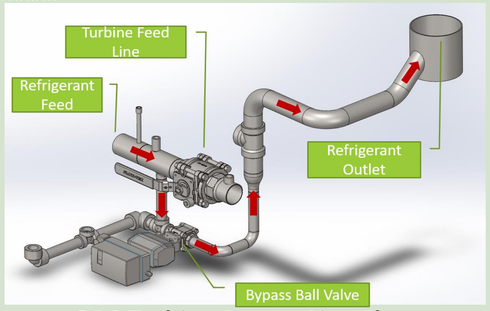
Noise Mitigation in an Organic Rankine Cycle (ORC) Turbine Bypass Line

Team 14: Chad Adams, Austin Houser, Luis Figueroa, William Mauch
Verdicorp Sponsors: Bala Datla, Cory Nelson **Academic Advisor:** Dr. Louis Cattafesta

Aim: The measurement, analysis, and manufacture of a passive noise mitigation solution for an ORC bypass line

Background

When vaporized refrigerant 245fa is diverted to the bypass line during startup and shutoff of the ORC system, an undesirable amount of noise is generated that poses heath concerns for employees and a nuisance near residential areas. The ORC test bed is housed within a 23.5’ x 8’ x 8.5’ shipping container limiting measurement techniques while increasing the reverberation of the noise.



ORC Turbine Bypass Line Flow

Motivation

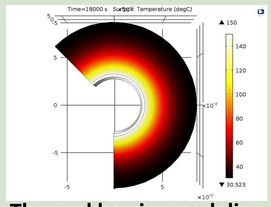
- Noise induced hearing loss (NIHL) accounts for 1 in 9 recorded work illnesses in manufacturing jobs
- Sound levels have significant impact on consumer perception

Constraints

- Bypass line operates at 150 ˚C
- Limited to 3’’ of spacing around pipes
- Walls and floors of the shipping container test bed are restricted
- Low installation time
- Lost cost with emphasis on in-house production across ORC fleet

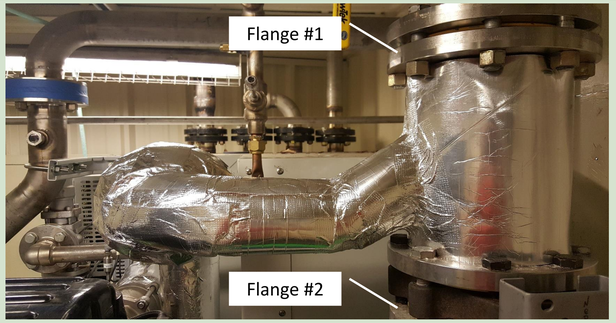
Comsol Testing

- Evaluation of various configurations of materials and thicknesses
- Near indefinite run time prior to interior reaching pipe temperature
- Guided the material collection phase



Thermal barrier modeling

Prototyping



Findings:

- Elastic cinch straps and velcro fasteners were not required for installation
- Installation Time: 12-14 Hours
- Potential acoustic leakage from outlet flanges

Concept: Acoustic Lagging

Thermal Barrier (Spun Ceramic Fiberfrax)

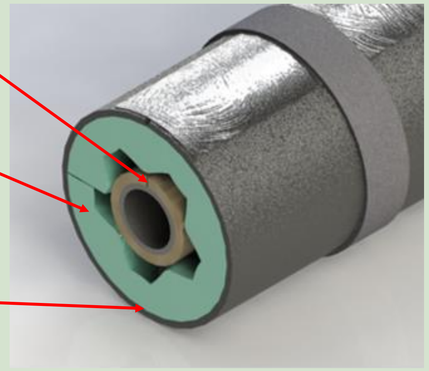
- Prevents absorption layer from melting
- Heat capacity 1130 J/KgK
- Flexible and malleable to pipe
- Thermal shock resistance

Acoustically Absorbent Layer (Open cell foam)

- Open cell foam for acoustic energy absorption
- Eggshell surface for increased surface area
- Efficient noise reduction coefficients(NRC) at high frequencies

Reflective Layer (Mass loaded Vinyl)

- High sound transmission loss (STL) values
- Effective at elevated frequencies
- Pliable for manufacturing



Pipe Lagging Concept

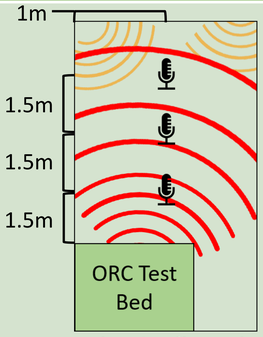
Noise Characterization

Methodology

- Reduce contamination by taking measurements 1 m from shipping container walls
- Measurement grid (inside & outside shipping container)
- Data average at each location (SPL)

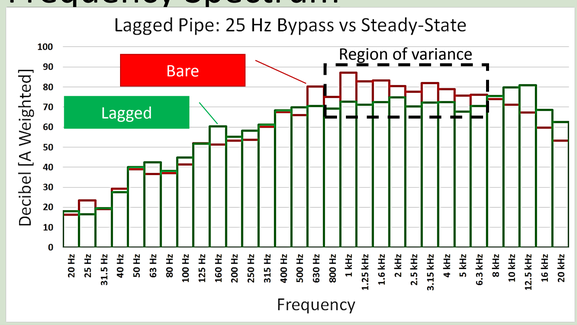
Measurements

- Sound Pressure Level (LAeq)
- Frequency Spectrum
- Sound intensity



Testing Configuration

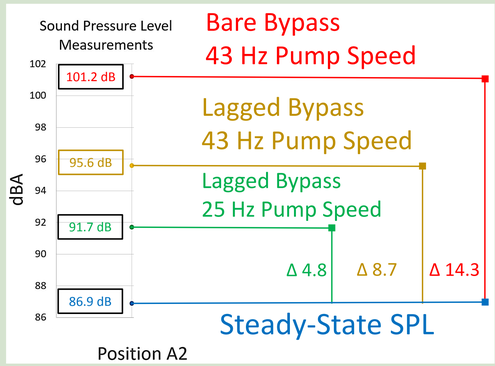
Frequency Spectrum



- Record all operating states of the system (Bypass, Steady-State, various pump speeds)
- Highest variance occurs between 1 to 6.3 kHz
- High pitch turbine whine is present in steady-state above 10kHz
- Flanges and open backplate may account for additional acoustic leakage

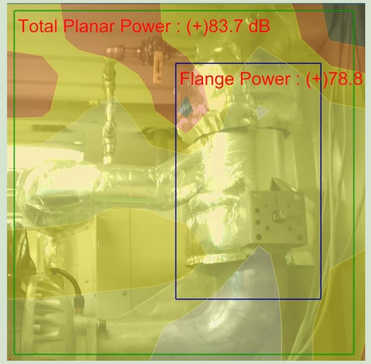
Prototype Results

Pipe Lagging SPL



- 4.8 dBA variance between steady-state and bypass in normal operation
- 5.6 dBA change when system is operating at 43 Hz (extreme case)
- May see improvement with flange covers

Acoustic Power



Covered Flange Power Measurements

Power Source	Total Planar Power	Flange Power
Uncover Flanges	91.1	86.5
Covered Flanges	83.7	78.8

- 7.7 dB (W) decrease between covered and uncovered flanges
- No significant change in SPL measurement indicates that the flanges were not a major sound source

Project Summary

Actions Taken

- Developed measurement strategy and layout
- Performed noise classification measurements
- Designed concepts using frequency data and localization from intensity measurements
- Installed prototype followed by post installation analysis

Results

- **4.8 dBA** variance between steady-state and bypass in normal operation, representing **57.5% dBA** change in SPL between current and desired levels
- **5.6 dBA** variance between bare and lagged bypass line during peak operation, representing **52.5% dBA** SPL difference
- Reduction in acoustic power from flanges did not lower total SPL measurements