

Advanced Distributed Optical Fiber Sensor Systems for Pipeline Integrity Monitoring

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Distributed fiber optic sensors allow the measurement of structural parameters such as static/dynamic strain, temperature, pressure, and vibrations at thousands of locations along a single fiber cable. Deep neural network (DNN) algorithms were developed for rapid data processing and vibration event classification. The distributed fiber interrogator development includes:

- ❖ Brillouin optical time domain analysis (BOTDA).
- ❖ Phase-sensitive optical time domain reflectometry (phase-OTDR).
- ❖ Optical frequency domain reflectometry (OFDR).
- ❖ Single-mode–multi mode–single-mode (SMS) fiber acoustic sensor.

Field validated on gas/oil pipelines



BOTDA

Sensing range = >100 km
Spatial resolution = <5 m
Measurable parameters:
static strain, temperature



φ-OTDR/DAS

Patented

Sensing range = >10 km
Spatial resolution = <2 m
Measurable parameters:
acoustics, dynamic strain



OFDR

Sensing range = >100 m
Spatial resolution = <1 mm
Measurable parameters:
static strain, temperature



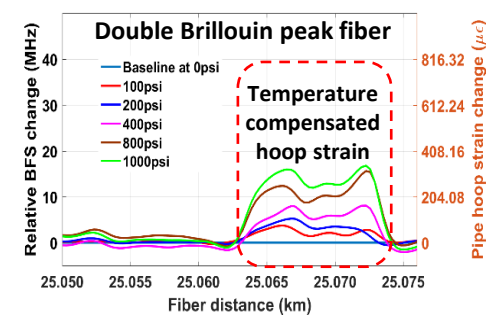
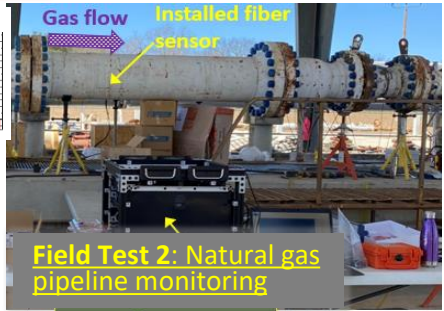
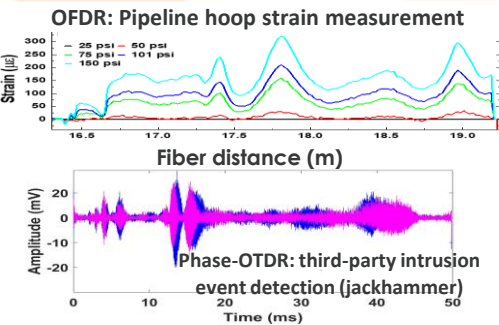
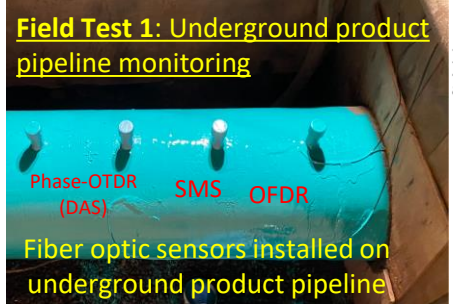
SMS

Patented

Frequency range= 1 Hz to 1.2 MHz
Resolution= <1 to 2 Hz



- #### Advantages
- Multi-parameter monitoring capability
 - Deep neural network assisted sensor system
 - High accuracy and reliability



[1]. N. Lalam, S. Bukka, H. Bhatta, M. Buric, P. Ohodnicki, and R. Wright, "Achieving Precise Multiparameter Measurements with Distributed Optical Fiber and Deep Neural Networks", *Communications Engineering*, vol. 3, p. 121, 2024.
 [2]. N. Lalam, H. Bhatta, N. Diemler, S. Bukka, P. Ohodnicki, and R. Wright, "DNN-Assisted Distributed Strain and Temperature Fiber Sensor System for Natural Gas Pipeline Monitoring", *IEEE Transactions on Instrumentation & Measurement*, 2024.
 [3]. N. Lalam, P. Westbrook, K. Naeem, P. Lu, P. Ohodnicki, N. Diemler, et al., "Pilot-scale testing of natural gas pipeline monitoring based on phase-OTDR and enhanced scatter optical fiber cable," *Scientific Reports*, vol. 13, p. 14037, 2023.