Optical Leak Detection
And
Locating System

Technical Description

TABLE OF CONTENTS

TABLE OF FIGURES

INTRODUCTION

Technologies

The pipeline industry has long been frustrated by the unreliable and ineffective leak detection systems. There were two detection technologies:

DISCRETE DETECTION

The Discrete Detection is based on identifying a number of locations, most likely exposed to faults, to position detectors at. The significant drawback of this system is the inefficient detection between two consecutive sensors. Amongst other important drawbacks is the exponential increase of costs associated with more detectors, installation and maintenance/repairs.

CONTINUOUS DETECTION

The technology overcame the most significant drawback of the "Discrete Detection". Before the introduction of the FOPSS™ LDS, the continuous detection technology implemented sensors made of a special type of cable installed in intimate contact with the pipeline. The disadvantages again include high costs of such a special cable and of its installation with associated pipeline unwrapping and rewrapping as well as the cost of maintenance and/or repairs.

FOPSS™ Leak Detection System (LDS)

FFT successfully commercialised the continuous leak detection FOPSS™ LDS. Although the technology behind the FOPSS™ LDS is sophisticated, its application in a system context is very simple.

The FOPSS™ Leak Detection System (LDS) simulates a real-time continuous microphone, sensor, designed to listen, over a bandwidth of 1 MHz, to the ultrasonic frequencies generated by high-pressure gas or fluid leaks. A sensor segment is terminated to an industrial PC, back-to-back with consecutive segment and finally at the Control Room.

The FOPSS™ LDS system offers significant overall cost reductions including:

- Supplies, a sensor covers up to 60 km of a pipeline. Few sensors are required to secure thousands of km.
- The sensor is made of 3 fibres extracted from a fibre optic communication cable, normally laid alongside pipelines.
- Installation & Maintenance, the cost is negligible with sensors require no intimate contact with pipeline-contact, within the 0.5 meters proximity. of the cable fibres are extracted from. It can be reducing the cost of Add-on to an existing pipeline, expansions of pipelines and the cost of the system maintenance or repairs as well as the cost of loss of revenue caused by operation interruptions.

The FOPSS™ also detects a third party interference, physical disturbance.

MERITS OF OPTICAL FIBRE LEAK DETECTION SYSTEMS

The economic benefits of deploying an effective pipeline leak detection system are significant and often hidden. The pipeline industry abounds with anecdotal evidence of systems that fail to operate reliably or meet pipeline operators' expectations. In many cases there may be leaks that go undetected for long periods of time before being discovered as a result of a major failure.

Also, when systems are unreliable and prone to false alarms, operators tend to disconnect them, in which case leaks may be ignored and, worse still, the capital expenditure on the asset has been wasted. The Foptic™ Pipeline Security System is an intelligent and robust system designed to offer cost and functional advantages over other leak detection technologies

Negligible Sensor Costs

Possibly the most significant aspect of the FOPSS™ is the fact that the length-dependent sensor costs are effectively eliminated in cases where an optical fibre telecommunications system is being installed to provide pipeline communications and telemetry. The FOPSS™ is able to employ spare (single mode) optical fibres in the communications cable to act as the sensor and the marginal cost of these fibres in a multi-fibre cable is negligible. Furthermore, the type of the cable sheath employed does not affect the system performance. The only requirement is that the cable be placed within 0.5 metre of the pipeline, which is often the case anyway.

Intelligent Control System

A further significant aspect that sets the FOPSS™ apart from competing technologies is the fact that, essentially, it comprises only two major components, an industrial PC that houses the intelligence and the external optical fibre cable.

The use of a PC-based, software controlled system provides useful flexibility in analysing and reporting pipeline leaks. With the FOPSS™, users are not limited to relatively 'informationless' leak/no leak signals. Now the characteristics of a leak can be monitored over time and analysed to determine what action is appropriate to take. For example, maintenance action may be deferred on a leak until it reaches a predetermined threshold established by economic realities. Leak data can also be stored for later analysis so that a profile can be established of any ad hoc environmental factors or incidents that might falsely be assessed as leaks. In this way the system can 'learn' to adapt to its environment. What tends to happen with unintelligent systems is that they are disconnected, due to their inflexibility, when false alarms become an insurmountable issue.

Independent Section Characterisation

Furthermore, the intelligence offered by the FOPSS™ allows the treatment of signal data to be analysed and handled differently for each system monitoring section. For example, one particular section may be influenced by the fact that

the pipeline passes through an industrial/city area with many environmental noise factors, whereas other sections may pass through relatively quiet desert areas.

This ability to alter the sensing characteristics of the system over sections of the pipeline applies currently on a full section-by-section basis. The location of any leak is determined instantly within metres over any section. This Locator allows leak signals to be treated differently according to their location, further minimising potential false alarms.

Length Independence

The major advantage of using the Foptic™ Pipeline Security System is the consistency of the detection response over distances regardless of length without the need for any external hardware other than the fibre cable itself.

Robust External Plant

The particularity of the fibre optic based systems is their immunity to electrical interference with its proximity to high voltage installations and being deterrent to lightning strikes. Metal structures, including pipelines, are prone to lightening strikes. The high current surges can damage copper cables and monitoring electronics attached to the pipeline resulting in significant increases in maintenance costs also.

The lightening is not an issue for the FOPSS™ since it employs neither metallic cables nor directly pipeline-mounted opto/electronic components. The external components are passive and rugged and the optical fibre cables. They are readily available and relatively inexpensive to replace or repair in case of damage.

Flexible Interfacing

The system also has the flexibility to interface with a wide variety of pipeline management systems so that it can interact with other security technologies such as video display systems and visual and audible alarms. Its interfacing capabilities include Ethernet TCP/IP, UDP, SMTP, SNMP and field-bus systems. Specific customer-defined interfaces can be developed if required.

Application of an Emerging Technology

The implementation of optical fibre sensors in security systems is relatively new. Future Fibre Technologies Pty. Ltd. may be the only company in the world to have developed this sophisticated technology to such sufficient level of operational reliability and is certainly the only company to have demonstrated the Locator capability.

OPTICAL FIBRE SENSING

Optical Fibres

Optical fibres are dielectric wave guiding devices used to confine and guide light. Figure (1) illustrates a cross-sectional view of an optical fibre.

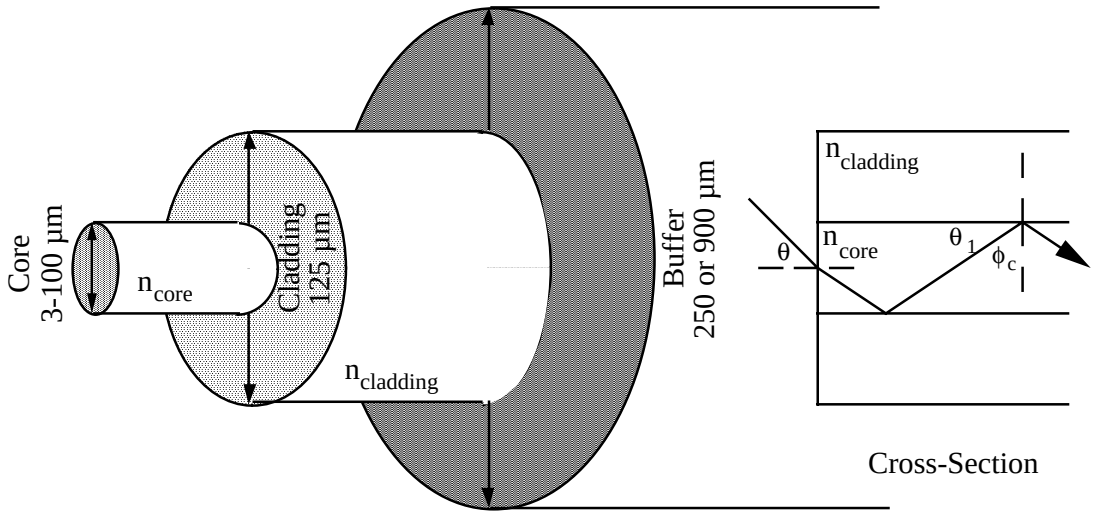


Figure 1: Cross-section View of a typical Optical Fibre

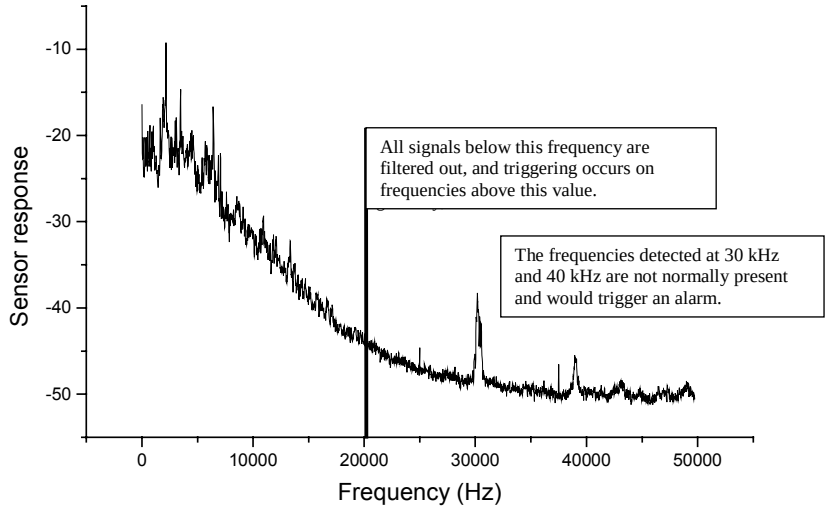
The high expectations of optical fibres as information carriers in communication systems have been justified by their performance over the past two decades. Due to their high bandwidth, low attenuation and mechanical properties, each fibre is capable of replacing over 1000 copper wires in telecommunication systems. With these characteristics it is no surprise that optical fibres have become the most affordable and efficient medium available in the field of telecommunications.

Sensing

Optical fibres can be more than mere signal carriers. Light that is launched into and confined to the fibre core propagates along the length of the fibre unperturbed unless acted upon by an external influence. Specialised sensing instrumentation may be configured such that any disturbance of the fibre which alters some of the characteristics of the guided light (ie amplitude, phase, wavelength, polarisation, modal distribution and time-of-flight) can be monitored. The precise changes, in the characteristics of a travelling light at a receiving point, are scaled in proportion to the strength and type of the disturbing influences. Such modulation of the light provided the measurement of a wide range of events and conditions useful for continuous on-line monitoring of engineered structures and machinery. Fibre optic sensors offer significant operational advantages over conventional techniques.

Foptic™ µStrain Sensor Technology

The Foptic™ µStrain™ sensor is the most sensitive fibre optic sensor over a wide bandwidth of (0 Hz) to (1 MHz) and of up to 60km sensing length. It is sensitive to ultrasonic vibrations generated by the pressurised liquids and gases in a pipeline. For a pipeline operating under normal conditions, the frequency of the leak event is expected to be in the 50 to 150 kHz range. The µStrain™ sensor utilises low-pass filtering to reject signals from environmental noises below 30 kHz, and high-pass filtering to detect leak signals.



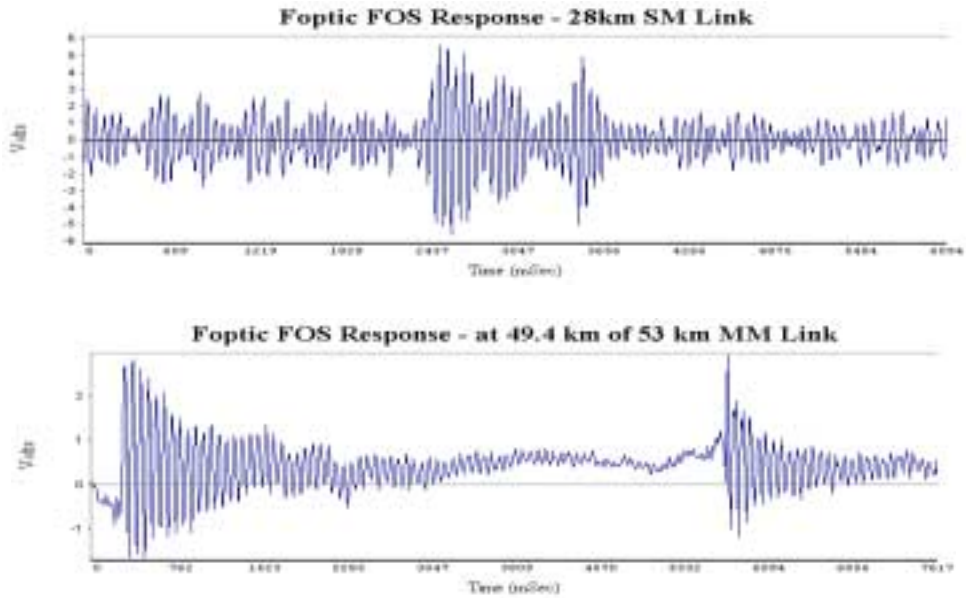


Figure 2: Sensor response and testing frequency spectra

SYSTEM CONFIGURATION

System Overview

The FOPSS™ is manufactured in Australia in conformity with the CE requirements and is a Y2K compliant.

The diagram below represents a typical FOPSS™ Pipeline Security System. The system utilises fibres, extracted from the existing and commercial Fibre Optic Cable laid alongside the pipeline, to simulate continuous microphone.

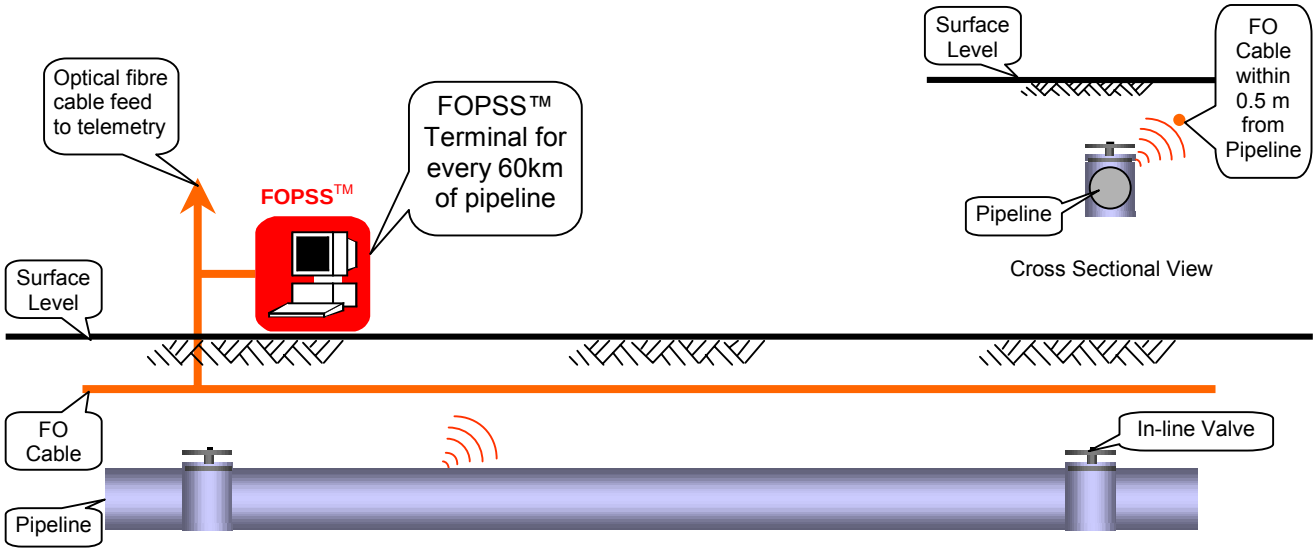


Figure 3: Foptic™ Pipeline Security System (FOPSS™) – Leak Detection System

The ultrasonic frequencies are picked by the optical continuous microphone and deliver them to **FOPSS™**. The collected data are continuously compared to the stored database norms of each section. The system alarms any occurrence of changes along each section as well as it displays the level of emergency and the position of changes.

The system records all occurrences and causes that may update the comparison references to minimise future false alarms.

Monitoring Long Pipelines

Each FOPSS™ System monitors and detects changes in a section of a pipeline of up to 60km long. Each system analyses and records the status of the section including any alarming condition.

Long pipeline networks can also be monitored and detected by FOPSS™ System. One master FOPSS™ Terminal, located in the Pipeline Control Room, can interact with as many Slave FOPSS™ Terminals as required.

The slave FOPSS™ Terminals are connected back-to-back and each continually delivers its records to the master FOPSS™ Terminal at the control room.

The displaying unit of the master FOPSS™ Terminal displays the status of all sections of a pipeline and alarms the occurrence of the changes and points to the type, level and location of each alarm along the entire pipeline. Figure 4 below sketches a multiple sections installations.

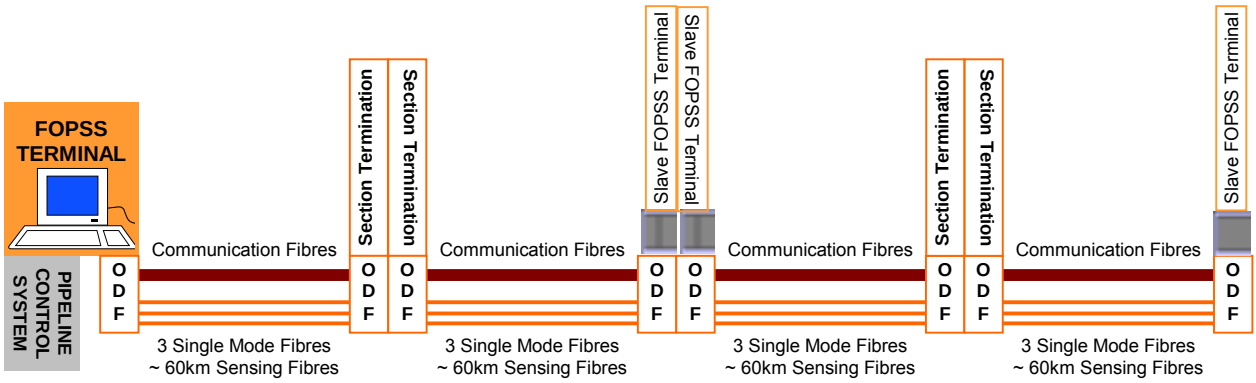


Figure 4: Multi FOPSS™ Detection System

FOPSS™ LDS TECHNICAL SPECIFICATIONS

System Terminal

EQUIPMENT

Stand-alone or 19" rack-mounted industrially hardened micro controller:

- Pentium Celeron or III 500Mz or higher Processor
- 132MB RAM
- 8 x PCI Slots
- 4Ghz HDD (minimum)
- 1.44MB FDD
- Optical Fibre Ethernet Adaptor (required for multiple section system only)
- 10/100BaseT Ethernet Adaptor or client-specified field-bus adaptor
- SVGA Video Monitor (optional)
- Operating Temperature: 0 - 50º C.
- Relative Humidity: 0 – 95% @ 40º C, non-condensing.

OPERATING PLATFORM

MS Windows NT4, SP 5.0 or later.

POWER REQUIREMENTS

AC: 1A @ 240V, standalone

DC: 18A @ +12V, rack-mount

4A @ -12V, rack-mount

50A @ +5V, rack-mount

1A @ -5V, rack-mount

INTERFACES

- 3 FC or SC, sensor
- 1 FC or SC, data
- Ethernet TCP/IP
- 10/100BaseT Ethernet/Field-bus, pipeline control system

Termination Equipment

EQUIPMENT

- Passive opto-electronic
- Stand-alone (50mmH x 250mmW x 250mmD) or 19" rack-mount

INTERFACES

- FC or SC, back plane of micro-controller or SM patch cord ODF

Sensors

EQUIPMENT

4 x single mode optical fibres conform with Telecommunications Specification SAL-004-SPC (9/125µm)

- 3 fibres for sensing and locating
- 1 fibre for data communications and system control

TYPICAL STRAIN RANGE

±10,000με and ±50,000με depending on fibre coating and condition

SENSITIVITY

< 10με possible

OPERATING WAVELENGTH

1300 to 1550nm

ATTENUATION

< 0.25dB/km at 1550nm

SPLICE LOSSES

≤ 2 – 3dB (total per section)

MINIMUM FIBRE BEND RADIUS

25mm

OPTICAL POWER BUDGET

~ 40dB

INTERFACES

FC or SC