™ - IFL™
Flexible Kevlar® Reinforced PVDF Liner
Revolutionary Subsea Pipeline Rehabilitation System
IFL in Summary

Benefits for the Offshore Pipeline Operator

- Significantly extends lifetime of existing pipelines
- Economical solution compared to new lay carbon steel pipelines
- Saves time in design, planning and installation compared to new lay
- Protection of environment due to dual containment
- Multiple IFL systems already installed within the PETRONAS pipeline network

Revolution in Offshore Hydrocarbon Pipeline Rehabilitation

- Multiple kilometers installed in single pull
- Accommodating multiple 5D 90° bends
- Excellent chemical resistance to hot sour crude oil and sour gas
- High temperature resistance up to 110 °C in hydrocarbon exposure conditions
- Extremely high resistance to permeation
Rising To the Challenge

Internal corrosion may cause a pipeline to prematurely reach the end of its useful service life before its intended design life, which will then necessitate either early pipeline closure or total replacement. Historically, there has been no viable means for installing an internal corrosion barrier into an existing hydrocarbon subsea pipeline once it has been laid. To replace such, offshore pipeline operators around the globe have therefore been faced with the extremely high costs of mobilizing large pipe lay marine spreads for the replacement of their severely corrosion impacted pipelines.

In 2013 PETRONAS & ANTICORROSION PROTECTIVE SYSTEMS (APS) concluded a three year multi-million dollar research & development program to develop the materials, means and mechanisms for the in-situ placement of flexible tight fit rehabilitation corrosion barriers. This development program has now been concluded and has led to the successful deployment of IFL liners into a number of existing high pressure oil and gas subsea pipelines.

APS were the inventors and project managers throughout, with full responsibility for the development, coordination and qualification testing on the utilization and implementation of a range of high performance raw materials, manufacturing processes and liner installation techniques.

The IFL liner is a flexible Kevlar reinforced liner that can be pulled in over long lengths in a single pull. The usage of high specification materials within its construction provide the IFL system with a high resistance to a wide range of hydrocarbon media at elevated temperatures of up to 110°C and exceptional host pipe matching pressure retaining capability within its tight fit operating criteria.

The IFL system thus now offers the subsea pipeline industry with a supremely viable, fast and economic preference when compared against the only other option of a new-lay pipeline replacement.
Technology in Line

The IFL liner comprises of Solvay’s Solef PVDF inner liner, a tightly woven Aramid core, using Dupont Kevlar fabric, with an outer layer of abrasive resistant Thermoplastic Polyurethane from BASF.

The inner PVDF layer provides a high chemical resistance to the most aggressive hydrocarbon exposure conditions, including hot sour crude oil up to 110 °C.

The Kevlar core provides the liner with an extremely high tensile strength, thus enabling the insertion of single lengths of multiple kilometers of liner through multiple 90 degrees bends of down to 5D radii.

The outer TPU covering provides a maximum protection and abrasion resistance, as may be required during the pulling and insertion process of the IFL liner system into the host pipeline.
**Outer Layer**
Thermoplastic polyurethane - BASF

**Core**
Seamless woven Kevlar fabric - Dupont

**Inner Layer**
Solef PVDF - Solvay Chemicals
Industry Scope

Corrosion is relentless. Unstoppable. The best a man can hope to achieve is to slow its advance to imperceptible levels and thereby extending the useful economic life of a structure or a pipeline.

Subsea pipelines are almost always barge-laid with no internal lining and thus have no inbuilt internal anticorrosion protective mechanisms for any extended life capability. Up to now additional wall thickness for corrosion allowance has been the Integrity Engineer’s only defense. Often however this still has very limited defense capability where Sulphate Reducing Bacteria (SRB) are liable to be present. In such a case the bacteria can randomly colonize and attack the pipe wall causing rapid pitting and ultimately leading to an early integrity failure. Chemical dosing may forestall such a failure, but unfortunately it will never delay the inevitable conclusion for any significant length of time.

Four (4) years. That can be the sort of period between a new-lay pipeline installation and a complete system abandonment where serious levels of SRB exists within the crude environment. With, up till now, no practical and economically viable recovery means for repair or rehabilitation of the pipeline, the only option that was left was a full pipeline re-ly.
The period between the 1970’s and 1980’s witnessed a massive upswing in the offshore hydrocarbon extraction industry. The end result of this was that during those two decades, approximately 50 million meters of subsea pipelines were laid with the typical design life of these, even under the best of conditions, being projected as some 40 years. The implication of this means that during this decade there will be the theoretical need to replace or rehabilitate at least some 50 million meters of pipelines worldwide.

In the decades since, the rate of new subsea pipelines laid has more than doubled and with the increasing percentages of water cuts experienced; combined with the production from more highly corrosive well environments, it now means that greater challenges must be met by much higher levels of intervention and applications of anticorrosion barrier systems.
Main Applications

The IFL system is ideal for rehabilitating in-field subsea pipelines running from platform-to-platform, or from platform to shore. IFL can also be used as a corrosion barrier for new pipelines which will be known to be exposed to extremely corrosive environments incurred due to aggressive environmental influences such as SRB or in combination with high water cuts, and thereby significantly reducing the predicted life-span of the pipeline without the application of a fully effective corrosion barrier.

The IFL system was originally developed as a viable and cost-effective method for subsea pipeline rehabilitation, however and in addition to this, the IFL system may also have specific applications for the onshore hydrocarbon pipeline industry as well. An example of this would be where a pipeline passes under an area where, for one reason or another, site access is extremely limited, and thus the pipeline has to be rehabilitated over much longer lengths with single pulls.
Fields of Application in Summary

- Rehabilitation of existing subsea hydrocarbon (also water injection) pipelines which have naturally reached the end their designed service life.
- Rehabilitation of existing subsea hydrocarbon (also water injection) pipelines, which have exhibited signs of early failure due to higher than expected rates of corrosion.
- Abandoned or decommissioned subsea hydrocarbon (also water injection) pipelines, whereby the IFL system can offer the possibility of recommissioning these very pipelines.
- The installation of an IFL Liner inside of new hydrocarbon subsea pipelines in circumstances where extreme corrosion conditions are known to exist.
- Rehabilitation of onshore hydrocarbon pipelines whereby the pipeline is required to be rehabilitated over long lengths where, due to the ability to gain access being extremely limited at shorter intervals.
IFL Manufacturing

IFL materials are manufactured under strictly controlled conditions. Only raw materials of the highest quality from approved and renowned specialist suppliers are selected and utilized after having first been subjected to vigorous quality control and testing and being in full conformity with the detailed IFL manufacturing and test plan.

Every element of the manufacturing procedure is carefully and continuously monitored and controlled with real time computer assessment and feedback so as to ensure absolute precision and reliability. Once commenced and stabilized, the manufacturing process is a continual and meticulous process until the full length of the desired liner has been produced. Every facet of the liner production quality assurance is recorded and the produced liner quality is thereafter further verified by extensive testing prior to factory acceptance and dispatch to the customer.

IFL is reeled ‘flat packed’, onto specialist shipping drums designed to be containerized in either conventional or high cube containers, with each drum capable of taking multiple kilometers of liner, dependent upon diameter.
IFL Installation

Thorough inspections and site visit reviews of the existing subsea pipeline, riser access, platform space and accessibility etc. are mandatory pre-requisites prior to the detailed planning of any IFL Liner rehabilitation project, as is the collation of all data relative to the prevailing operating parameters and pipeline conditions.

This data is used to assess the general condition and remaining wall thickness of the existing pipeline and to verify the IFL Liner size requirements in the event that a tight-fit liner is to be chosen. Prior to the offshore deployment of the IFL installation marine spread, the host pipeline will have been decommissioned, cleaned and finally gauged and its immediate topside pipe-works removed in preparation for the liner insertion program.

The IFL liner, although manufactured in a circular profile, is able to be temporarily flattened for transportation and reeled onto a transportation drum that can be sized so as to fit into conventional shipping containers. Each drum can be loaded with multiple kilometers of IFL liner, dependent upon the liner diameter.

These drums are then shipped to an onshore location close to the point of marine mobilization/embarkation, usually comprising of a local marine supply base, where the liner is then re-profiled into a folded format prior to being sent offshore for the final installation.

The actual IFL Liner insertion process is extremely fast, with the pulling process normally being run at speeds of up to 10 meters per minute, however this will be dependent upon overall operational and environmental parameters. The IFL Liner installation drum is normally located and operated from the deck of a DP2 work vessel which is usually located within meters of the entry riser point, from where the liner can then be unspooling into the host pipe system as quickly and as easily as possible.
A feeder cable will have been blown through the pipeline during the final cleaning and gauging processes and this will then be used to pull back through a higher tensile strength installation winch cable for connection to a towing head which is securely located on the leading end of the liner.

Once the IFL Liner has been drawn through the entire length of the pipeline, it is then re-rounded by applying a slight internal pressurize into the liner. The liner, whose external diameter is manufactured to match the same bore as that of the host pipeline, is then fully expanded to form an intimate and tight fit with the inner wall of the host pipe.

With the liner then fully re-rounded against the wall of the host pipeline; the last installation task to be undertaken is the installation of the end termination connectors which then ensure complete and reliable seals and restraint at the liner ends. The re-lined pipeline will then be hydro-tested in the conventional manner and all the topside pipe work reconnected. Following this the pipeline is then fully ready for re-commissioning and for its new and extended operational life.
Licensed Installer Network

APS manages the installation of the IFL liner system through its own offices and operational facilities which can be found across a range of international locations; presently however, the initial IFL installation operations and programs are primarily directed from APS's main Middle Eastern (Dubai) and Southeast Asian (Kuala Lumpur) offices.

In the regions where APS has no direct presence, APS is working on establishing a network of licensed installers to handle the local installation of the IFL liner system. These contractors are selected on a set of rigid norms, with criteria's such as proven track-records in offshore contracting, availability of their own fleet of appropriately sized and equipped vessels, direct affiliations with subsea pipeline rehabilitation and of course intimate knowledge of the operational players and business environment of the target locations under consideration.
After the selection process, the actual appointment of a licensee is followed by a rigorous practical training on all aspects of the installation process and the procedures stipulated in the franchisee manual.

Through APS’s own contracting operations units, or through our licensed installer network, APS are ensuring the highest quality installation programs, under the most challenging operational environments and conditions on a worldwide basis.

For details of our existing licensed installers, or if you are interested in becoming a licensed installer in your local geographic area, then please contact APS’s International Business Development Department.
Track Record

After years of concerted effort by a combined team of highly skilled development engineers, not only from APS but also from our project developmental co-partners, and spreading from the original liner development concept criteria through to the fully successful installation of the world's first platform to platform, subsea tight fit, hydrocarbon resistant rehabilitation system within a sour environment.

The joint PETRONAS and APS IFL installation program has not only made history, but has also opened a completely new and exciting chapter in not only extending installed pipeline life but also in fighting subsea pipeline corrosion. Since then, multiple IFL liners have now been installed for the remediation and refurbishment of additional PETRONAS pipelines. In addition both corporate and operational preparations are well in hand to further extend the system to affiliates and external users, by way of a concerted global commercialization process.

For a detailed and complete project experience list, please contact APS’s Business Development Department.