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Reducing Whole-Body Vibrations in Neonatal Transport

Team Members:

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Clients: Dr. Ryan McAdams, Dr. Joshua Gollub

Advisor: Dr. Melissa Kinney

The Clients

Dr. Ryan McAdams, MD

- Neonatology Division Chief
- UW faculty member for the UW School of Medicine and Public Health
- 24 years of experience in neonatal transport medicine
- 10 years of experience with aeromedical transports in the Air Force

Dr. Joshua Gollub, MD

- Fellow at the University of Wisconsin School of Medicine and Public Health
- Specializes in neonatal medicine

Joey Byrne

Problem Statement

- Ill neonates may require transport to neonatal intensive care units (NICU).
- Transport subjects neonates to whole-body vibrations (WBV).
- WBV can lead to head bleeding, neurodevelopmental impairment, and death.
- No current vibration-reducing device used.

Figure 1: Ambulance ground transport [1]

Figure 2: Hospitalized neonate receiving treatment [2]

Joey Byrne

Background Information

- Critically ill neonates
  - Birth defects or preterm birth
  - Fragile germinal matrix [3]
  - Intraventricular Hemorrhaging (IVH)

- Current Transport Setup
  - Incubator
  - Incubator control box
  - Support systems
  - Platform/ Deck
  - Mattress

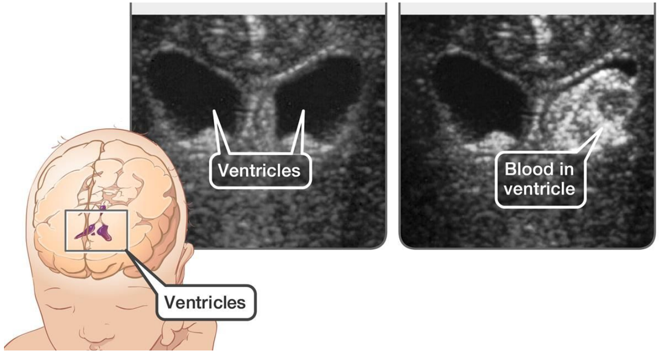

Figure 3: Intraventricular Hemorrhaging in Neonate [4]

Figure 4: International Biomed Travel Incubator [5].

Joey Byrne

Competing Designs

- Quasi-zero-stiffness (QZS) isolator [6]
  - Pair of repelling ring magnets
  - Coil spring
  - Viscous Damper

- Isolation device for shock reduction [7]
  - Between isolette and stretcher platform
  - Air or gas springs
  - Adjustable pressure for range of frequency attenuation

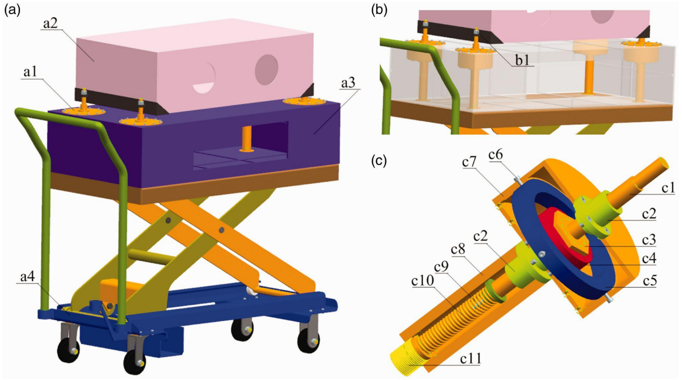

Figure 5: Quasi-Zero-Stiffness Isolator Diagram

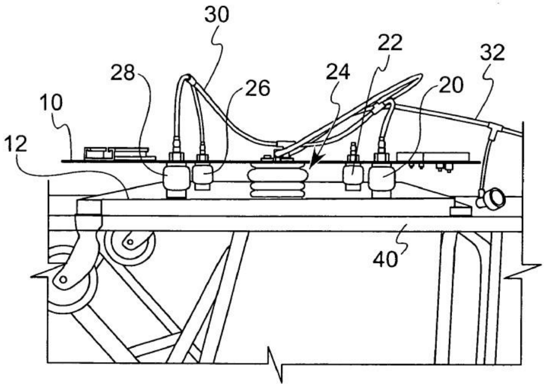

Figure 6: Isolation Device for Shock Reduction Diagram

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Product Design Specifications

- Limits:
  - Reduce vibrations below 0.315 m/s^2 [8]
  - Human Sensitivity Range: 3-20 Hz [9]
- Device:
  - Allow the infant to maintain vital signs
  - Device must attach to current incubator setup
    - Or include all associated functions
  - Must fit inside or under incubator
    - 53 cm H x 48 cm W x 99 cm L [10]
- Testing:
  - Develop testing method which meets industry standards
  - Continuously collect data for 1 week
  - Utilize accelerometers
    - Capable of 100 Hz sampling frequency [11]

Joey Byrne

Design 1: Gel Composite Design

- A total of four inserts, placed in between the inner and outer trays.
  - Reduce vibrations as close to the location of the neonate as possible, primarily in the x and y directions
- Three repeated layers of foam, aluminum, gel, and aluminum, and a stainless steel outer layer on each of the four inserts to reduce the amplitude and longevity of the vibrations [12].

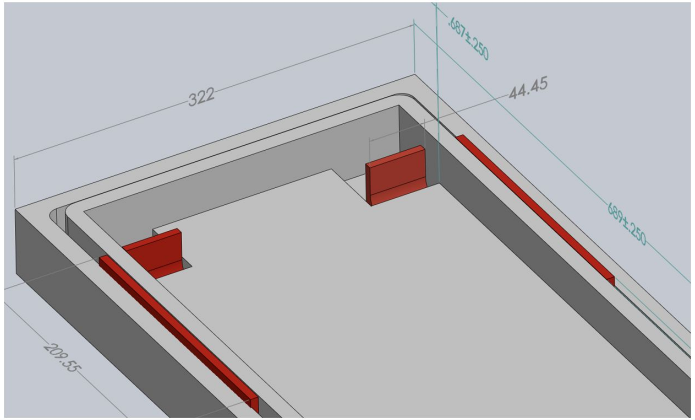


Figure 7: Model of gel Composite Dampers placed in the isolette and outlined in red. Dimensions in mm.

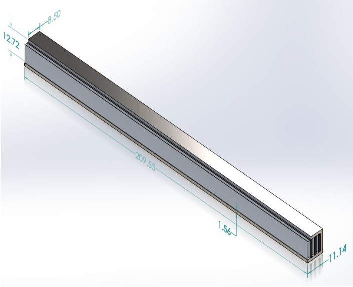


Figure 8: Side damper model. Dimensions in mm.

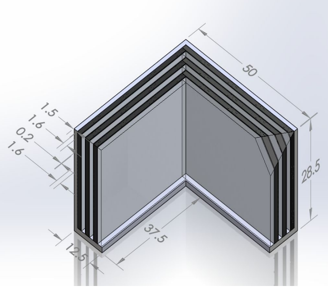


Figure 9: Corner damper model. Dimensions in mm.

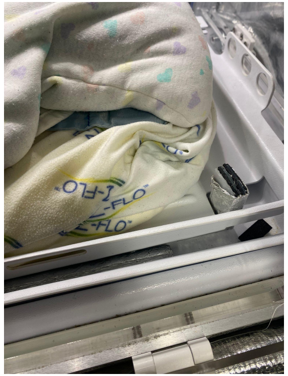


Figure 10: Gel Composite Dampers placed in between the inner and outer trays in the isolette.

Sydney Polzin

Design 1: Gel Composite Design Results

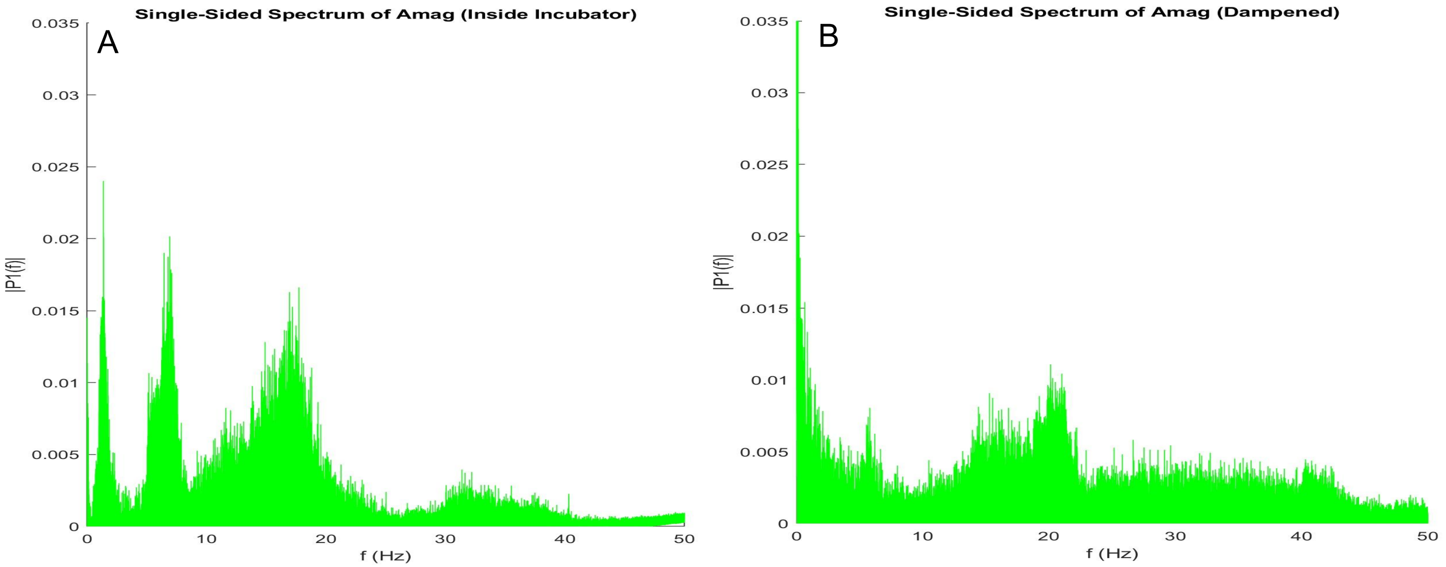


Figure 11: Power spectral density graphs for measurements (A) inside the incubator without the dampening prototype, and (B) inside the incubator with the dampening prototype.

Sydney Polzin

Design 2: Spring Viscous Damper Design

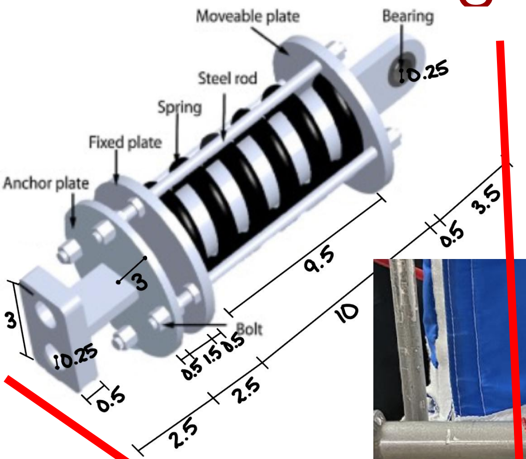


Figure 12: Depiction of the Spring Viscous Damper Component with dimensions in cm [13].

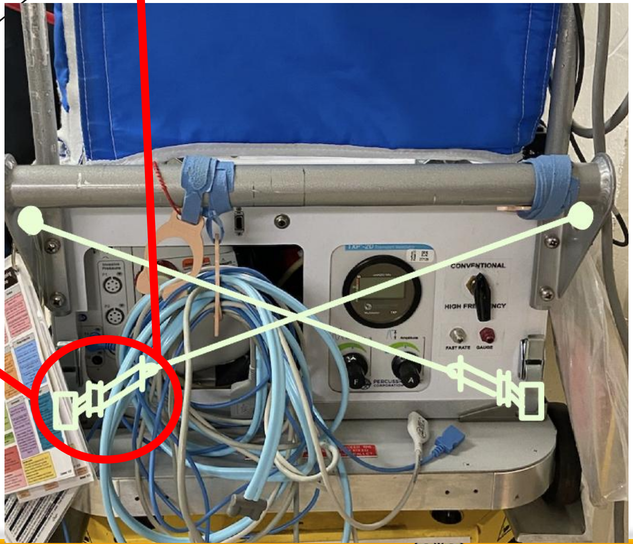


Figure 13: Superimposed placement of spring, damper, and cables on the neonatal transport system.

- Common in buildings to dissipate seismic energy from earthquakes [14]
- The piston provides resistance to velocity by compressing on a viscous fluid such as oil, glycerin or silicone
- The spring provides a restoring force that increases proportionally with displacement
- The tensions in the cables extending from the bearing can be tuned to act as an additionally damper for the system [15]

Joshua Varghese

Design 3: Spring and Damper Design

- Placed between the inner and outer trays of isolette and underneath the inner tray
    - Reduce vibrations and absorb shock in x, y, and z directions
    - Combines both damping and oscillating components [16]
- Different spring constants to improve accuracy
- Close proximity to neonate for more precise vibration attenuation
- May require redesign of inner tray and reduce vertical space

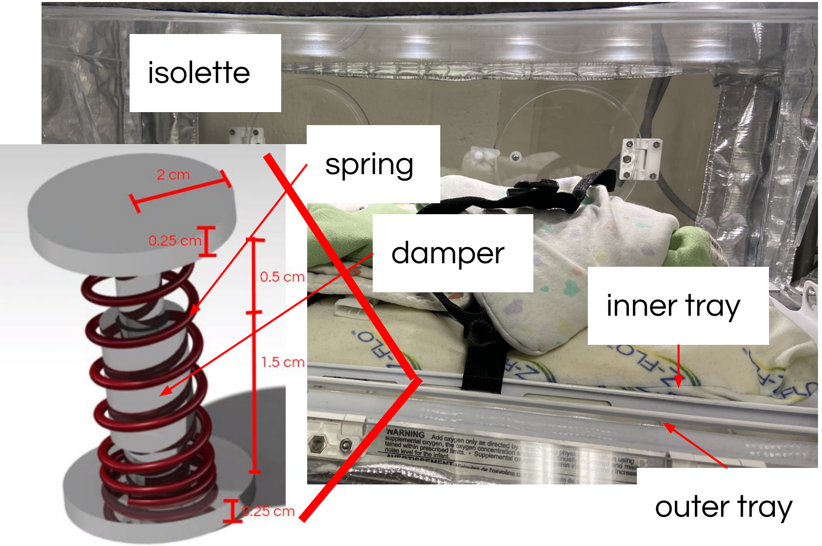
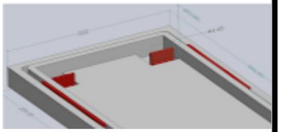


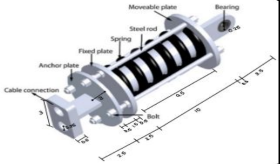
Figure 14: Neonatal transport incubator and Spring and Damper design [17]

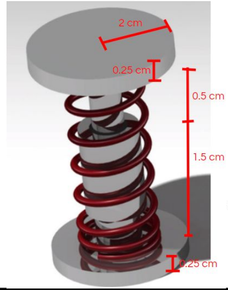
Nicole Parmenter

Design Matrix

Table 1: Design matrix evaluation comparing the three preliminary vibration attenuation devices.







		Gel Composite Continuation		Spring Viscous Damper		Spring & Damper Design	
	Weight	**Score**	**Total**	**Score**	**Total**	**Score**	**Total**
Efficacy of Vibration Reduction	25	3	15	4	20	5	25
Accessibility to Neonate	20	4	16	5	20	4	16
Compatibility with Equipment	20	5	20	3	12	4	16
Ease of Fabrication	15	4	12	2	6	3	9
Safety	10	5	10	4	8	5	10
Cost	10	5	10	3	6	4	8
TOTAL	**100**	**83**		**72**		**84**	

Meghan Horan

Future Work

1. Choose between magnetic and air pocket dampening mechanism
2. Investigate accelerometers for use in preliminary testing
3. Begin prototyping

Figure 15: A photo of the team doing a med flight tour to see the equipment impacted by the design.

Meghan Horan

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Meghan Horan

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Questions?