COMSOL CONFERENCE 2016 BOSTON

Simulation of Sound Wave Propagation Inside a Spherical Ball Submerged in a Pipeline

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10/06/2016

OUTLINE

- Statement of Problem: Why Pipeline Inspection?
- Objectives and scope
- Numerical Model
- Simulation Results
- Sensitivity Analysis on Leak Noise Propagation
- Conclusions
- Future Work

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Why Pipeline Inspection?

- High environmental, financial and human risks due to leaks
- Every day leaking pipes lose more than 7 billion gallons of clean drinking water

  → $11 billion in loss per year from water leaks only.
- In 2013 alone, 623 gas and hazardous liquid pipeline incidents

  → 10 fatalities, 47 injuries and $336 million in property damage.

Why Pipeline Inspection?

72-inch Pipe failure causing more than 100 homes to flood on 2009, Baltimore, MD

Why Pipeline Inspection?

66-inch Pipe water main failure on 2008, Interstate 25, Denver, Colorado

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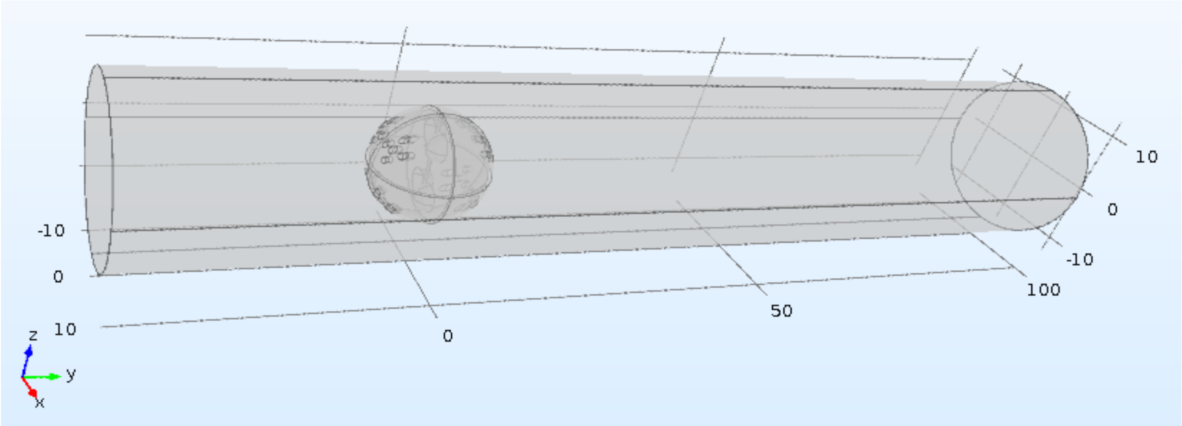
Objectives and Scope

→ Innovative solution to detect leaks inside a pipeline

- **Numerical study Goal:** Leak noise propagation inside the pipeline

- **How the results will be used?**

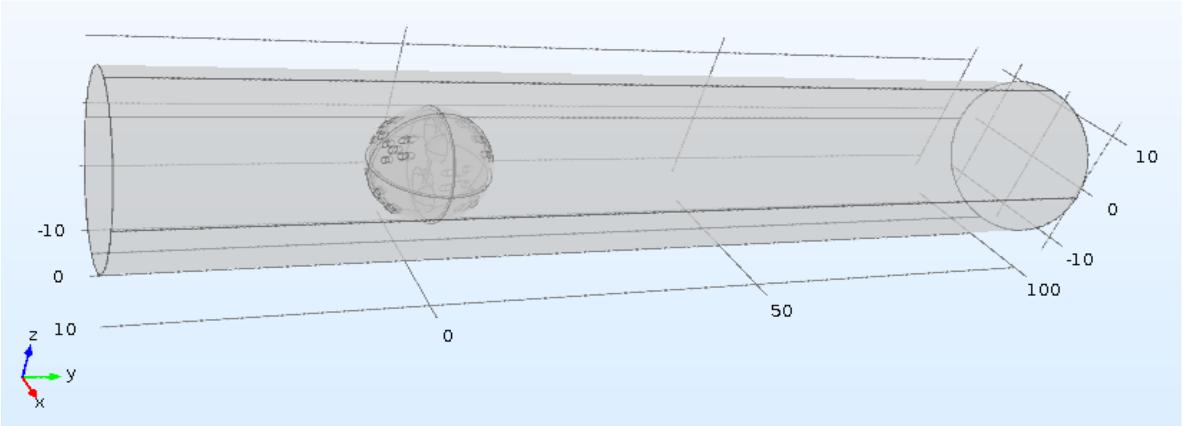
→ Calibrate an inspection tool: a smart spherical ball flowing inside a pipeline



Objectives and Scope

The ball is equipped with a control system and multiple acoustic sensors:

→ Relates sound pressure levels to leak detection
→ Accounts for the perturbations caused by the fluid flow around the ball



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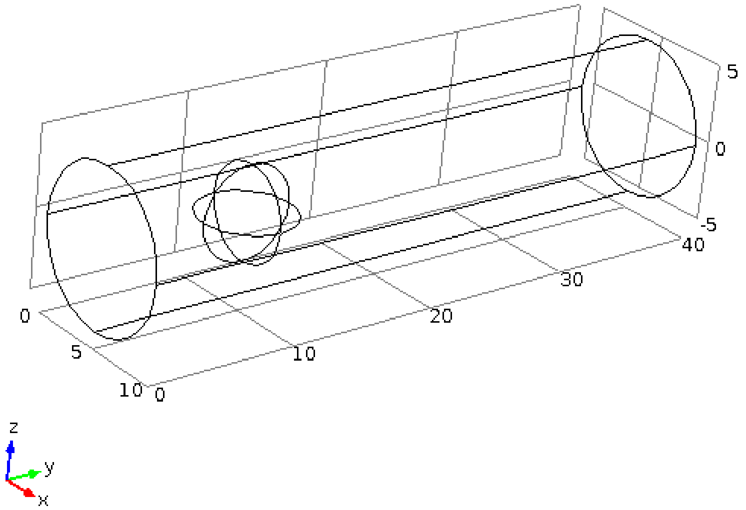
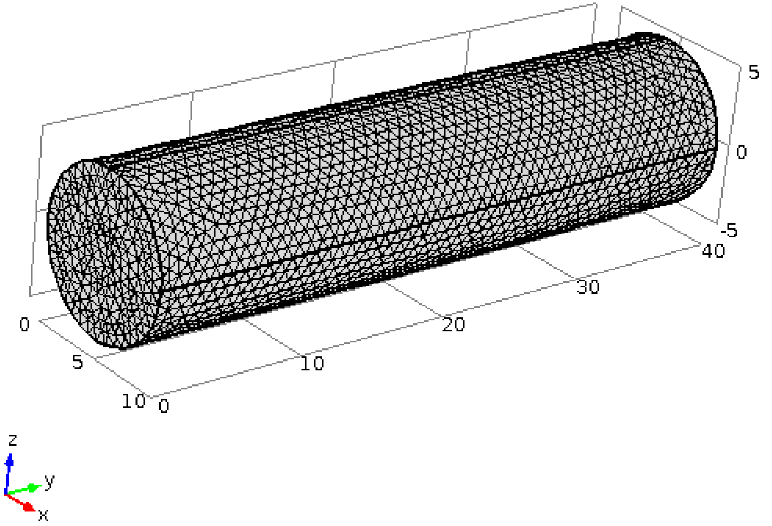
Numerical Model



Geometry



Meshed Model

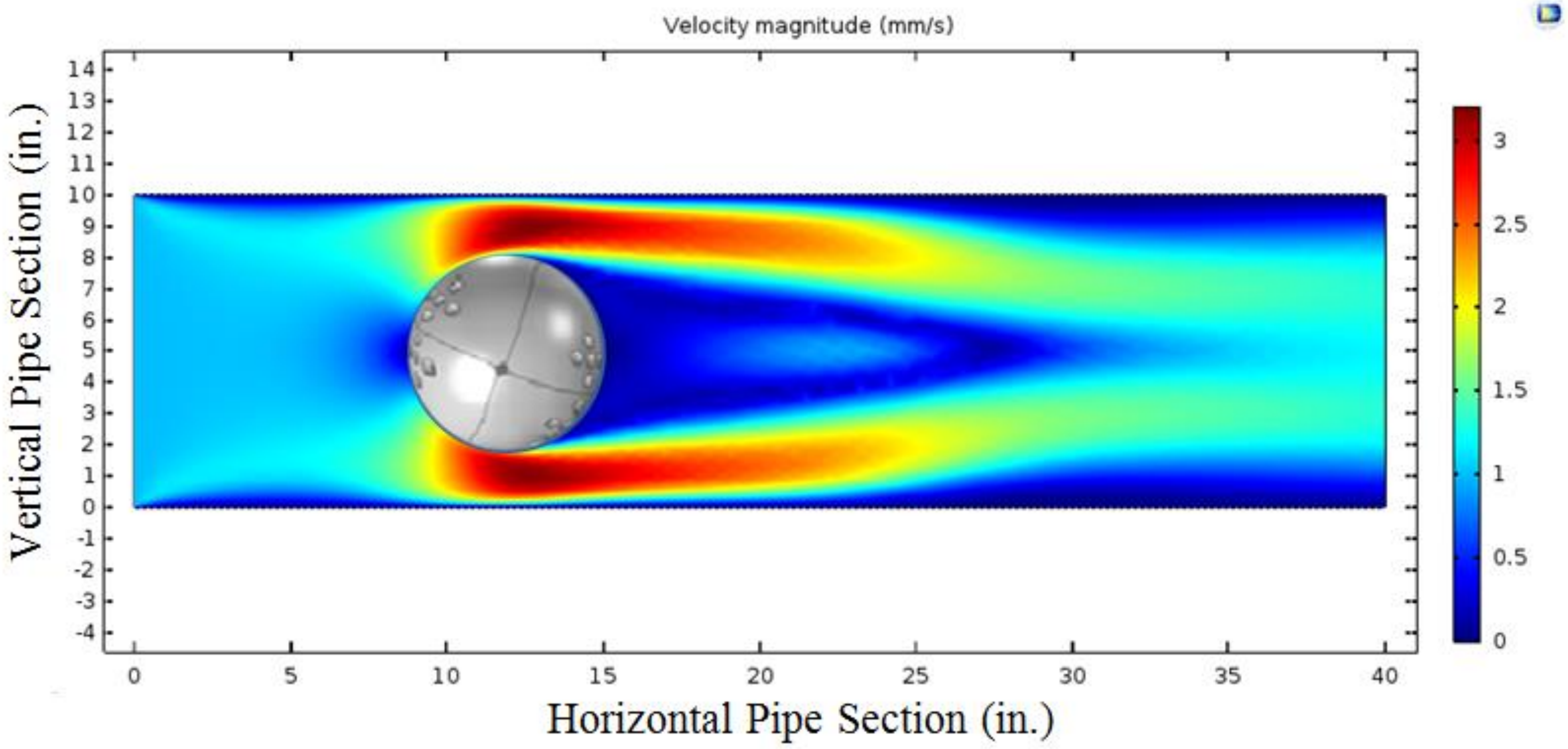
Numerical Model

Simulation Goals:

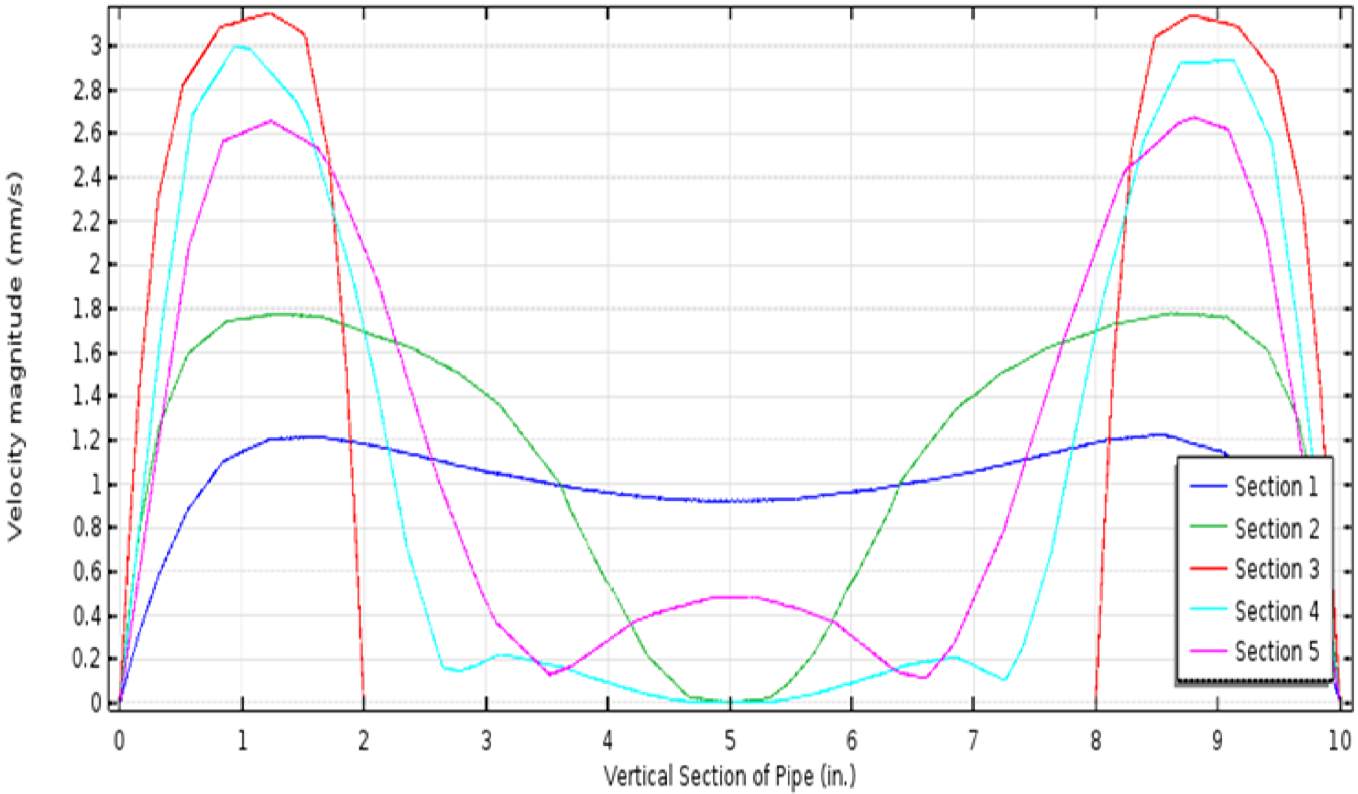
- Fluid flow around the spherical ball
- Noise level propagation inside the pipeline
- Effect of fluid type, ball material, leak location and initial leak noise on the sound pressure level propagation inside the pipe and through the ball

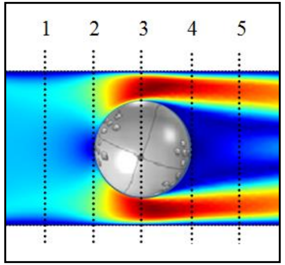
OUTLINE

Velocity Results

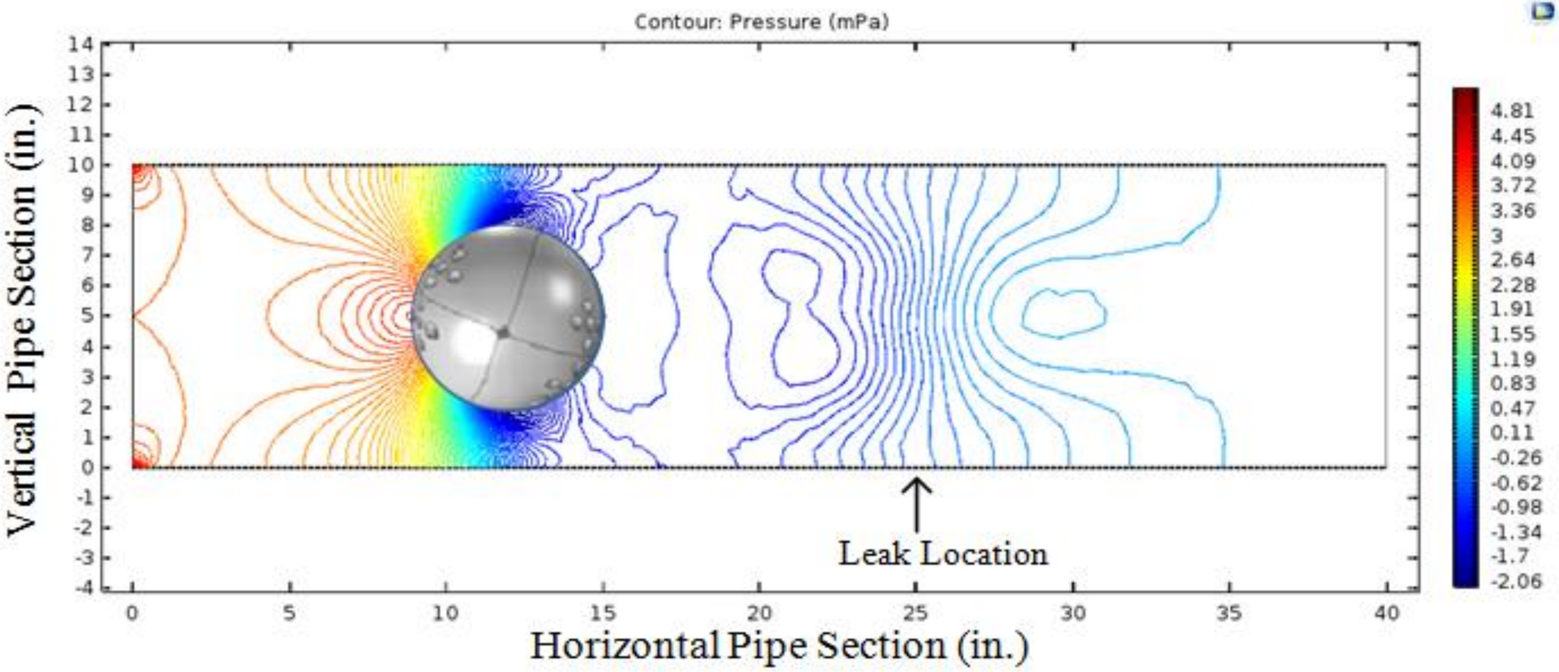


Velocity Results

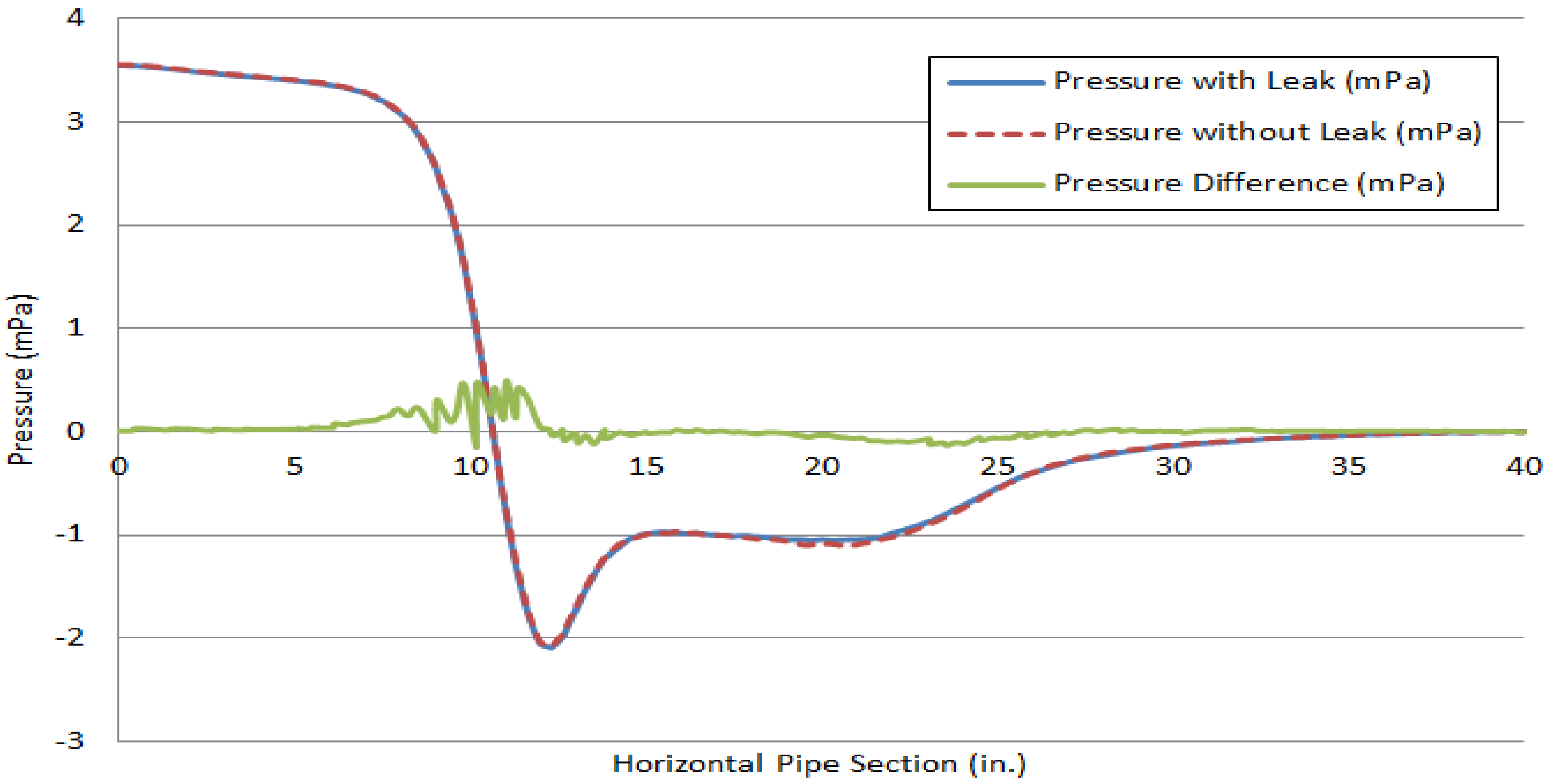




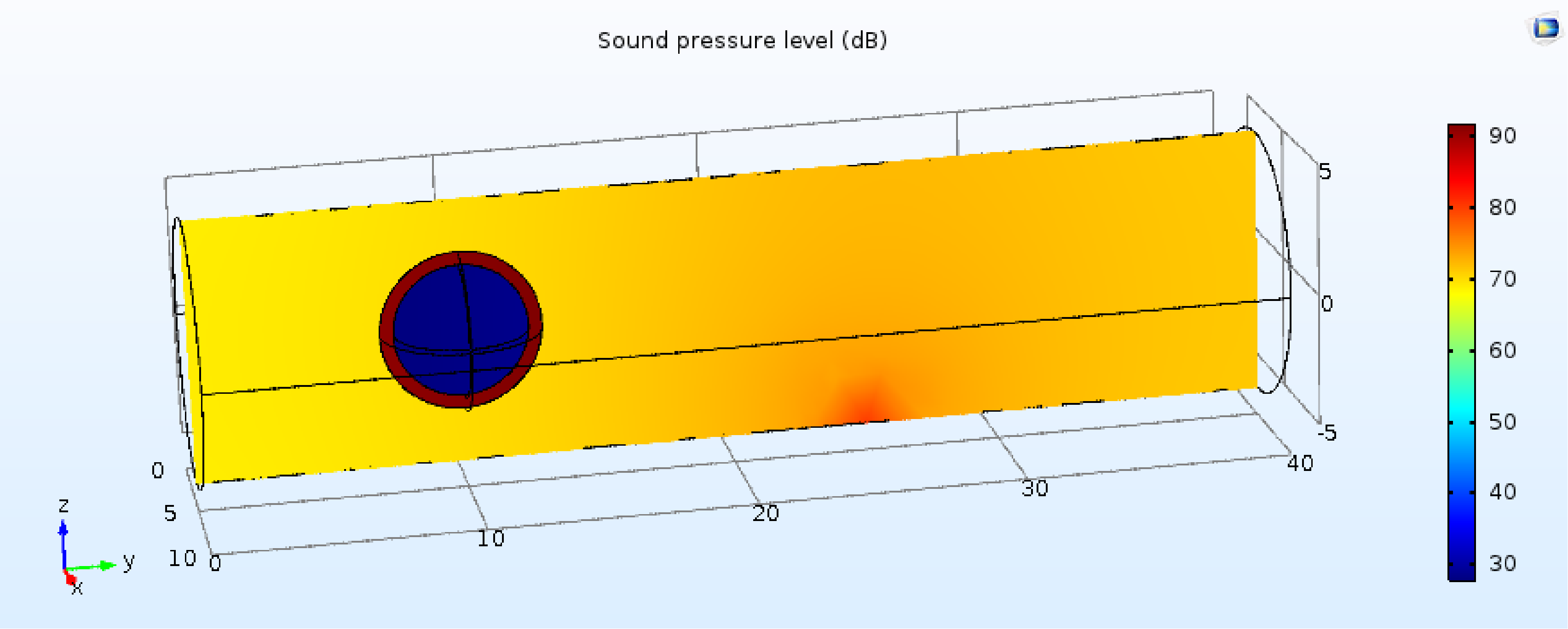
Pressure Results



Pressure Results



Sound Pressure Level Propagation



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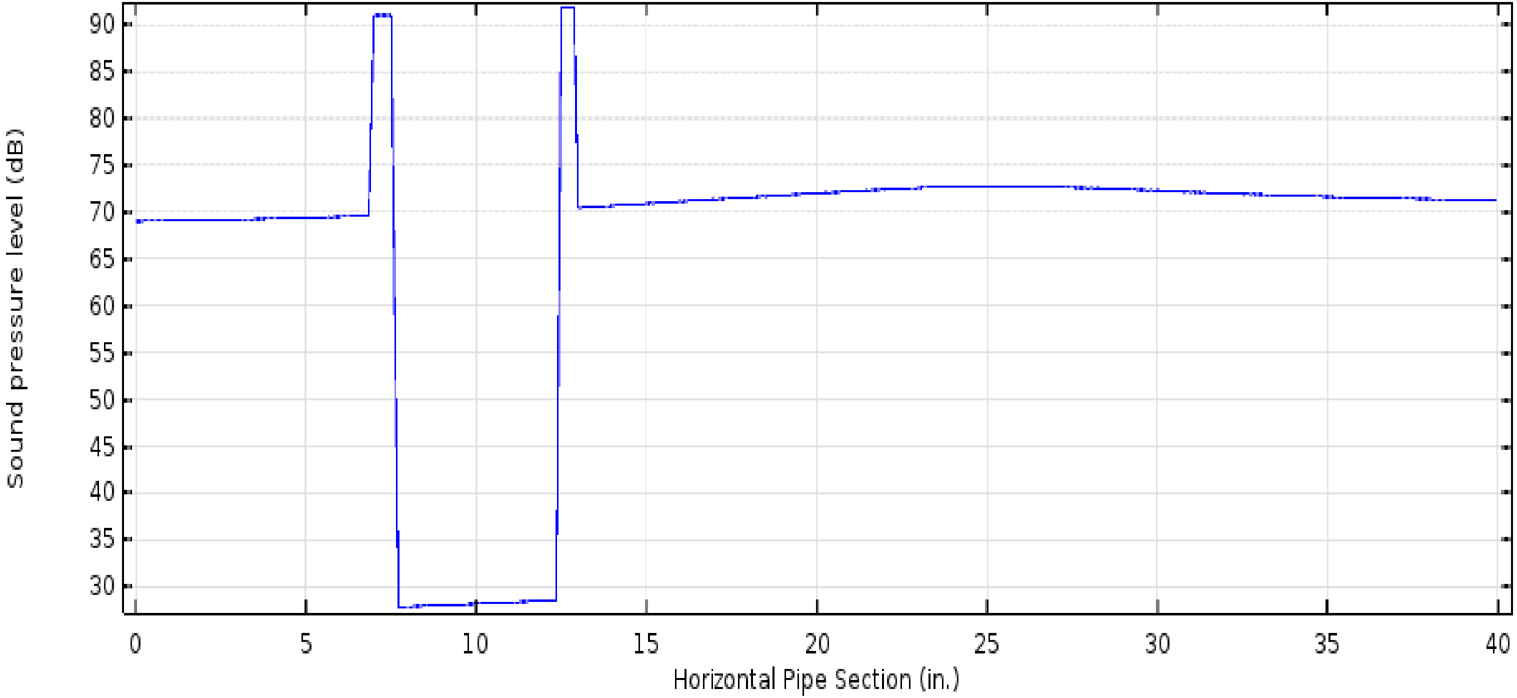

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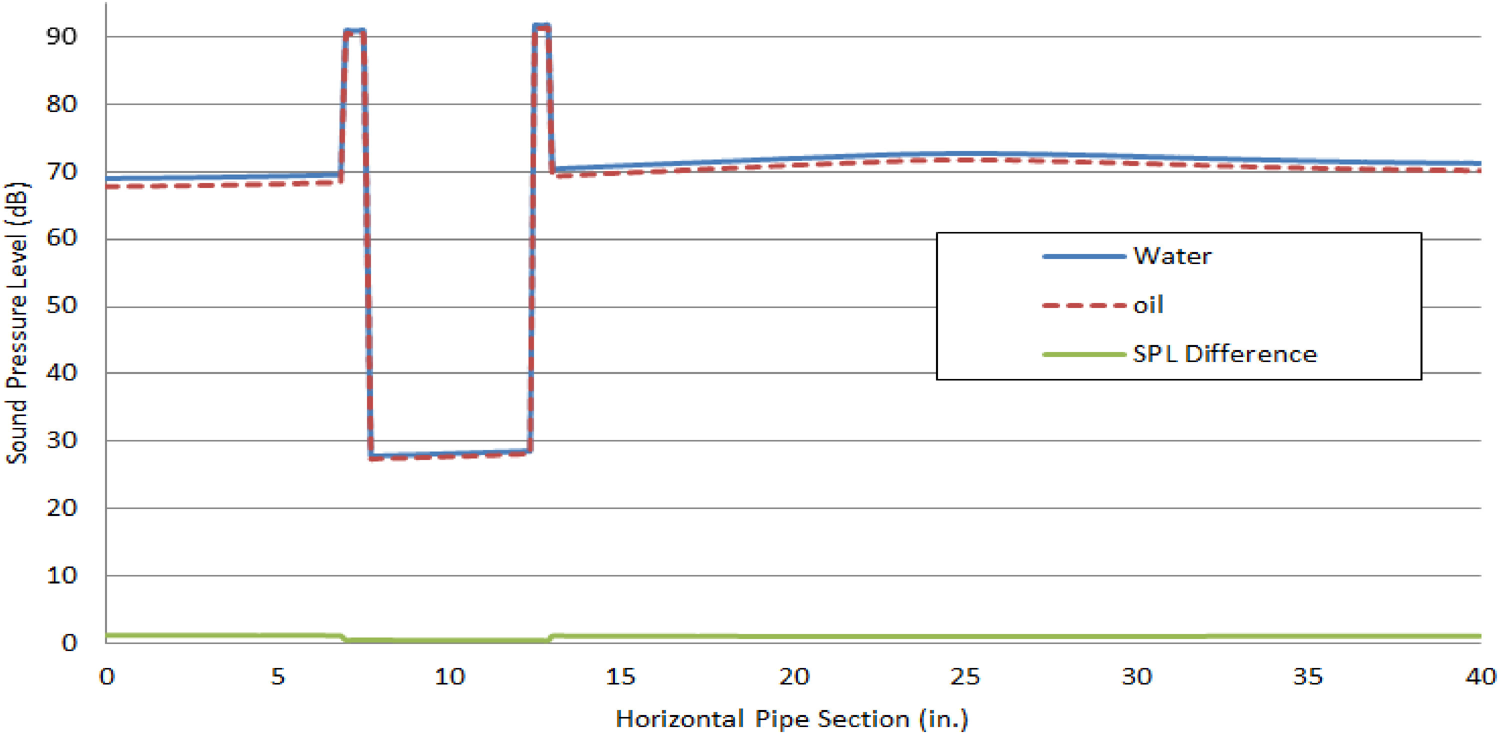
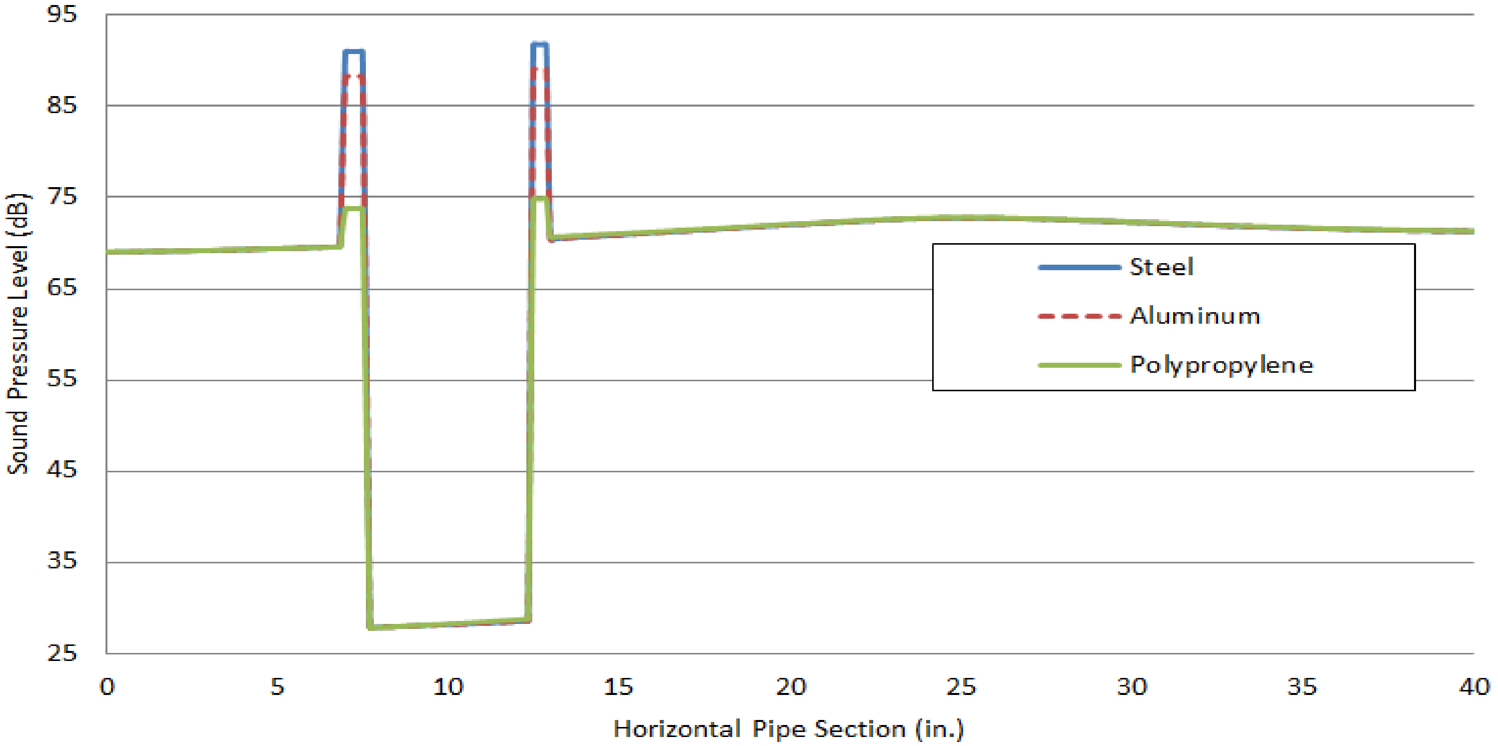
Effect of Fluid Type



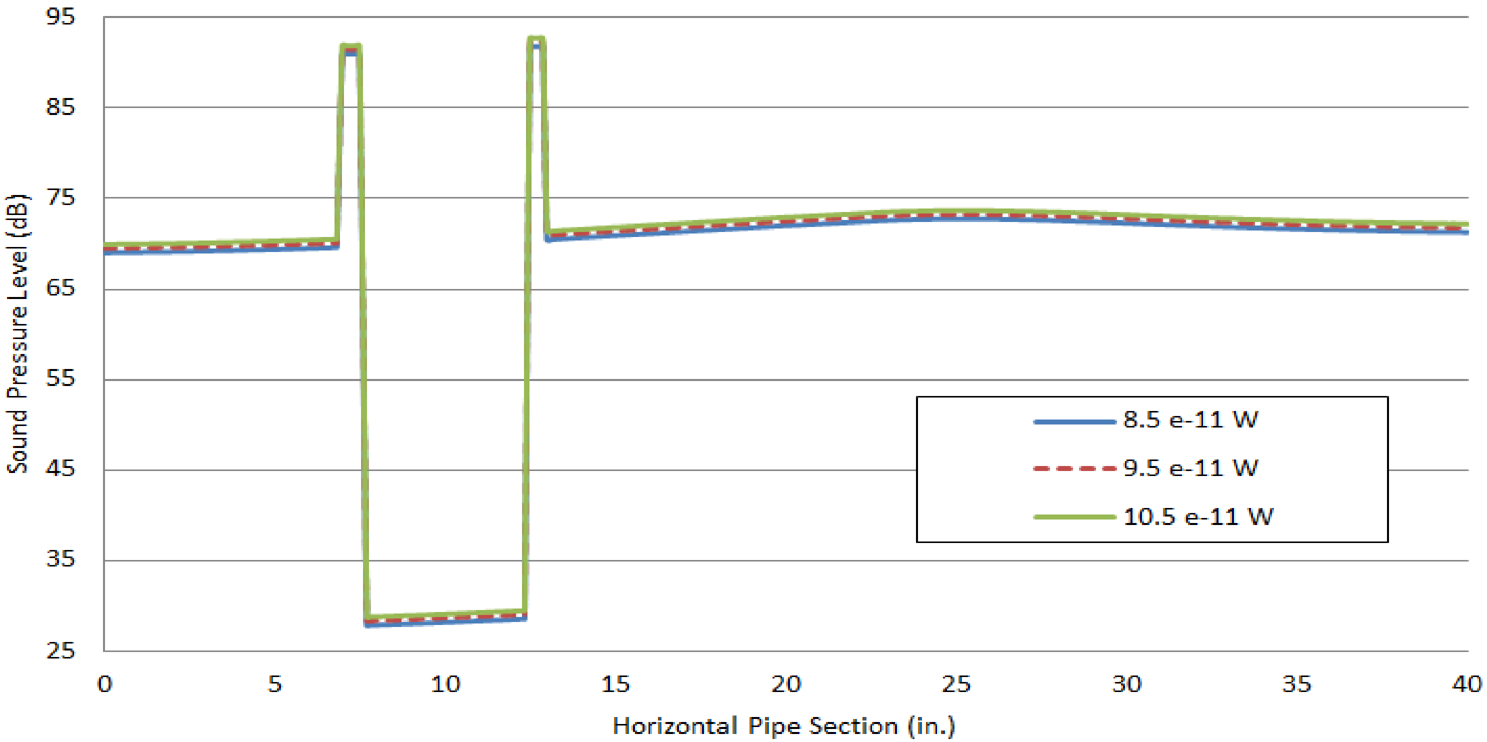
Effect of ± 1.2 dB on the sound pressure level

Effect of Ball Material



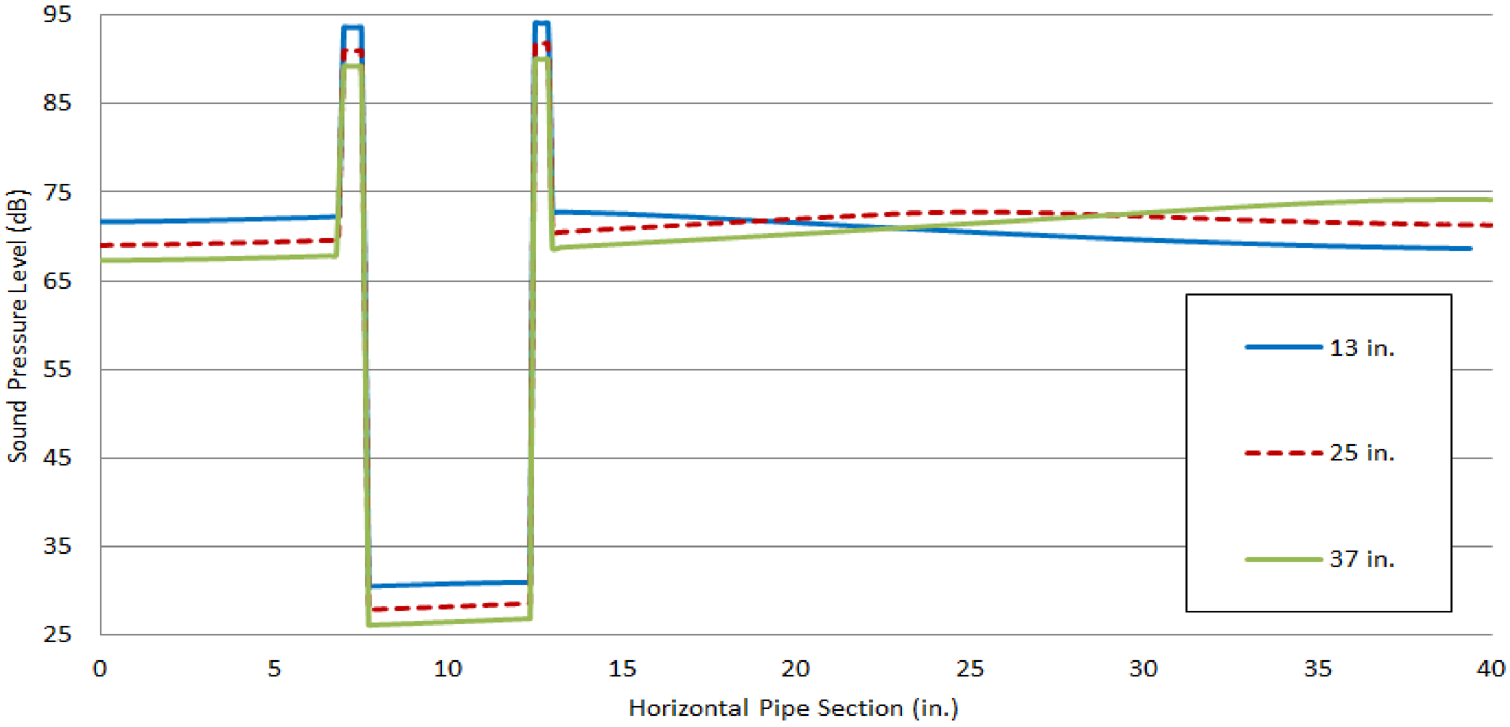
Effect of ± 17.2 dB on the sound pressure level

Effect of Initial Leak Noise Power



Effect of ± 0.48 dB per 1e-11 on the sound pressure level

Effect of Leak Location



Effect of ± 23.6 dB per 1 ft. on the sound pressure level

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Conclusions

- The fluid type has an effect of ± 1.2 dB on the sound pressure level
- The ball outer layer material has an effect of ± 17.2 dB
- The leak noise has an effect of ± 0.48 dB per 1e-11 W
- The leak location has an effect of ± 23.6 dB per foot

→ Calibrate the control system of the ball connected to the acoustic sensors

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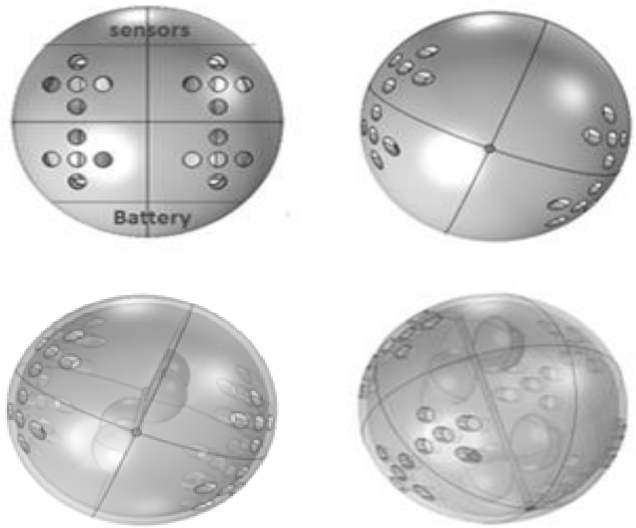
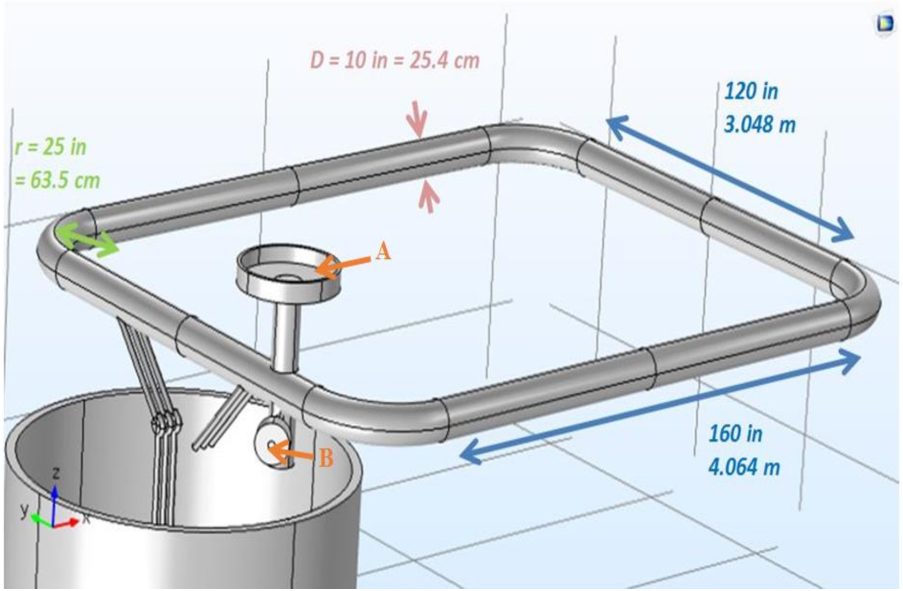
Future Work

- Design the Smart Ball
- Real time data
- Build a prototype
- Closed flow loop





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Thank you

Any Questions?

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