LOCATION OF LEAKS IN PIPELINES USING ACOUSTICAL PRINCIPLES

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Thousands of miles of pipeline are used in this country to transfer petroleum and chemical products from both underground and aboveground storage tanks (USTs & ASTs). Pressurized pipelines commonly found at retail service stations are typically 2 inches in diameter and operate at 20 to 30 psi; larger lines (4 to 12 inches in diameter) used at bulk storage tank facilities generally operate at much higher pressures. In either case, these pipelines are usually constructed of steel and small leaks resulting from corrosion can result in catastrophic releases unless they are detected, located, and repaired. Passive-acoustic measurements, combined with advanced signal-processing techniques, provide a nondestructive method of leak location that is accurate and relatively simple, and can be applied to a wide variety of pipeline systems.

Experiments were conducted at the Edison, NJ UST Test Apparatus in which three acoustic sensors separated by a maximum distance of 125 feet were used to monitor signals produced by 3.0, 1.5, and 1.0 gal\h leaks in the wall of a 2 inch diameter pressurized petroleum pipeline. The line pressures and hole diameters used in the experiments ranged from 10 to 20 psi and 0.01 to .03 inches, respectively. Application of a leak location algorithm based upon the technique of coherence function analysis resulted in a mean difference between predicted and actual leak locations of approximately 4 inches.

Spectra computed from leak-on and leak-off time series indicate that the majority of acoustic energy received in the far field of the leak is concentrated in a frequency band from 1 to 4 kHz. The strength of the signal within this band was found to be proportional to the leak flow rate and line pressure. Energy propagation from leak to sensor was observed via three types of wave motion: longitudinal waves in the product, and longitudinal and transverse waves in the steel.

The similarity between the measured wave speed and the nominal speed of sound in gasoline suggests that longitudinal waves in the product dominate the spectrum of received acoustic energy. The effects of multiple-mode wave propagation and the reflection of acoustic signals within the pipeline were observed as non-random fluctuations in the measured phase difference between sensor pairs. Additional experiments with smaller holes and higher pressures (20 to 50 psi) are required to determine the smallest leaks that can be located over distances of several hundred feet. The current experiments indicate that improved phase-unwrapping algorithms and/or lower noise instrumentation are required to optimize system performance.