A NEW LINE IN INTERVENTION
FIBER OPTIC SENSING FOR QUALITY WELL DATA AT THE SPEED OF LIGHT

Unique
Single use
Disposable
Lightweight
Portable
Low risk
Cost effective
**Game Changing Technology**

**FiberLine Intervention (FLI)** from Well-SENSE is a unique and innovative method of collecting diagnostic data from oil and gas wells using disposable fiber optics. FLI will quickly and cost-effectively install a temporary fiber optic line into a well for the purposes of performing distributed data sensing over its entire length in real time. FLI deploys a bare line and is completely disposable, being designed to dissolve in the well environment after use.

Temperature, pressure and acoustic data can be captured, plus active single point measurements and live HD video, providing operators with a detailed understanding of a single well or field of wells. FLI's tractor conveyancing permits tools to be deployed to depths and deviations previously thought uneconomical. The increase in understanding from this type of accessible, fast, low cost well monitoring will lead to much more efficient recovery of hydrocarbons.

**THE FOURTH INTERVENTION**

FLI is an entirely new discipline for intelligent well intervention. It provides clients with a fourth and alternative option over conventional wireline, slickline or coiled tubing intervention at a significantly reduced cost. Being extremely compact, simple to deploy and disposable, the time to rig up and down and the amount of equipment and personnel required to perform the job is drastically reduced.

FiberLine Intervention enables cost effective:

- Distributed and single point sensing
- Production logging
- High-bandwidth data capture

FiberLine Intervention reduces:

- Health, safety and environment risks
- Personnel and equipment on wellsite
- Intervention cost and NPT
HOW DOES FLI WORK?

The FLI probe, containing the fiber optic line on an internal spool, is dropped down the vertical section of the well, unspooling the line without tension as it free falls downhole.

During the survey, the fiber line uses a continuous beam of laser light which encounters interference at points along its length, depending on environmental factors. For example, if it is measuring acoustic profiles, a sound will be generated at source and the changes in soundwave pressure frequency will be measured. Our fiber optic lines deliver real-time measurements, over their full length, over a period of time and data is captured by a recording device at the surface.

FLI is different to other fiber optic measurement devices as it is run into the well as bare line without being encased within an intervention media. Once it is run and has delivered the necessary data it is disposed of in the well and does not result in an obstruction. This is the only fiber optic sensing method for oil and gas wells that is disposable.

TYPICAL LAUNCH SEQUENCE

> FLI probe and launcher assembled and tested at base
> Launcher attached to wellhead (replaces Wireline Lubricator)
> Tool released from launcher
> Survey captures DAS/DTS/Active sensor data
> Remove launcher, drop fiber into the well and leave site
KEY FEATURES AND BENEFITS

> **Unique** — FLI is a unique method of well intervention using disposable fiber optics for data measurement and well profiling.

> **Fourth Line in Intervention** — FLI is a fourth method of well intervention, alongside wireline, slickline and coiled tubing, offering clients an alternative low cost option for data acquisition. Instead of piggy-backing on other well intervention or workover activities, FLI can be quickly and independently deployed at low cost, any time. Fiber optic data capture is also faster, more reliable and more accurate than other intervention methodology, such as measurements taken using wireline tools and transmitted via copper wire.

> **Disposable** — FLI’s fiber optic line and probe are disposable, so they completely degrade in the well environment over time. Once the data has been captured, the line is cut and ‘rig down’ is immediate. There is less risk of stuck in hole or lost in hole situations and no NPT associated with pulling out of hole.

> **Compact** — FLI is compact and portable, ideal for offshore, onshore and remote locations worldwide. The FLI kit can be delivered to site on the back of a pick up truck onshore, or in a small container offshore, and be ready to run in less than an hour compared to around ten hours for slickline. It uses bare fiber optic line rather than being encased in a carbon rod or other media. It requires no heavy, bulky, costly tool strings, lubricators, slickline or other ancillary equipment which can be complicated and time consuming to rig up and down on site.

> **Fast** — FLI is a plug and play system. It is taken onsite ready to run for rapid implementation. It takes two people around an hour to rig up and prepare the equipment on site. The survey can take as long as required from hours, to days, to months and ‘rigging down’ is immediate.

> **Low Cost** — FLI is the most cost-effective method of downhole data capture available. FLI abolishes the need for teams of personnel and removes almost all of the mobilisation costs associated with conventional intervention. Compared to an onshore well intervention in the US, FLI offers an approximate 75% product cost saving and an approximate 90% operational cost saving offshore the US.

> **Low Risk** — FLI is the lowest risk method of downhole data capture available. There is no need for high levels of personnel or support equipment and project logistics and time are significantly reduced. There is less risk of getting stuck in hole, less risk of lost equipment and no lost in hole charges. There is no non-productive time associated with rigging down and the cost savings are dramatic.

> **Active Technology** — FLI can be upgraded with technology to enable access to previously unobtainable depths and deviations. It can provide single point measurements and 4K HD camera surveillance alongside pressure, temperature and acoustic information.

> **Multiple Fibers** — FLI can install multiple fibers. For example, a typical ‘Bi FLI’ deploys one single mode fiber and one multimode fiber simultaneously. This gives an optimised solution for performing both DAS and DTS and/or single point measurements or video on the same FLI survey.

> **Well Access** — FLI is deployed in vertical and deviated wells, in both liquid and gas. For vertical and moderately deviated wells, FLI descends in free fall with speed adjusted to the well conditions as needed. FLI can also access highly deviated and horizontal wells using a conveyance system.

> **Complete Lifecycle Solution** — FLI can be used across the full lifecycle of the well, from exploration to production and decommissioning. It can perform low cost surveillance on an entire field of wells, leading to more efficient and safer recovery of hydrocarbons.
APPLICATIONS

Data profiling can be used to understand a huge variety of behaviours, events and anomalies throughout the lifecycle of a well. We can look to gather data which will help with both exploration, production and late life integrity challenges.

FLI is most commonly used for completion and production applications such as cement assurance, gas lift optimisation, sand detection or flow monitoring etc., however there are many more ways FLI can help, such as offset micro-seismic assessment for fracking or drilling and looking at leaks or corrosion.

Below are just a few examples of activities where FLI can quickly and economically help you to make more informed decisions:

- Cement assurance
- Lift optimization
- Leak detection
- Micro-seismic monitoring
- Vertical seismic profiling
- Directional surveys
- HD downhole video
- Injectivity testing
- Fracture diagnostics
- Stimulation monitoring
- Pressure/temp/flow/fluid id/holdup
- Cement plug integrity assessment
Technology Development

Well-Sense is employing a phased approach to the development of our FiberLine Intervention system.

The first phase of Passive FLI, which allows Distributed Acoustic Sensing (DAS) and Distributed Temperature Sensing (DTS) to be recorded over the entirety of the deployed line, is complete. The technology has been well tested and field trials have been successful.

We are currently providing FLI solutions for cement cure assurance, gas lift diagnostics and optimization, production and injection logging, leak detection and similar applications. To further assess and impact both exploration prospects and producing assets, borehole seismic measurements, using DAS, are also available. Full wellbore data provides time-depth relationships and interval velocities as well as Vertical Seismic Profile (VSP) imaging. FLI is also used for micro seismic monitoring for hydraulic fracture applications, which allows operators to improve production and avoid risks by identifying patterns of fluid movement, fracture development, connectivity, compaction and whether the frac and proppant are staying in zone or travelling out of zone.

We have incorporated an optical pressure-temperature gauge into our FLI system to allow high pressure, high temperature (HPHT) and long-term single point measurements to be recorded in addition to DAS and DTS measurements. Bragg grating gauge technology allows these measurements to run concurrently, reducing time and operational cost whilst increasing functionality. The optical gauge is compatible with HPHT fiber for applications such as ultra-deep wells, thermal recovery (e.g., steam injection) and geothermal applications.

Additional sensor technologies are under development, both electronic and optical, to expand the functionality of FLI for fluid ID, well trajectory and flow profiling. The functionality is equivalent to wireline production logging tool (PLT) measurements but with the additional benefit of temperature and acoustic profiles.

Self-conveyance of the FLI tool for highly deviated and horizontal wells is under development. Single trip and multi-trip devices are designed with start/stop and speed control commands sent from the surface to control FLI movement.

ACTIVE-FLI

‘Active’ FLI features include 4K real-time video streaming functionality, digital caliper measurements and horizontal conveyancing. This allows visual, measured and quantified well integrity inspection opportunities and access to deviated wells, plus retrieval of the FLI tool if required.

Well-SENSE are also developing their own surface Data Acquisition System to allow data to be imported into all 3rd party, industry standard, logging and interpretation software.

<table>
<thead>
<tr>
<th>Year</th>
<th>Surface Acquisition</th>
<th>Offshore Deployment</th>
<th>DTS</th>
<th>DAS</th>
<th>Optical P/T Gauge</th>
<th>HD Video</th>
<th>Conveyance Device</th>
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For more information on FLI product applications, specifications and capabilities please visit our website at well-sense.co.uk
Well-SENSE Technology uses technical expertise, design excellence and innovation to deliver practical solutions to industry challenges. We want to extend the life of fields, maximise productivity and improve industry practices, leaving a beneficial legacy for future generations. We are not afraid of disruptive technology or the risk of innovation for industry advancement.

Change is achieved through bravery, collaboration and partnership and we are passionate about meeting other like-minded specialists to complement our efforts and achieve more.

THE TEAM
Well-Sense is a team of like-minded, forward thinking individuals who have an enviable mix of creativity, technical expertise and oil and gas industry know-how.

CRAIG FEHERTY – CEO
Craig brings over twenty years of industry experience to Well-Sense, having previously worked at GE Oil and Gas as Product Line Director for Wireline Products. Prior to this he held management roles at Sondex Wireline and Archer, with an early career carved out in the aviation and sonar industries.

During his time at GE Oil and Gas, Craig managed a portfolio of technologies designed to measure downhole well conditions via sensors and electro-mechanical intervention tools deployed on wireline cable. This experience significantly bolsters the company’s position as it moves forward with commercialisation of its FiberLine Intervention (FLI) Technology.

DAN PURKIS – TECHNOLOGY DIRECTOR
Dan’s love of invention from a young age led him to pursue a career in engineering, which now spans over twenty years, eight of which he worked at Petroleum Engineering Services (PES) where he joined a world-class team designing intelligent wells. After PES was acquired by Halliburton, Dan jointly established Petrowell, where an inspiring company ethos resulted in pioneering solutions and the company eventually being purchased by Weatherford.

Dan’s ability to think outside the box has resulted in a number of world firsts and new technologies coming to market. Recognised as one of the best innovative thinkers in his peer group, he has over 50 granted patents and has won the Significant Contribution Award at the Offshore Achievement Awards in recognition of his influence on the industry.

TAD BOSTICK – COMMERCIAL DIRECTOR WESTERN HEMISPHERE
Tad has over thirty five years of experience in the oil and gas industry and has been actively involved in the application of novel sensing and monitoring technologies for oil and gas applications around the world. Prior to joining Well-Sense, Tad held senior positions at Weatherford, leading the reservoir monitoring global product line before becoming Vice President of the global production optimisation business unit.

Tad began his career with Western Geophysical working in surface seismic exploration and borehole seismic logging. In 1997 Tad joined CiDRA Corporation and led the early development and commercialization of the Clarion® fiber optic in-well seismic system. CiDRA’s Optical Sensing Systems group was acquired by Weatherford in 2001.
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