



NASA Space Environments Complex Vacuum Equipment Room Sound Mitigation

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HX5 Sierra

37th AIAA WGDSS

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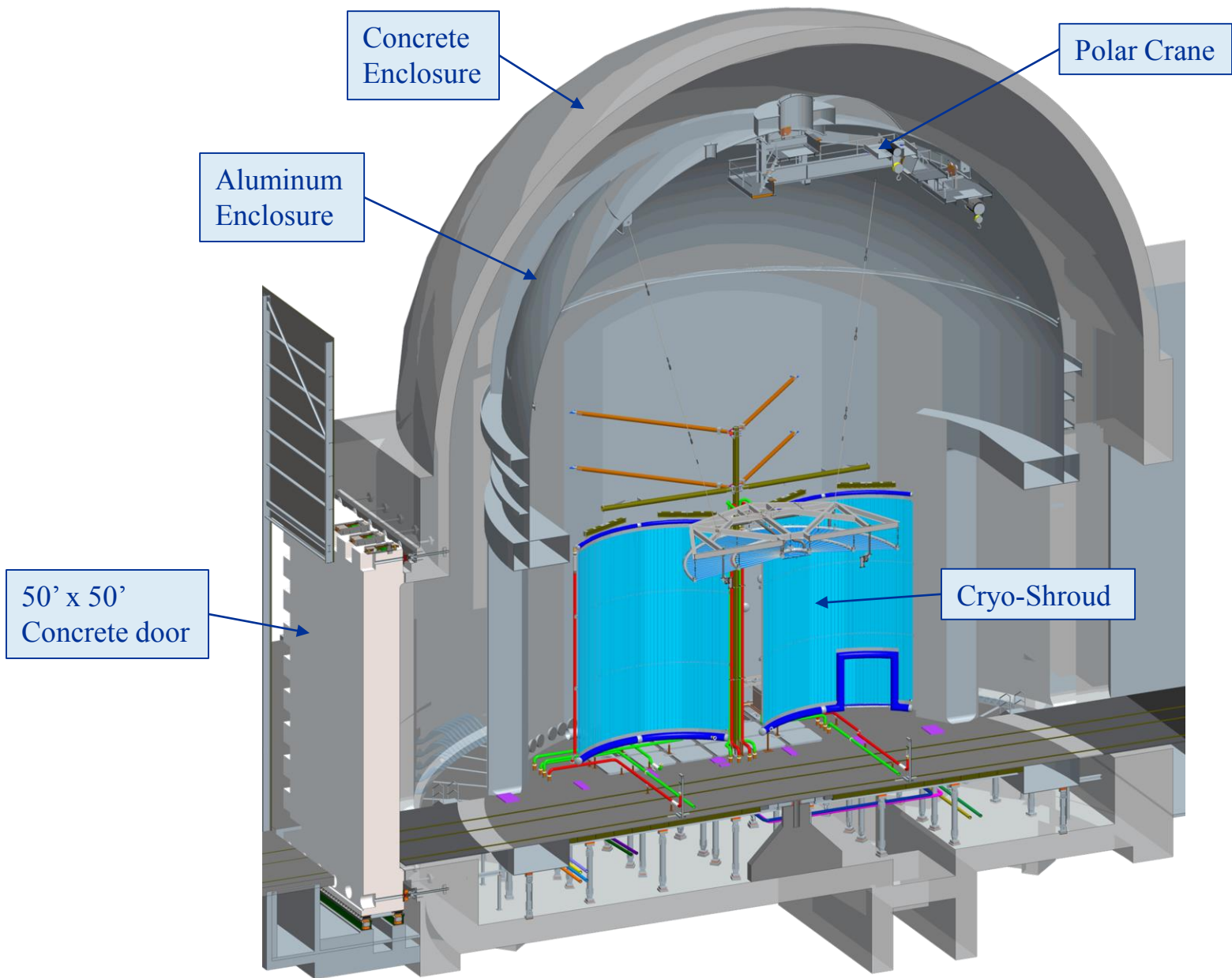
Presentation Outline

- Introduction to the World's largest Vacuum Chamber
- High noise levels in vacuum equipment room
 - Introduction to OSHA
 - A-Weighted vs Unweighted
 - Findings from dosimeters
 - Possible Solutions
 - Installation of Baffles/Panels
 - Results
 - Summary/Go-forward plan



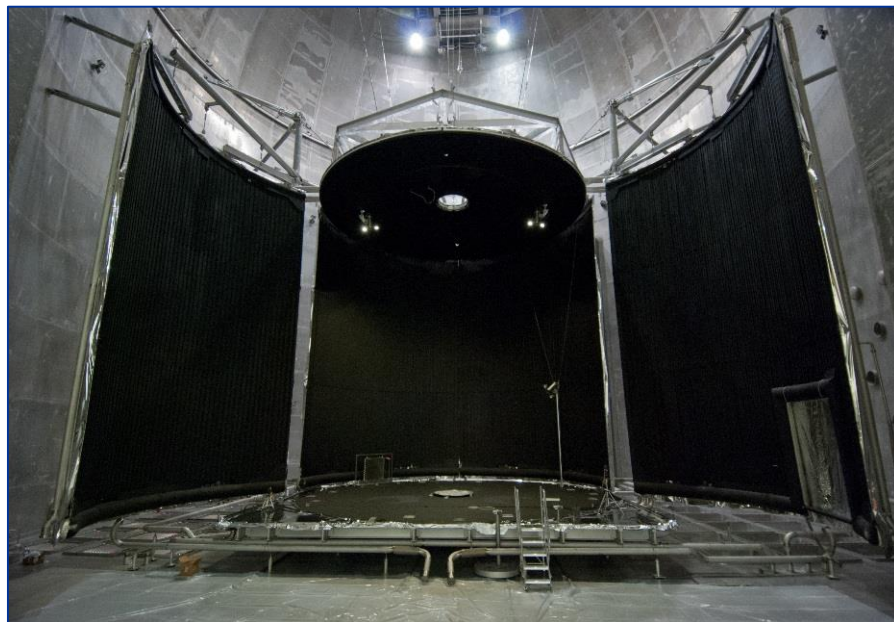
Space Environments Complex (SEC)





SEC Thermal Vacuum Chamber

- 122 feet (37 m) tall and 100 feet (30 m) diameter
- The inner and outer chambers make up a volume of 800,000 ft³ (60 tons of air)
- Cryo-shroud is a 40 feet (12.2 m) diameter cylinder by 40 feet (12.2 m) tall
- Temperatures range from 175°F to -250°F



How we get to high vacuum

Roughing system

- 10 Rotary Lobe Blowers
- 6 Rotary Vane mechanical pumps

High-vacuum system

- 5 turbo-molecular pumps
- 10 scavenger plates
- 10 cryogenic pumps



By utilizing a combination of these systems, we can achieve high vacuum (approx. $10E-6$ torr) in less than 8 hrs



Occupational Safety and Health Administration

- OSHA Technical Manual, section III, chapter 5
 - Based on OSHA and consensus standards

Under OSHA standards, workers are not permitted to be exposed to an 8-hour time weighted SPL average (TWA) equal to or greater than 90 dBA.

$$T = \frac{8}{2^{\frac{L-90}{5}}}$$

Where T is the permissible duration (in hours) and L is the measured sound pressure level (in dBA).

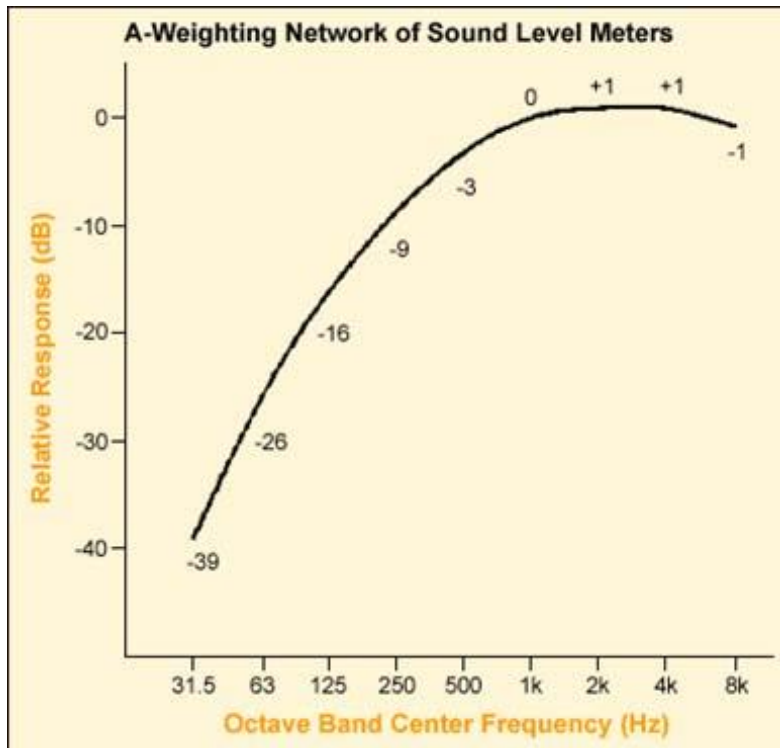
Permissible Duration (Hours per Day)	Sound Level (dBA, Slow Response)
16	85
8	90
4	95
2	100
1½	102
1	105
½	110
¼ or less	115

Source: https://www.osha.gov/dts/osta/otm/new_noise



A-Weighted vs Unweighted scales

- A-weighting is said to best fit the frequency response of the human ear.
- Unweighted (Z-weighted) measurement scale that does not apply any attenuation or weighting to any frequency.



Octave Band Center Frequency (Hz)	Example L_p (dB)	A-Scale Correction Factor (dB) *	Corrected Values (dB)**
31.5	94	-39	55
63	95	-26	69
125	92	-16	76
250	95	-9	86
500	97	-3	94
1,000	97	0	97
2,000	102	+1	103
4,000	97	+1	98
8,000	92	-1	91

* Look up on A-weighted network chart for each value L_p .

** L_p corrected to the A-scale = L_i .

Source: https://www.osha.gov/dts/osta/otm/new_noise

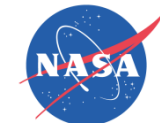


First stage blowers

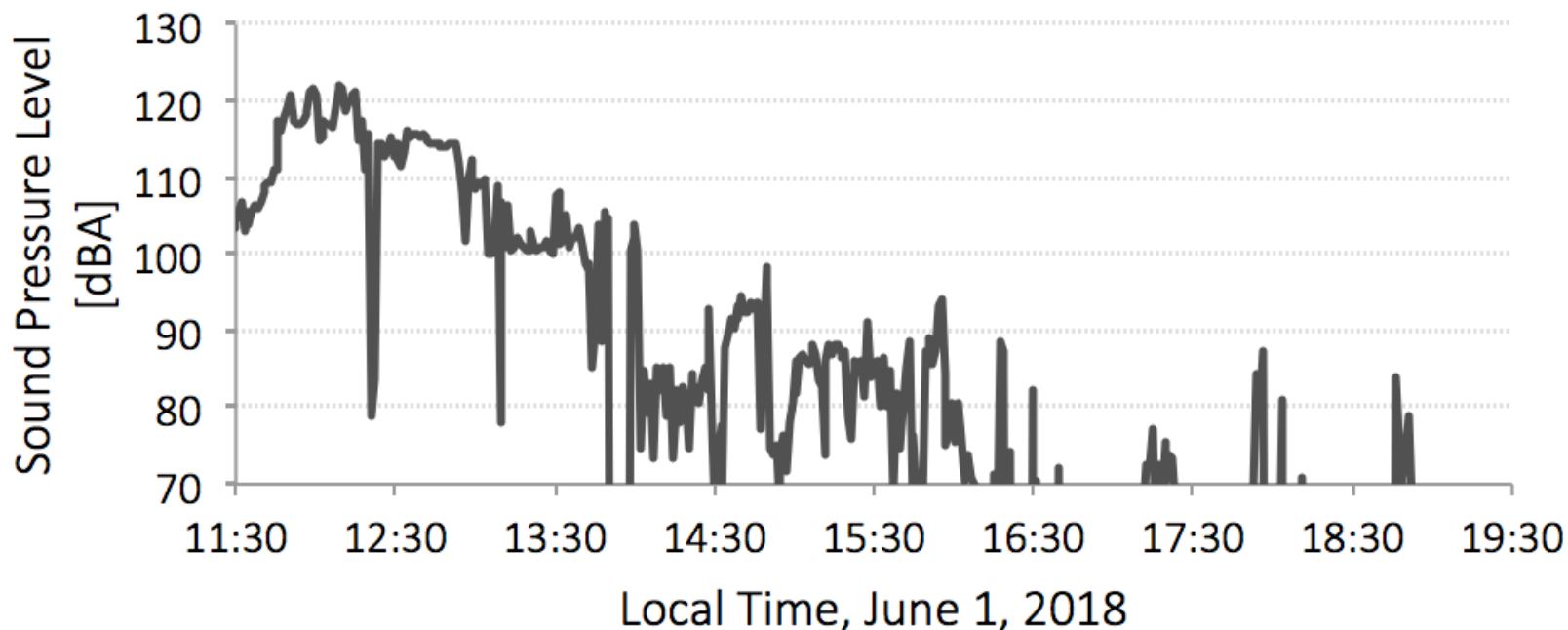


Stages 2, 3, and 4 blowers





Findings from personnel dosimeters



TWA = 110.5 dBA

Under OSHA standards,
personnel would be limited to this
environment for less than 30 min

Possible Solutions

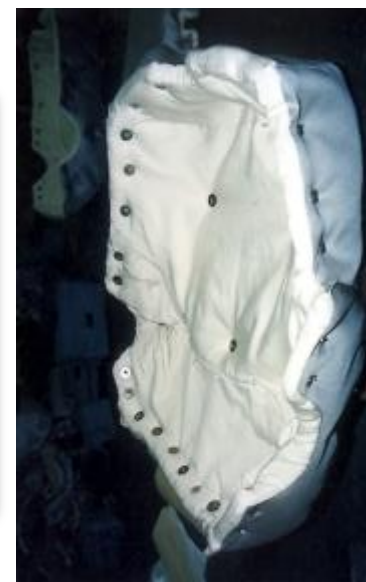
Sound Absorption baffles/panels

- Advantage: reduces noise from all noise sources
- Disadvantage: practical benefit limited to ~ 5 dBA



Path noise control

- Advantage: much higher sound absorption
- Disadvantage: External lagging only option and would obstruct technician's view of blower





Installation of Acoustical Baffles/Panels

- MBI Cloud-Lite Acoustical Baffles
 - Fiberglass core
 - PVC film finish
 - Incombustible Class A per ASTM E84 25/0/50
- MBI Spectrum Acoustical Panels
 - Fiberglass core
 - PVC film finish
 - Incombustible Class A per ASTM E84 25/0/50

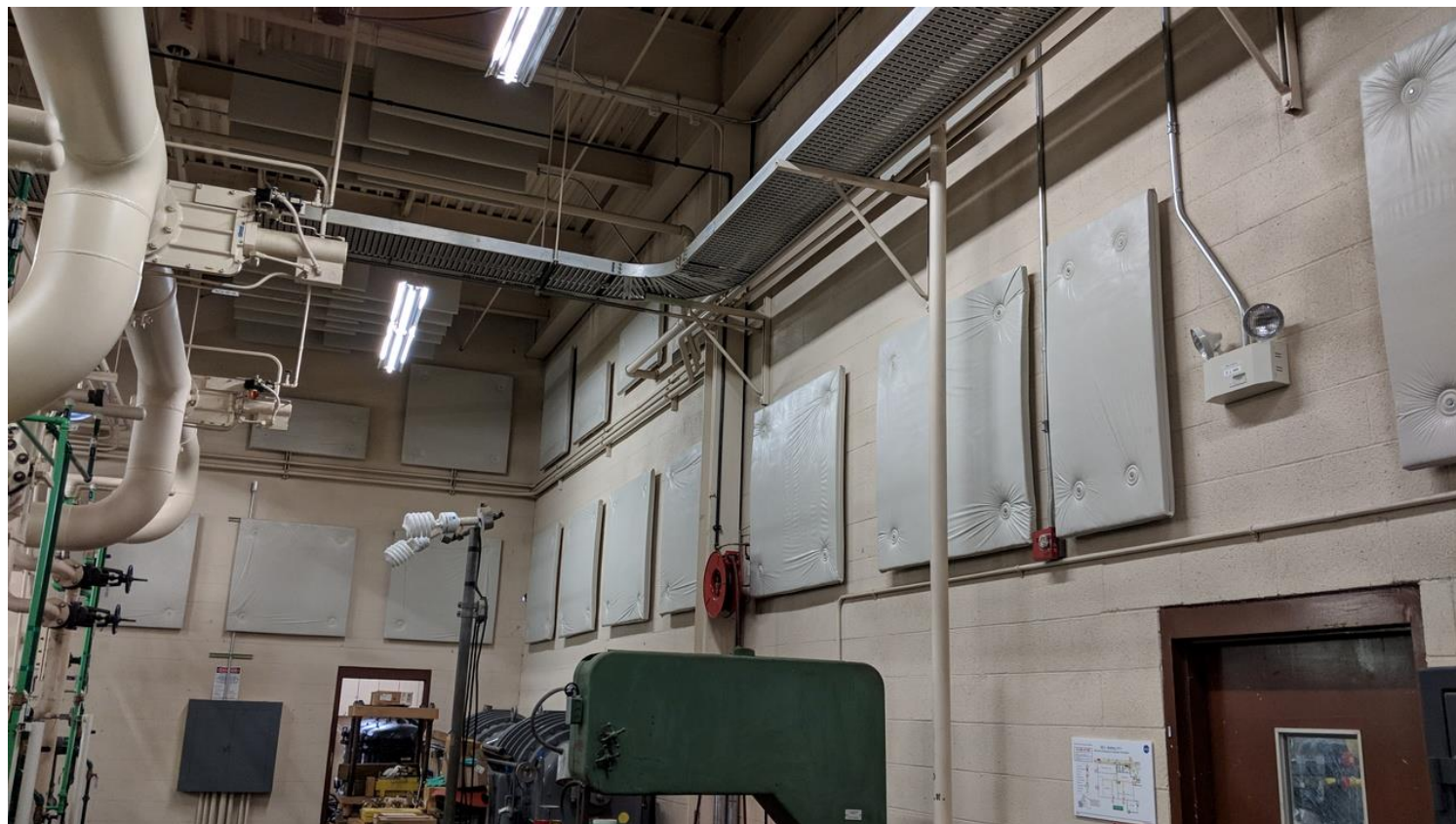
This material typically used in stadiums, gymnasiums, and factories. Benefits are low cost and high absorption

Installation of Acoustical Baffles/Panels

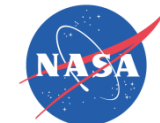


Installed a total of 320 (4' x 2') baffles

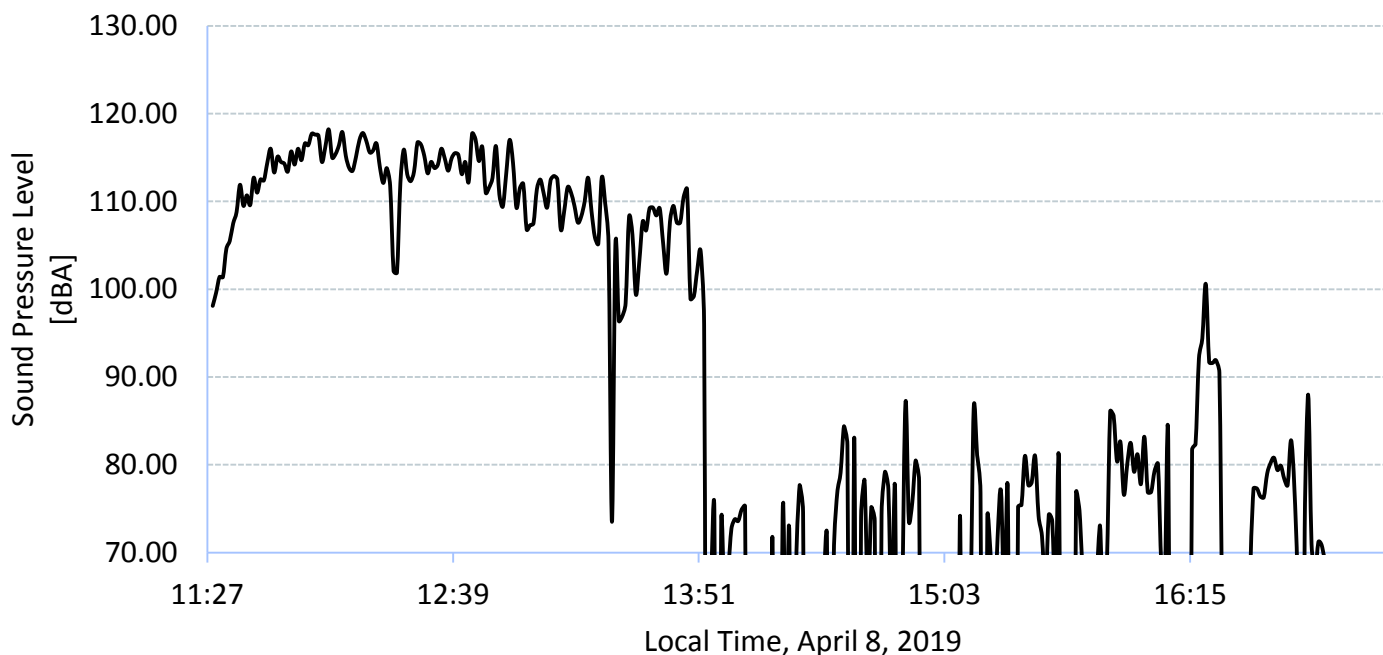
Installation of Acoustical Baffles/Panels



Installed a total of 640 sqft of wall panels



Results from personnel dosimeters (post-mitigation)

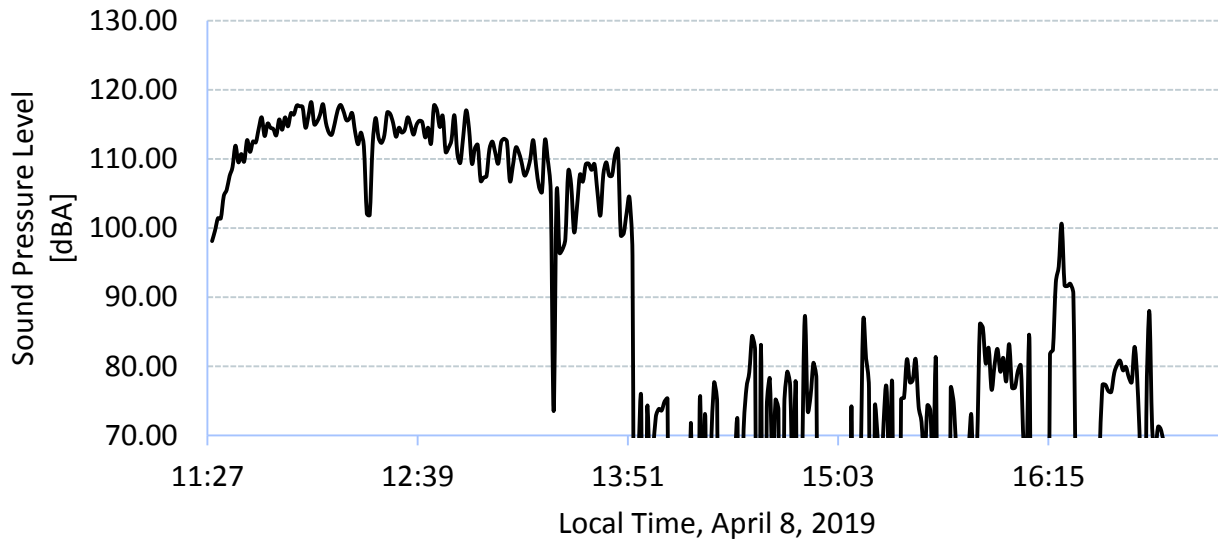
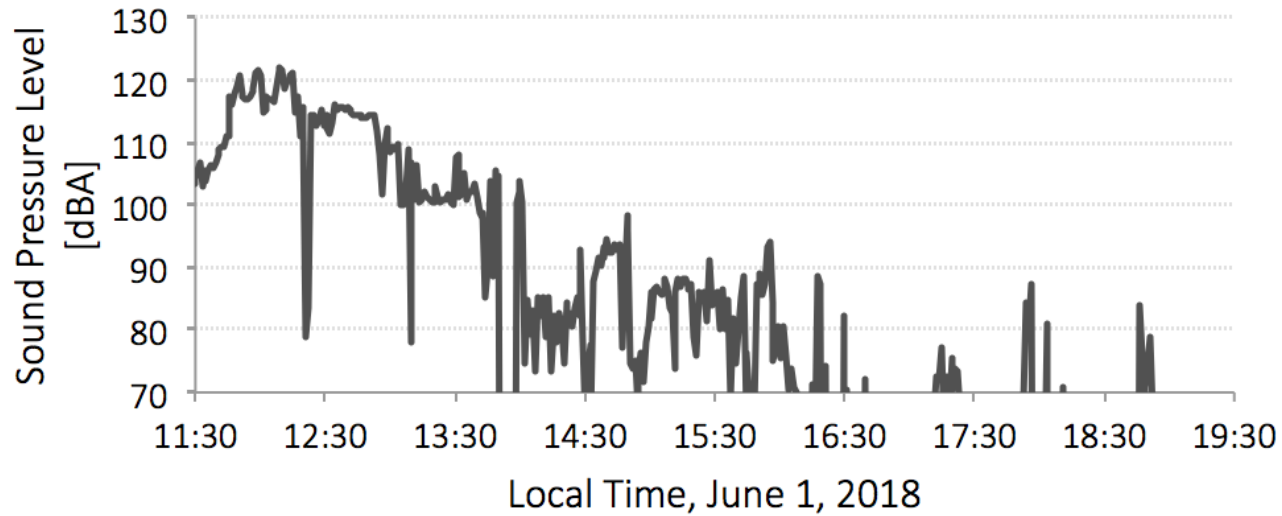


TWA = 107.5 dBA

3 dB reduction from prior conditions -- Allowable exposure increased to nearly an hour



SPL Comparison





Summary

Noise reduction demonstrated in Vacuum equipment Room with acoustical panels/baffles

- Reduced number of workers needed from 5 to 3
- Additional controls are needed, as currently only 2 workers available and not all of the exposure can be controlled through reducing reflections
 - Lagging of equipment components in Vac Room (need frequency spectrum data on components)
 - 3 worker rotation
 - Long-term plan of remote monitoring without 100% worker roving



One last note....

- Setup Ono Sokki CF-3600 4-channel analyzer in vacuum equipment room for data acquisition
- Upon startup of our blowers, the system immediately crashed. Our current theory is that the high noise levels compromised the on-board hard-drive of the system.
- We plan on attempting data collection again for our certification test pump down (approximately June 3rd)
- This time, we will have the Ono Sokki CF-3600 located in our sound proof room instead

One last note....





Questions?