



Objective

- Reduce engine sound propagation in forklift truck cabs for a more comfortable driving experience by modifying or rebuilding the floorplate
- Achieve a 20% (~1 dB) reduction in total noise experienced by the operator

Background

- The forklift industry is essential for the global movement of goods
- Hyster-Yale, our sponsor, is the 6th largest forklift manufacturer in the world

Value Proposition

- Reducing engine and transmission noise via improved floorplate insulation
- Boost operator comfort and concentration, increasing work efficiency and reducing costs
- Promote long-term operator health and safety through a quieter work environment

Key Requirements

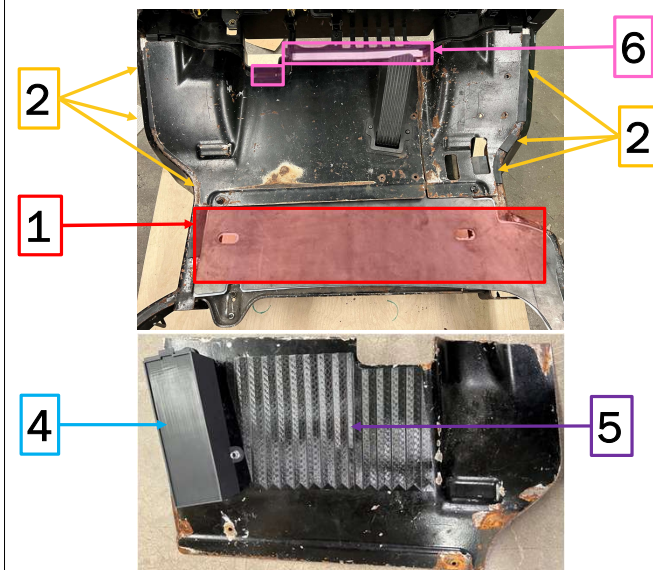
- Reduce noise by 20% (~1 dB), recorded from a decibel meter at head height in the cab
- Sustain 300lbs in the center of the floorplate
- The maximum part weight is 25lbs
- Mounted on top of the overhead guard, with toolless screws to allow for easy access to components underneath the floorplate
- Last the life of the forklift, roughly 20000hrs
- Rust resistant and painted black



Conceptual Approaches

- Multi-Layer Design (1) – Altering the material properties of floorplate
- TrimLok Seals (2) – Seal the edges of the floorplate
- Engine Barrier (3) – Barrier to block engine noise
- Pedal Box (4) – Eliminating gaps in floorplate
- Acoustic Paneling (5) – Reduce sound attenuation through floorplate
- U-Channel & Dovetail Joint (6) – Restrict movement of floorplate

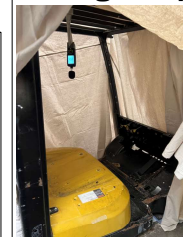
The Final Design



Validation Plan & Procedure

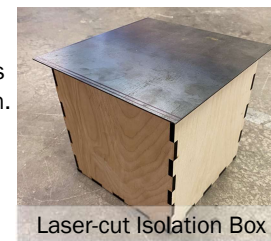
- Noise measured in dBA using a decibel meter at operator height
- A blankets and cardboard used to keep all noise within our system, also preventing outside noise from affecting the data
- K-factorial design would require 1280 tests; our testing procedure is as thorough with only 560 tests using three experimental design methods: Plackett-Burman, Response Surface Design, and Mixture Method

Testing Setups



The left image shows the testing setup for the methods above for each of the concepts excluding the multi-layer design.

The right image shows the isolation box, used for testing different multi-layer combinations.



Laser-cut Isolation Box

Overall Testing Results

Best Low Idle Individual	Best High Idle Individual	Percent Reduction	Low Idle (%)	High Idle (%)
75.45 Engine Barrier	75.75 Engine Barrier	Engine Barrier	14.89	18.79
Best Low Idle Combination	Best High Idle Combination	Fin+EB+Soft	Fin+EB+Soft	Fin+EB+Soft
75.19 Fin+U-chan+EB	75.35 Fin+EB+Soft	Fin+U-chan+EB	24.66	14.10

Isolation Testing	A36 0.06"	A36 0.12"	A36 + UHMW + A36	A36 Epoxy UHMW	A36 Epoxy TPU
Low Idle (dBA)	77.01	74.84	74.64	75.27	77.89
High Idle (dBA)	80.69	79.73	78.71	79.74	80.97

Summary & Conclusions

- Total noise attenuation was 1.42 dBA or 29%
- Total noise attenuation for Multi-Layer design was
- Maintained all other product requirements
- Recommendations
- Develop an engine barrier, as it could significantly attenuate the noise
- Make the Acoustic Paneling cover the entire floorplate
- Restrict movement of floorplate via concepts like U-Channel & Dovetail
- Consider a multi-layer design without adhesive between layers

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