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The Influence of Sensor Technology on the Performance of Acoustic Leak Detection for Water Networks

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Agenda

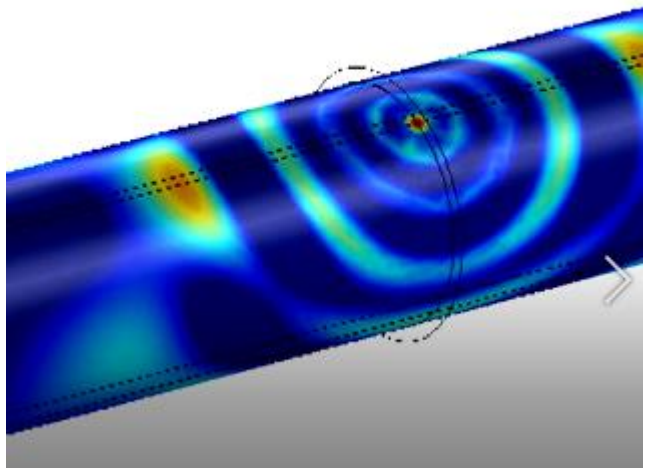
1. Considerations for Acoustic Leak Detection on Water Mains
   - Water-Borne Axi-Symmetric Mode of Propagation due to Leakage
   - Sound Propagation and Frequency Bands of Interest

2. The Right Sensor Technologies for Specific Pipe Types and Applications
   - Consideration of Sound Attenuation in Pipes
   - Field Experiments at Echologics R&D Innovation Site

3. Echologics Leak Detection and Monitoring Systems
   - EchoShore-DX for water distribution networks
   - EchoShore-TX for transmission mains and critical water supply lines

1. Considerations for Acoustic Leak Detection on Water Mains

- Water-Borne Axi-Symmetric Mode of Propagation due to Leakage
  - Pipes are waveguides for sound
  - Dominant mode
  - Speed of sound in pipes



"Investigations found that the dominant mode that propagates over significant distances in buried water mains is a mode which at low frequencies is characterized by predominantly axial water-borne displacements. The established method of locating leaks by acoustic signal analysis assumes that leak noise propagates as a single non-dispersive mode at a velocity related to the low frequency asymptote of this water-borne mode."

$$v = v_o \sqrt{\frac{1}{[1+(D/e)(K_{water}/E_{pipe})]}}$$

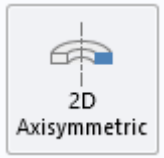
Where:

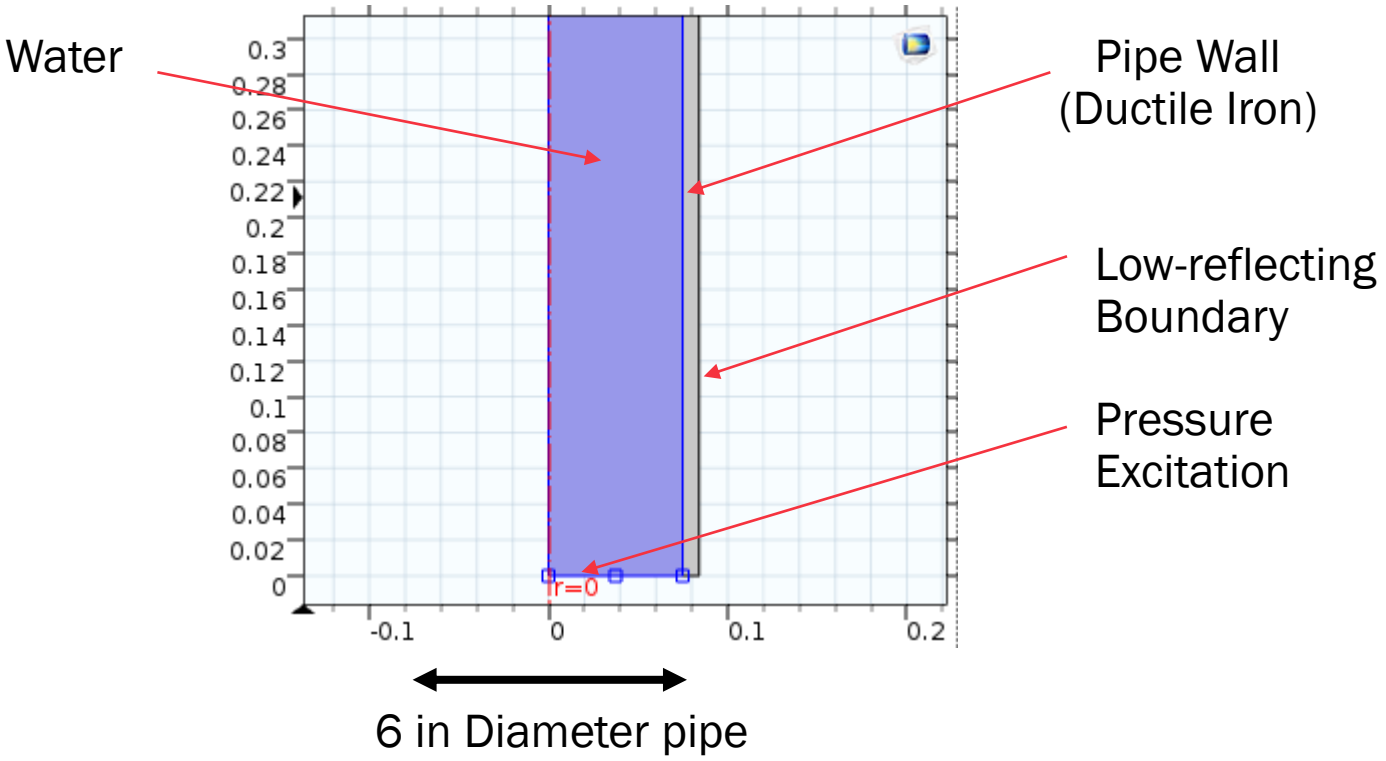
v =	propagation velocity of leak noise in pipe
v_o =	propagation velocity of sound in an infinite body of water
D =	internal diameter of pipe
e =	thickness of pipe wall
K_{water} =	bulk modulus of elasticity of water
E_{pipe} =	Young's modulus of elasticity of pipe material

"Axisymmetric Modes That Propagate in Buried Iron Water Pipes", Long et al., AIP Conference proceedings, 2003

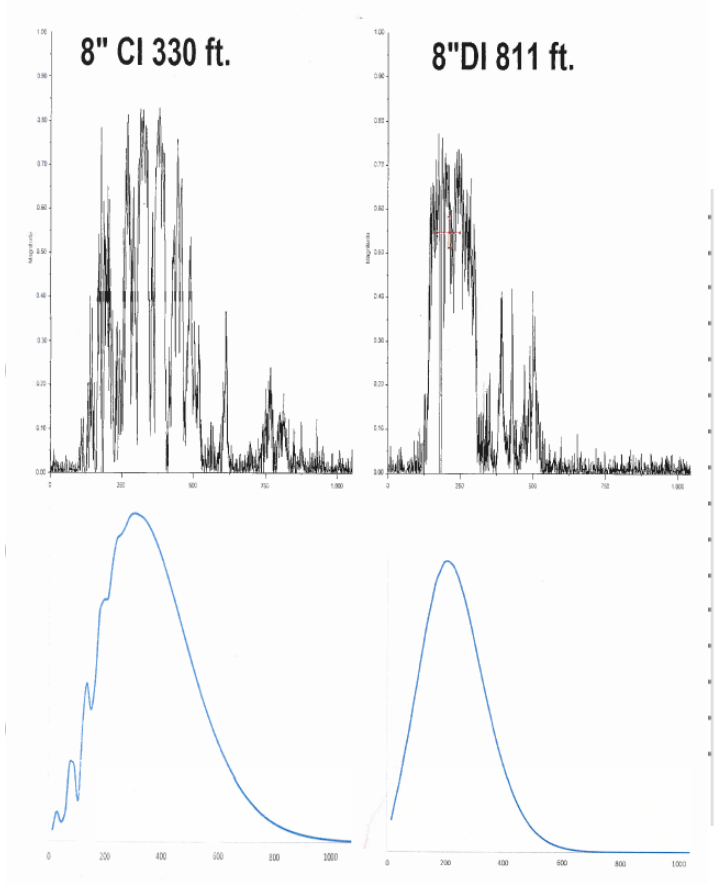
1. Considerations for Acoustic Leak Detection on Water Mains

- Sound Propagation and Frequency Bands of Interest
  - Comsol Multiphysics 2D axisymmetric





- Frequency Bands of Interest



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2. The Right Sensor Technologies for Specific Pipe Types and Applications

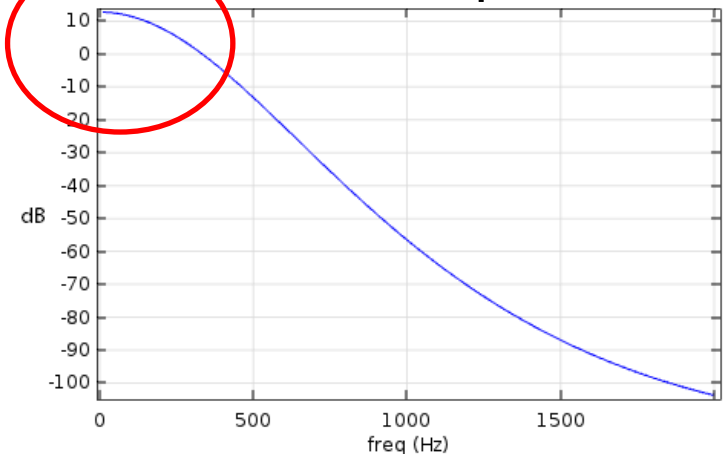
- Consideration of Sound Attenuation in Pipes
  - Comsol Multiphysics 2D axisymmetric

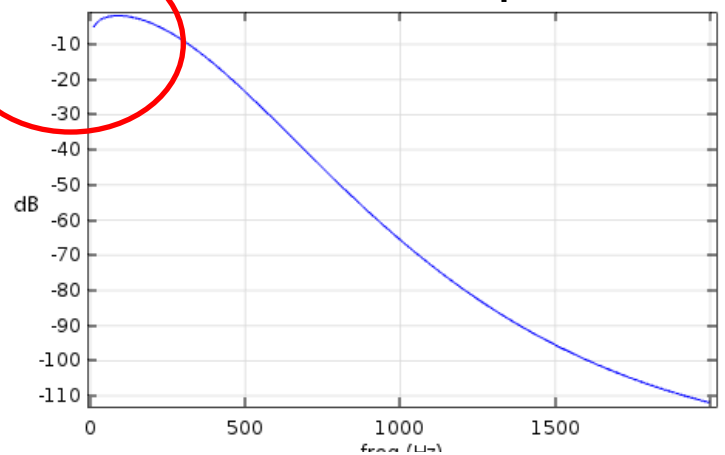
Hydrophones are more sensitive to really low frequency compared to Accelerometers

Pressure response

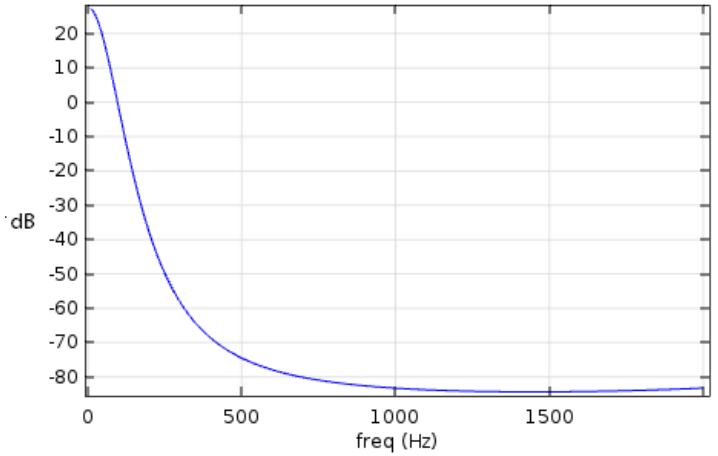
Acceleration response

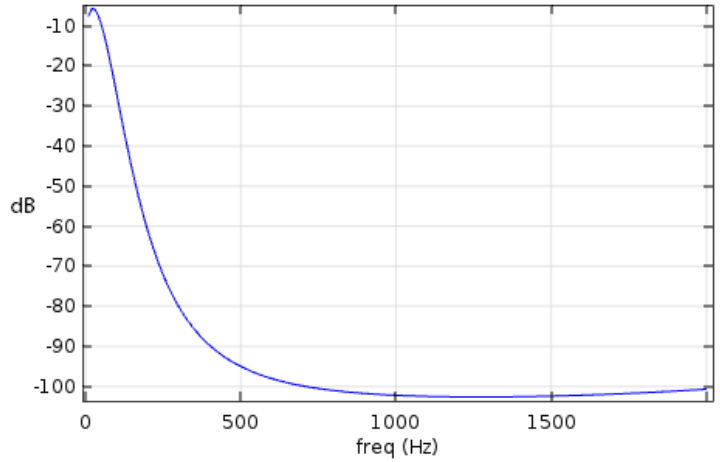
6 in Ductile Iron





18 in Ductile Iron





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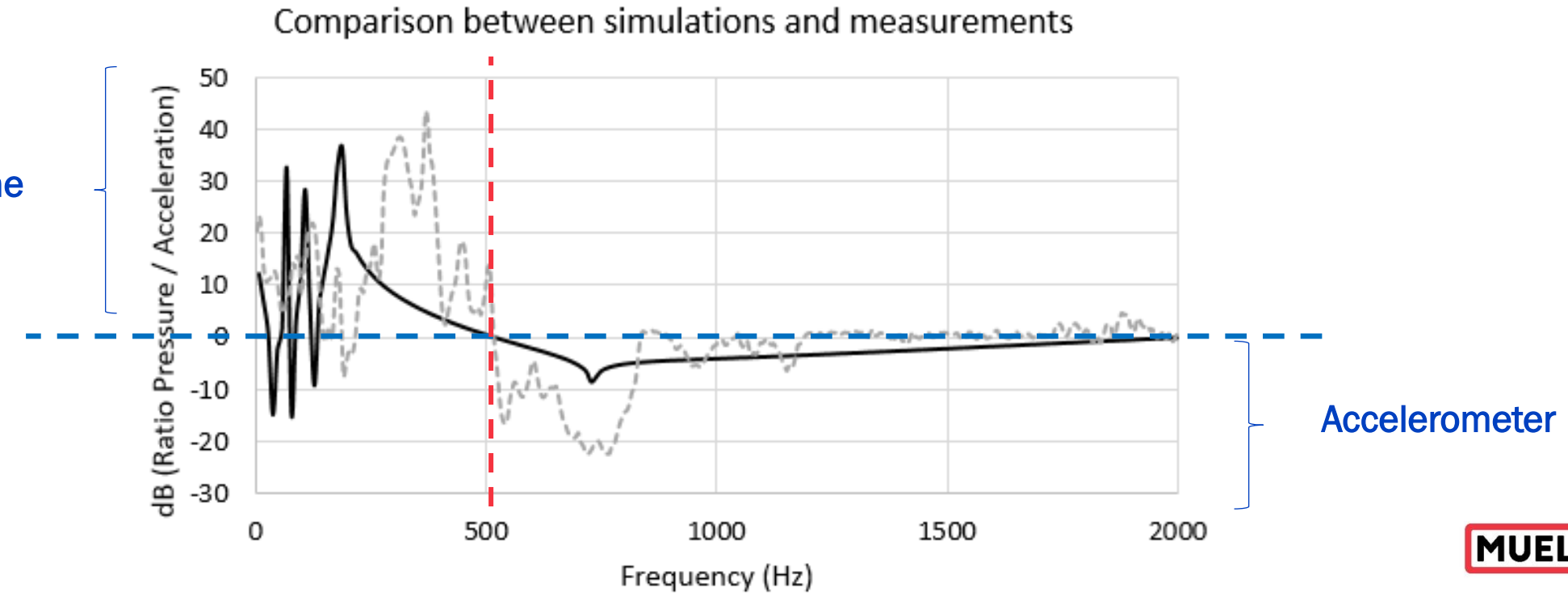
2. The Right Sensor Technologies for Specific Pipe Types and Applications

- Field Experiments at Echologics R&D Innovation Site
  - Responses in terms of Pressure and Acceleration were measured on both a 6in DI pipe and a 18in DI pipe.
  - Results are presented below in terms of ratio between Pressure and Acceleration measured on the 6in DI pipe in order to identify the optimal range for hydrophones and the optimal range for accelerometers
  - The graph below compares simulations with measurements



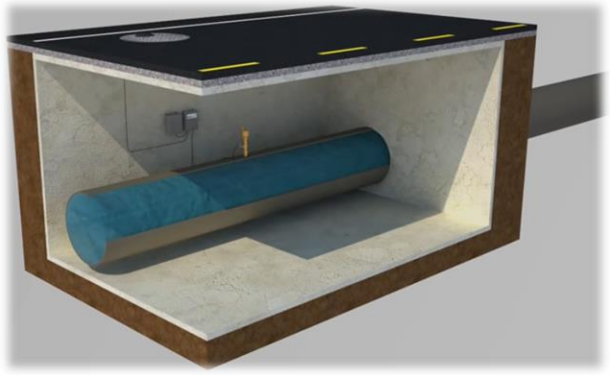
3. Echologics Leak Detection and Monitoring Systems

- The larger the diameter, the lower the frequency band of sound propagation.
- The longer the distance, the more sound attenuation → Frequency band of propagation decreases with distance
- Therefore, hydrophone use is recommended for leak detection on large diameter pipes, or for leak detection over long distances because the frequency band of leak sounds will be low in frequency (Transmission pipes).
- Accelerometer use is recommended for leak detection on small diameter pipes, or for relatively short distances (up to 1300 ft or 400 m) because the frequency band of leak sounds will typically be between 200 and 800 Hz (Distribution pipes).

3. Echologics Leak Detection and Monitoring Systems

- EchoShore-DX Permanent Monitoring System for Distribution Mains
  - Accelerometer-based technology with leak detection nodes installed directly into the caps of fire hydrants creating a grid of sensors to detect leaks on the entire distribution network

- EchoShore-TX for Critical Supply Lines and Transmission Main Monitoring
  - Hydrophone-based technology with leak detection nodes installed typically in chambers or on access points allowing hydrophone connection to ensure monitoring of critical pipes



DRIP, DROP, LEAKS COST MONEY & WE CAN HELP!

For more information, visit Echologics.com or call 866-324-6564.

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