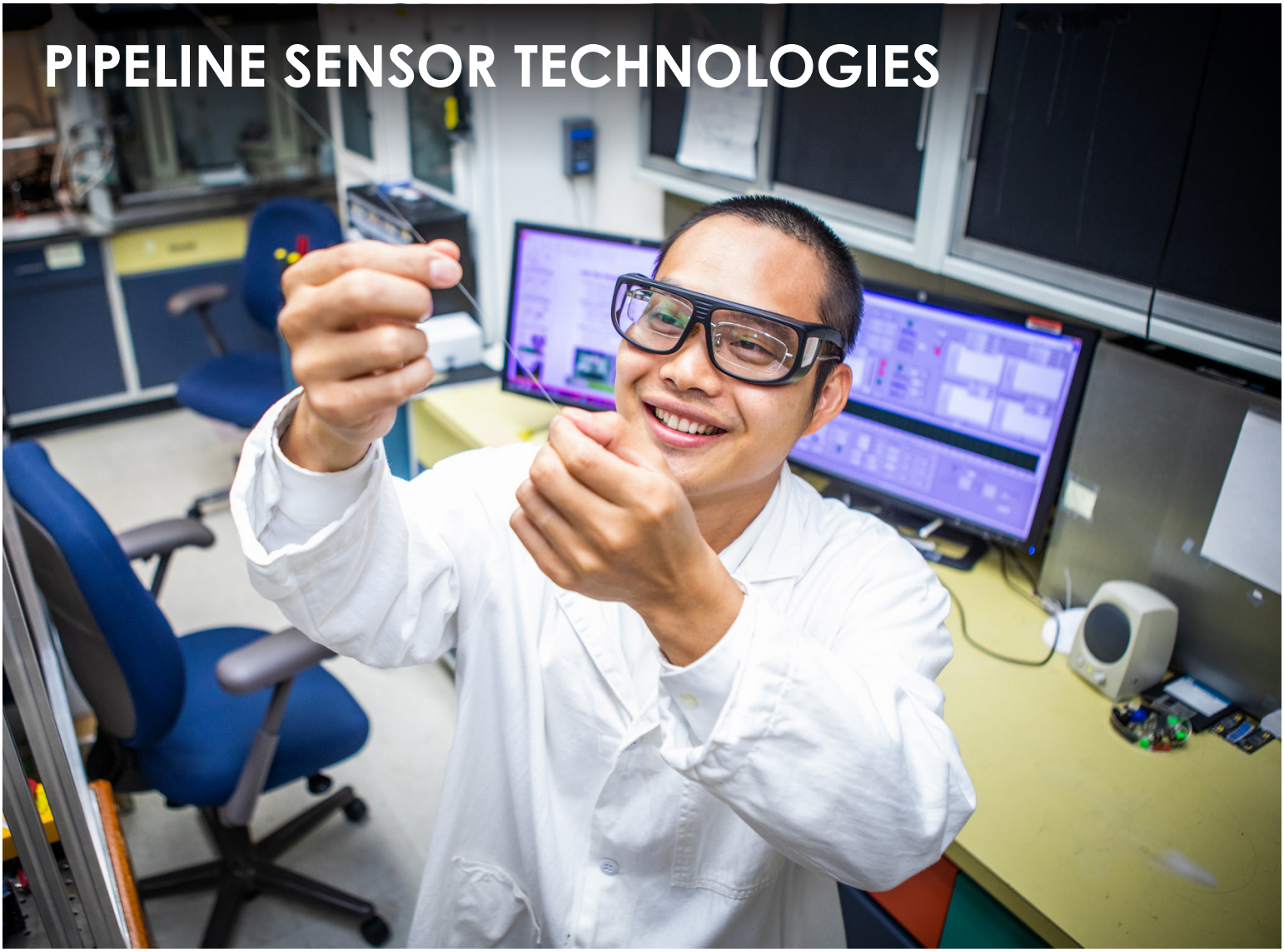
PIPELINE SENSOR TECHNOLOGIES



NETL

NATIONAL ENERGY TECHNOLOGY LABORATORY

Pipeline Sensor Technologies is one area of research within NETL's Natural Gas Infrastructure Program, which aims to strengthen natural gas pipeline reliability and ensure infrastructure security. This research area focuses on developing sensor technologies for low-cost, low-maintenance monitoring of pipeline corrosion rate and gas stream chemistry. Corrosion has been a great concern in the oil and natural gas industry, as it adversely affects the infrastructure in exploration, production, processing and transport with significant economic costs and safety considerations. Over time and if left unmitigated, corrosion can cause steel to lose its strength and possibly render it unable to contain the fluid in the pipeline at operating pressure.

There are more than 328,000 miles of natural gas transmission and gathering pipelines and 74,000 miles of crude oil transmission and gathering pipelines in the United States. Each year, corrosion costs industry $5.8 billion to monitor, replace and maintain assets. According to the Pipeline and Hazardous Materials Safety Administration database, corrosion has caused around 25% of the natural gas transmission and gathering pipeline incidents over the last 30 years, and 61% of those were due to internal corrosion, which is not readily apparent during regular maintenance and inspection.

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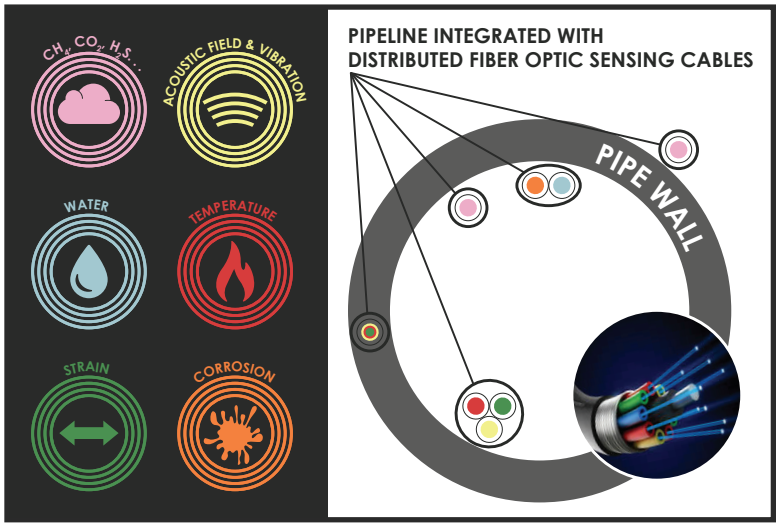
PROGRAM OBJECTIVES

The Pipeline Sensor Technologies research area aims to develop and demonstrate sensor devices and enabling material technologies for increased reliability and resiliency of the natural gas infrastructure to safely and securely deliver and transport natural gas. Research in this area will also improve operational efficiency and enable a more flexible pipeline infrastructure capable of carrying multiple gas streams (e.g., CO_2 or H_2) moving into the future.



Early research is focused on pipelines transporting natural gas with selected sensor technologies that include:

- Advanced electrochemical-based sensors.
- Optical fiber-based sensors.
- Passive, wireless surface acoustic wave-based sensors.

The goal of the project is to provide a suite of sensing technologies and analytic techniques and tools to industry. This suite will help to equip the natural gas infrastructure for increased reliability and resilience and minimize environmental impacts with complementary cost and performance characteristics. Improved cyber-physical security and situational awareness of the natural gas infrastructure will also be a primary outcome.

Short-term primary sensing targets include methane detection external to the pipeline and internal corrosion within the pipeline to enable detection of existing leaks, as well as early detection of incipient failures to prevent costly and disruptive incidents through enabling the implementation of preventative maintenance and/or upstream process controls to mitigate the undesired conditions.

APPROACH

Three primary thrusts are being pursued in terms of advanced materials and sensor device technologies for natural gas pipeline monitoring applications.

- Advanced electrochemical point sensors for quantification of general and localized corrosion and environmental monitoring.
- Distributed sensor technologies for multi-parameter monitoring (temperature, strain, methane, H_2O, CO_2, etc.) and early corrosion onset.
- Passive sensors for low-cost and wirelessly interrogable multi-parameter monitoring.

Within each of these sensor device classes, a combination of sensor material research and device fabrication/optimization are being pursued for the specific environmental conditions relevant to natural gas infrastructure monitoring. Parallel activities in all three areas will complementarily leverage NETL's Research and Innovation Center expertise in electrochemistry and corrosion, chemistry and materials science and engineering, photonics and fiber optics, and applied electromagnetics in the microwave frequency range to promote more rapid development of all technologies pursued.

An additional thrust is also being pursued in the area of advanced data analytic techniques and methods, including artificial intelligence and machine learning, for identification of signatures and patterns representative of hazards, defects and operational parameters of the natural gas pipeline network.

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