Detection of Unauthorized Construction Equipment in Pipeline-of-Ways & Real-Time Acoustic Monitoring of Contact to Pipelines

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Outline of Presentation

> The need for 3rd-party damage detection

> Two solutions under development:
  – Use an optical fiber to detect encroachment in the right-of-way
  – Detect acoustic signal generated when pipeline is hit

> Brief overview of each technology & deliverables
Prevention of 3rd-Party Damage is a Industry Concern

> Third-party damage on HP pipelines can be extremely costly and disruptive

> DOT statistics on transmission lines from 1994-2002 give:
  - 237 third-party incidents
  - 8 deaths
  - 36 injuries
  - $168 million in property damage

> One incident cost ~$25 million

> True cost 2 to 5 times greater
Optical Fiber Sensor for Detection of Unauthorized Construction Equipment in Pipeline Right-of-ways BEFORE the Pipe Is Hit

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  – DOE NETL
  – GRI
  – OTD
  – Test site at ANR Pipeline

> Proof-of-Concept Phase
Optical Fiber Sensor: Objective

> Develop a system that can detect hazardous encroachment with minimum false positives

  - System must be automatic, 24 hours per day/ 7 days a week
  - Effective
  - Reliable
  - Economical
An Optical Fiber is the Sensor

> Optical fiber buried along pipeline

> Compression of soil and vibrations change light transmission properties of the fiber

> Light pulses and an OTDR* detect these changes

> After disturbance, fiber returns to original condition (fiber is not broken)

* OTDR = Optical Time Domain Reflectometer
OTDR Technique Can Discriminate Simultaneously Occurring Events

Round trip travel time of a light pulse locates encroachment.

Variations in amplitude identify type of encroachment.
Optical Fiber Sensor: Disturbances to the Fiber Will Reflect Part of a Light Pulse

*OTDR = optical time domain reflectometer
Optical Fiber Sensor: When Displayed on a Scope, the Position of the Signal Is Proportional to Distance to the Encroachment

AMPLITUDE OF REFLECTED SIGNAL

TIME DELAY (DISTANCE TO ENCROACHMENT)
Optical Fiber Sensor: The Variation in Signal Strength Used to Discriminate Among Encroachment Types

Returning signal from successive light pulses
Minimizing False Positives and “Masked Events” Is Critical for Industry Acceptance

> Encroachment is common, 3rd-party damage is rare

> Economics requires monitoring long distances from one location

> Pipelines in noisy areas will have “events” occurring simultaneously

> Thus, being able to detect and distinguish simultaneous events at different locations is important

> Also critical to identify what is causing encroachment
Optical Fiber Sensor

Key technical issues:

> Demonstrate the ability to detect encroachment

> Develop methods to discriminate between potentially hazardous and benign encroachments
### Optical Fiber Sensor: Project Deliverables

- Design and build custom OTDR
- Select, install and test optical fibers
- Collect data characterizing right-of-way encroachment types
- Develop techniques to distinguish potentially harmful from harmless encroachment
- Demonstrate sensitivity and discrimination capabilities
Optical Fiber Sensor: Custom OTDR
Optical Fiber Sensor: Field Site

Farm land

Open field

Forest

Microwave tower

6" deep

12" deep

18" deep

22" pipeline

30" pipeline

16'

1700'

256'

453'

1430'

826'

887'

16'

256'

453'

1430'

826'

887'
Real-Time Monitoring of Contact to Pipelines Detects Impacts

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- GRI
- PRCI
- PSE&G
- Questar
- NGA (NYGAS)

> Phase 7  Battelle is subcontractor
Acoustic Monitoring: Detect the Impact Signal

> When construction equipment strikes a pipeline, it creates an acoustic signal that propagates in the gas stream.

> Sensors on the outside of the pipe can detect these impact signals and be used to send an alarm.
3rd-PARTY DAMAGE DETECTOR

- Sensor
- Electronics
- Power Supply
- Radio
- Acoustic Waves
- Backhoe Arm

Diagram shows a sensor detecting 3rd-party damage with acoustic waves, radio and power supply connections, and an electronic component.
Acoustic Monitoring: Overall Objectives

> Continue development by designing & constructing new hardware and incorporating background noise management

> Design equipment to accelerate bringing a real-time monitoring system to market
Acoustic Monitoring: Two Applications

> Permanent installation on critical pipeline segments

> Temporary monitoring at construction sites with hardware moved to the next site when construction is complete
Developed understanding of acoustic signal propagation in pipelines

Developed understanding of signal characteristics created by contact with the pipe

Detected simulated impact at up to 3 miles in low-noise areas

Built catalog of impact signals

Investigated noise discrimination techniques

Demonstrated technique in field trials in rural areas
Acoustic Monitoring

Key technical issues:

> Main issue is economics: cost per mile of system

> Sensor spacing and noise management are critical
Acoustic Monitoring: Development Approach

- Develop rugged, practical hardware
- Install equipment at utilities ~ 1 year after start of project
- Conduct field trials and analyze data for ~ 1 year
- Use real-world data to develop noise management
Acoustic Monitoring: Project Deliverables

- Plan for selecting test sites
- System architecture & hardware design
- Six to ten sets of hardware
- Installation of units at participating utilities
- Results of the reliability testing
- Library of background noises
- A suite of noise management techniques
3rd-party damage is a major gas industry concern

24/7 coverage needed

A minimum of false positives is critical

Complementary approaches
  - Optical fiber sensor for detecting equipment in right-of-ways BEFORE the pipe is hit
  - Real-time acoustic monitoring for alerting on impact

Practical systems need to be developed and demonstrated
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