Infrasound Isolation Chamber for Improved Sensor Calibration

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Introduction

Infrasound isolation chambers are used to isolate sensors from ambient conditions in order to perform calibrations of the sensors being evaluated. Calibrations are typically performed on sensors to be deployed within a monitoring station. Calibrations identifying that a sensor meets performance requirements are necessary before a station can be certified for inclusion within the International Monitoring System (IMS) of the Comprehensive Nuclear-Test-Ban Treaty (CTBT). Infrasound isolation chambers are able to attenuate variations in ambient pressure and temperature that may otherwise affect the outcome of a sensor calibration. Recent advances in infrasound chamber design have improved the isolation through the use of sturdier materials and provided a large volume for evaluating more sensors simultaneously. Infrasound sensor designs have been observed to have performance that is variable at different elevations. In response to this, researchers at Sandia National Laboratories (SNL) have been developing improvements that will allow a chamber to be pressurized or evacuated in order to replicate the static pressure observed at different elevations. In addition, developments are underway to control the temperature within the chamber to improve traceability and to generate higher dynamic pressures so as to evaluate sensors over a greater amplitude range.

Chamber Construction

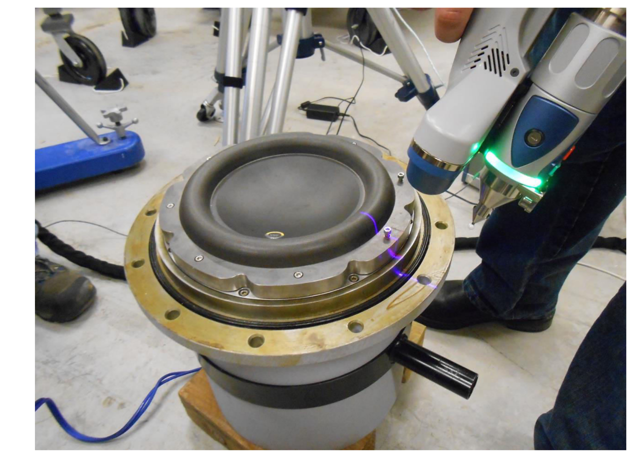
- Chamber designed and built for SNL by National Center for Physical Acoustics (NCPA) at the University of Mississippi
- Approximately 2 m in length x 1 m in diameter
- 2.5 cm thick steel, weighs over 1800 kg.
- Initial interior volume estimate of 1400 L.
- Accommodates variable frequency / variable amplitude pressure drivers on either end.
- Targeting evaluation frequency range of 0.01 – 10 Hz.

Volumetric Uncertainty

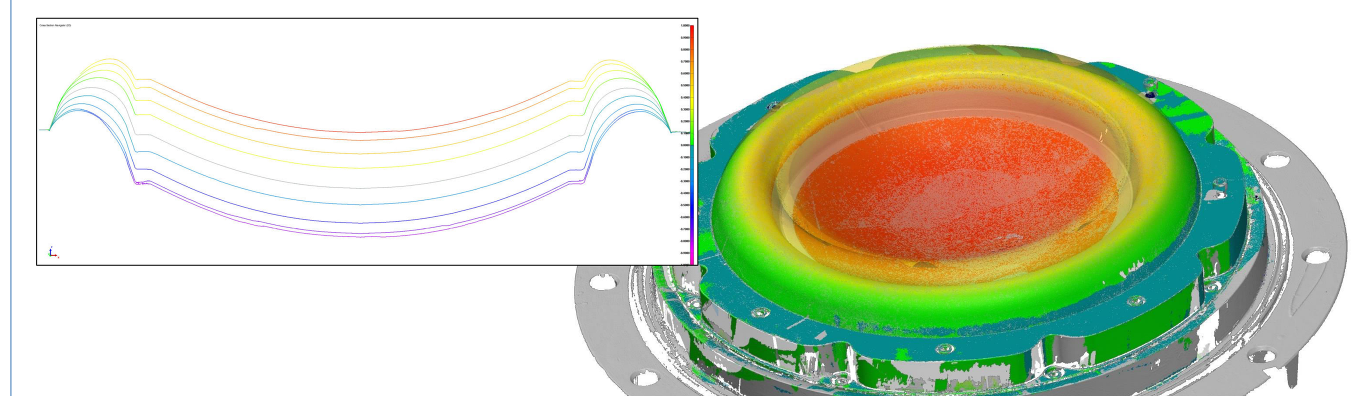
- SNL Primary Standards Laboratory calibrated the interior volume of the chamber and speaker.
- Measurements made using 3D laser scanning tools. Generated 3D models of all components to support future analysis and modelling.

- Chamber volume is:
  - Front Hemisphere: 311 – 317 L
  - Body: 832 – 844 L
  - Back Hemisphere: 262 – 271 L
  - Total: 1418.7 L, +/- 14 L

  - Grate: - 7.2 L
  - Need to account for other objects (sensors, cables, patch panels, …)

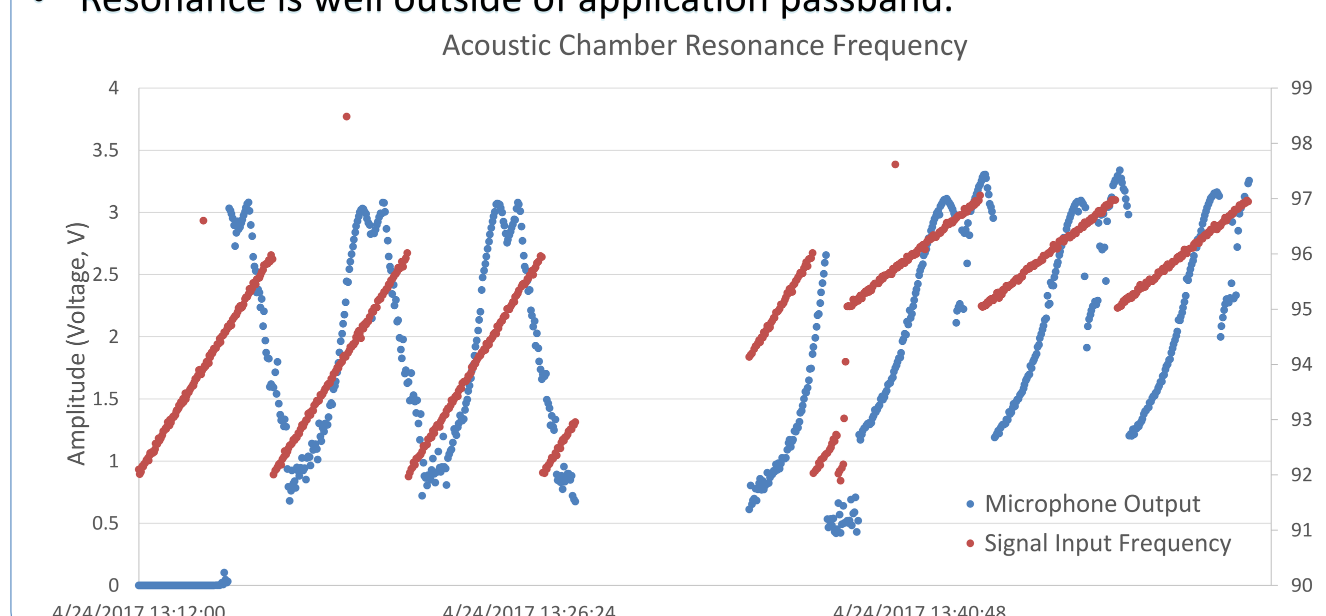


Measured speaker displacement across its range of motion. It was found to have minimal change in radius through its range of motion.



Measured mechanical resonance of structure, which is a function of volume:
- Empty: 96.57 Hz
- Occupied with sensors: 94.97 Hz

- 1.5 Hz shift in resonance due to change in volume.
- Resonance is well outside of application passband.

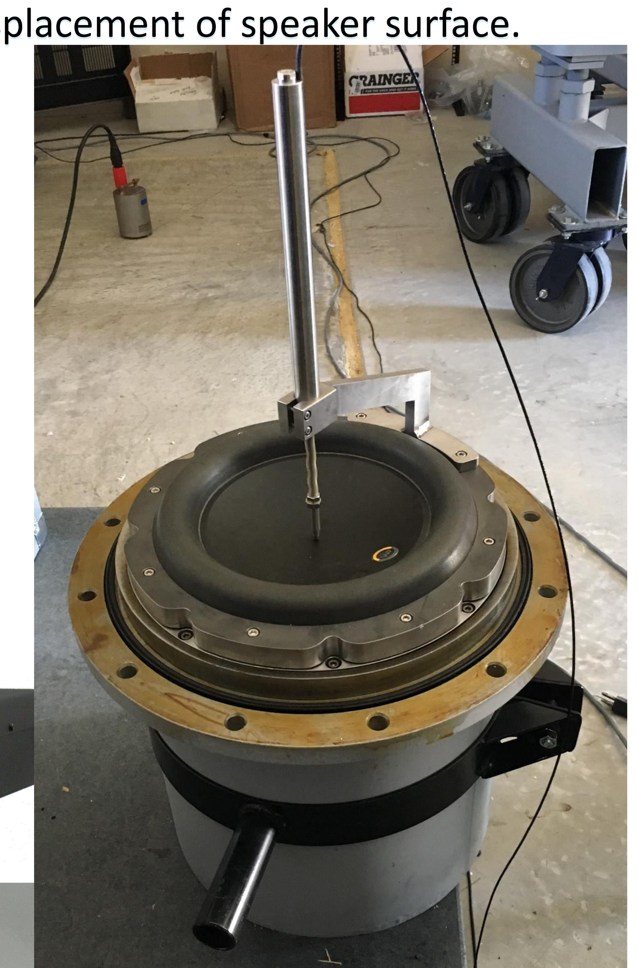


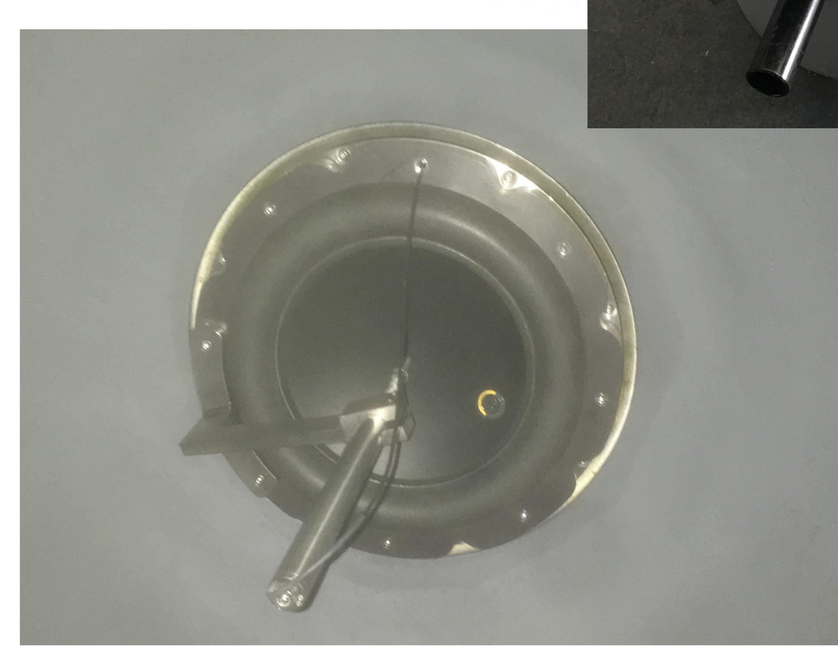
Static Pressure Control

- Test site is at approximately 1830 meters elevation / 81 kPa (+/- 1 kPa).
- Elevation has been observed to have an affect on some infrasound sensors.
- Ability to change static pressure within the chamber interior to sea level (+20 kPa / +3 PSI) or evacuate to 10 km elevation (-75 kPa / -11 PSI)
- Manifolds and controls in place to ensure safe operation.
- Test pressurizations have been performed, now identifying leaks.

Pressure Driver

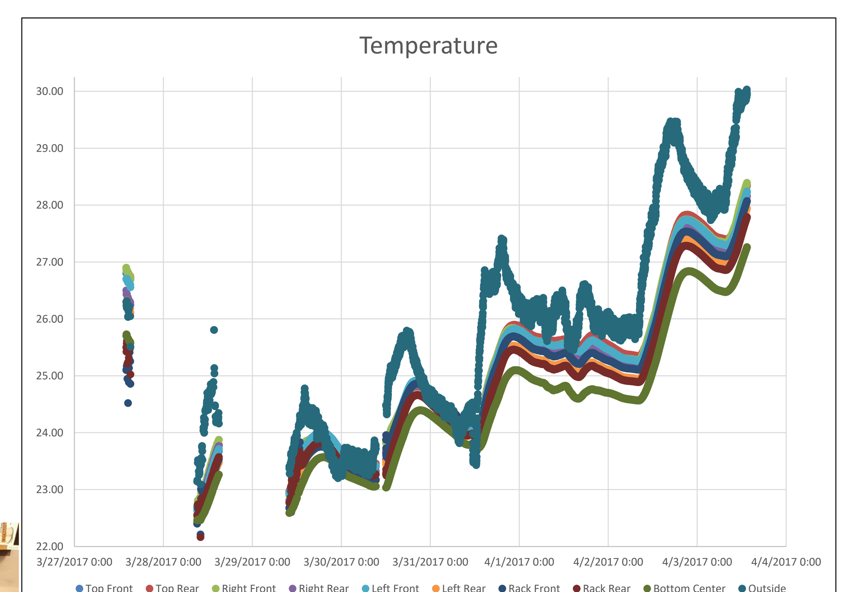
- 750 W continuous power, 10" reference speaker with a rigid cone.
- 0.0386 m^2 area x 0.023 m displacement = 0.9 L
- ~ 50 Pa of peak pressure
- 1 kW DC-coupled amplifier to power the speaker
- LVDT to measure and record displacement of speaker surface.

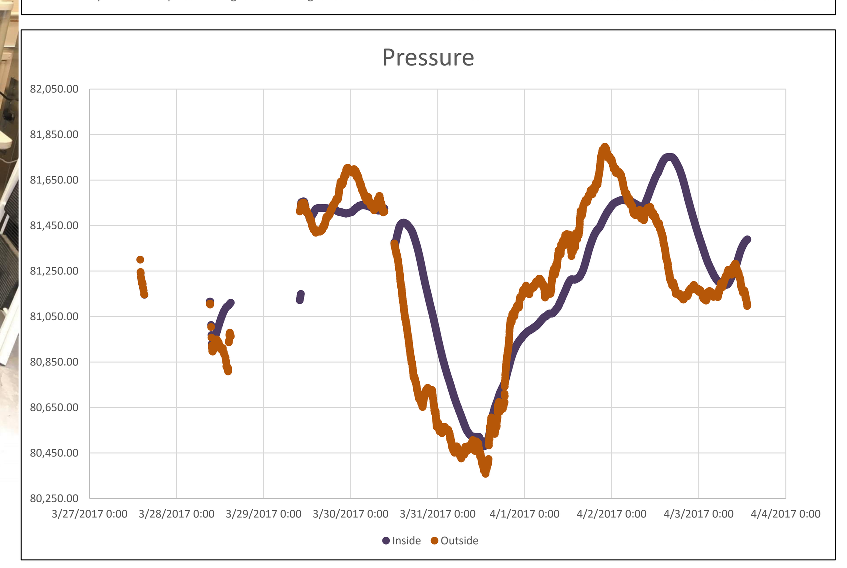




Thermal Control

- Mass to dampen temperature swings (~ 8 hr time constant without insulation)
- Calibrated thermistors mounted across interior of chamber to monitor thermal gradients horizontally and vertically
- Measured vertical thermal gradient of < 1 C
- Heating pads on top and bottom of chamber to regulate temperate at a specific set point (typically 23 C) to within +/- 0.25 C. Also able to maintain a positive temperature gradient in order to suppress convective currents.
- Wrapped in insulation to reduce heat transfer and stabilize temperature.





Conclusion

- Implemented controls for isolating ambient temperature and pressure variations.
- Added the ability to regulate static temperature and pressure so as to be able to test at standard conditions (100 kPa, 23 C) and across ranges.
- Developed a pressure driver capable of 50+ Pa input amplitudes.

Future Work

- Identify and correct minor air leaks around seals.
- Validate test procedures and comparison tests against earlier infrasound chamber
- Replace LVDT on the pressure driver with a non-contact optical measurement.
- Complete second pressure driver to support 2-tone tests.
- Goal is to work towards a calibrated transfer function between driver displacement and observable pressure in the interior.
- Perform full-wave modelling of the interior using the developed 3D models.

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