Low Temperature Characterization of Mechanical Isolators for Cryocoolers

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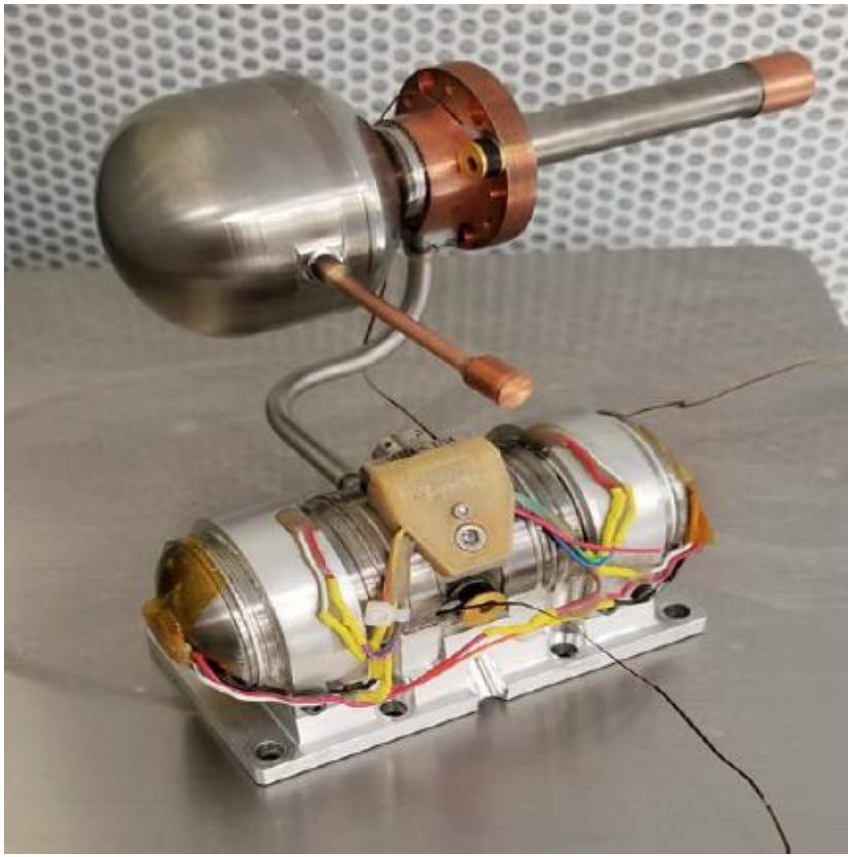
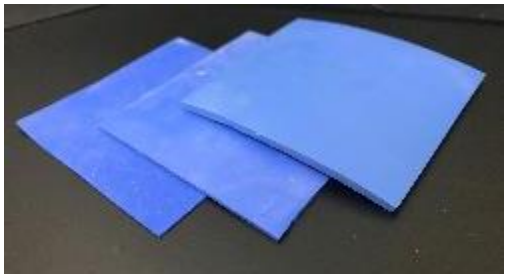
Overview

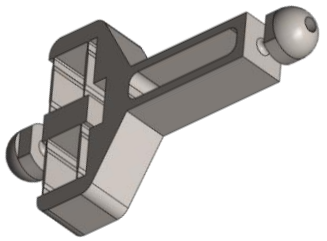
- Jet Propulsion Laboratory is developing the Mapping Imaging Spectrometer for Europa (MISE)
- MISE will use a Lockheed Martin Micro1-2 Cryocooler
  - 135 Hz drive frequency
  - 220 K reject temperature
- Vibration output from the cooler is a concern
  - Exported vibration in compressor radial direction is as large as piston axis
- Need isolators that can:
  - Mitigate Vibrations
  - Withstand Europa Radiation
  - Perform at 220 K



Test Plan

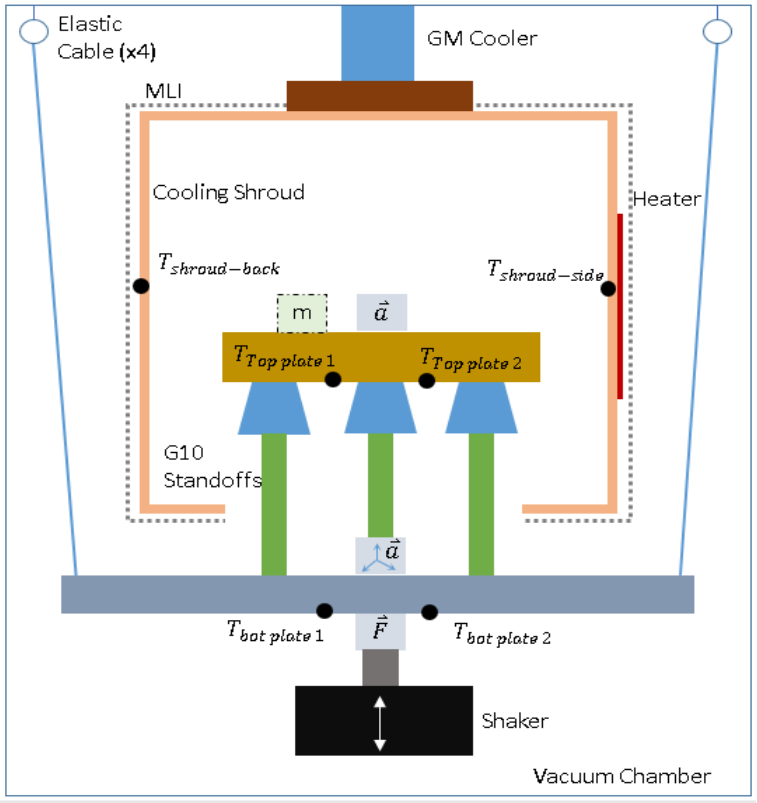
- 4 different types of radiation tolerant isolators/materials were tested for their vibration isolation capabilities at low temperature.
- Samples were tested between 205 and 295 K
- Performance metric is transmissibility ratio
  - Transmitted Acceleration / Input Acceleration

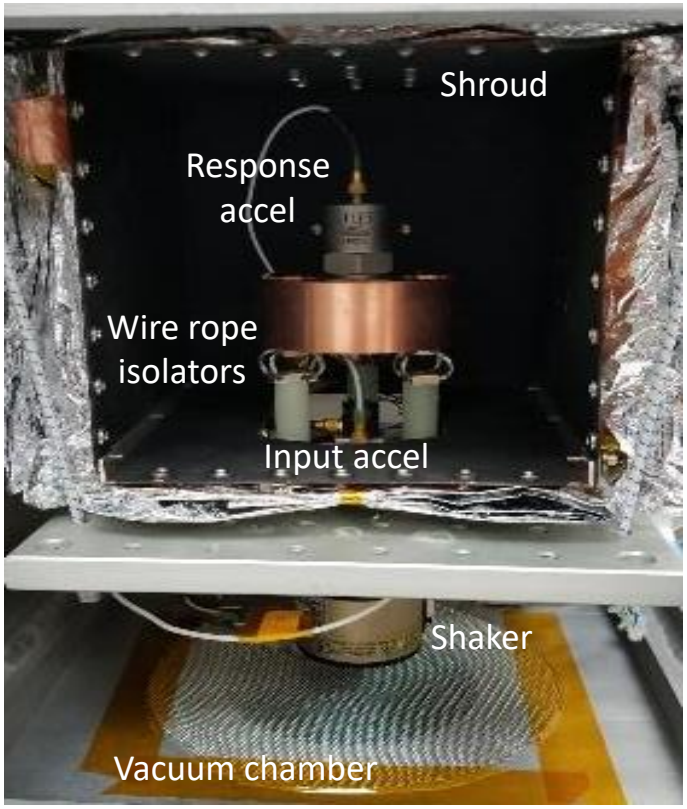




Isolator Type	Manufacturer /Model Number
Large Silicone Gel	Advanced Antivibration Components / V10Z61MTHB
Small Silicone Gel	Advanced Antivibration Components / V10Z61MTHC
Large Wire Rope	IIT Endine / CR2-100-D
Small Wire Rope	IIT Endine / CR3-400-D
Fluorosilicone Sheets	AAA-Acme Rubber Co. / (various thicknesses)
JPL Custom Designed Titanium Flexures	All Tech Precision

Test Setup

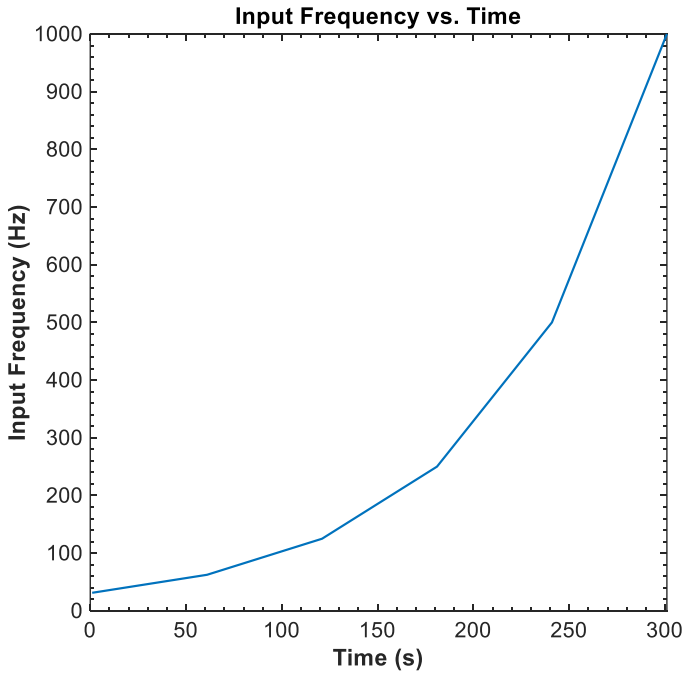


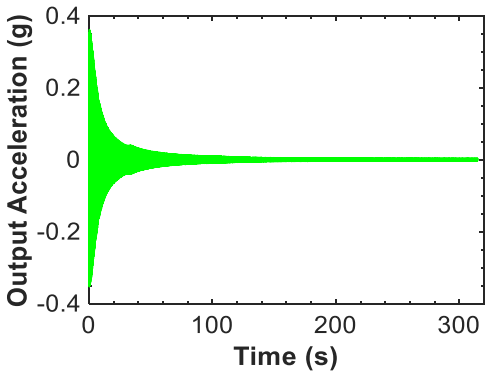


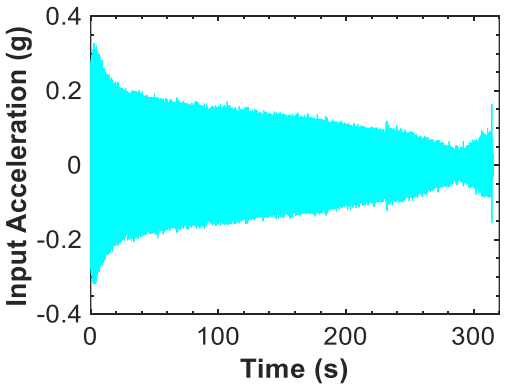
- Tests conducted in 12” cubic thermal-vacuum chamber
- Test platform suspended with elastic cables for isolation
- Three isolators were installed between G10 standoffs and copper puck
- Samples cooled by radiation shield
- Sample temperature determined by temperature of copper puck

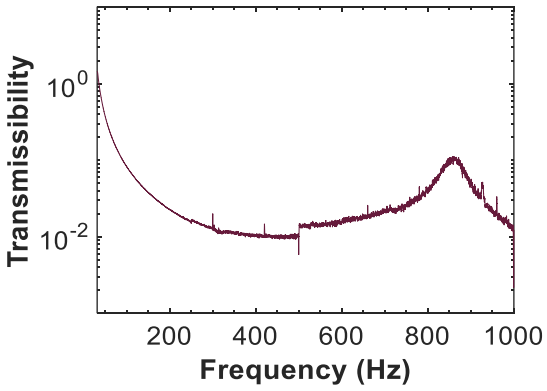
Test Procedure and Data Processing

- Frequency was swept between 31.25 and 1000 Hz at one octave/min
- Data sampling rate=2500 S/s
- FFT done on time domain output and input acceleration data
- Moving mean and custom filter applied to data to reduce electrical noise
- Transmissibility ratio is transmitted force / input force



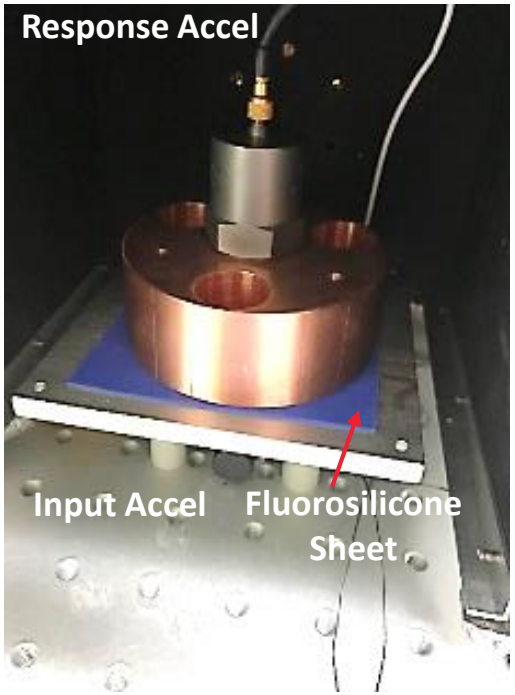


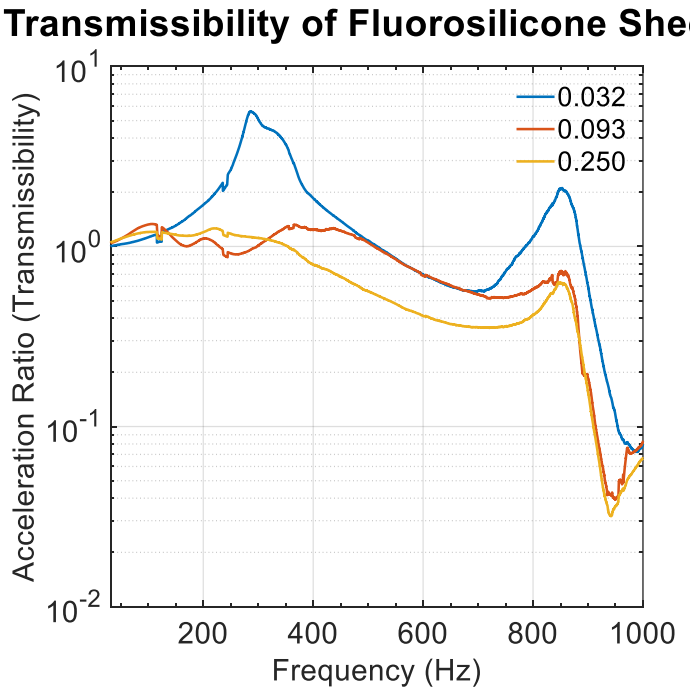




Results Fluorosilicone Rubber

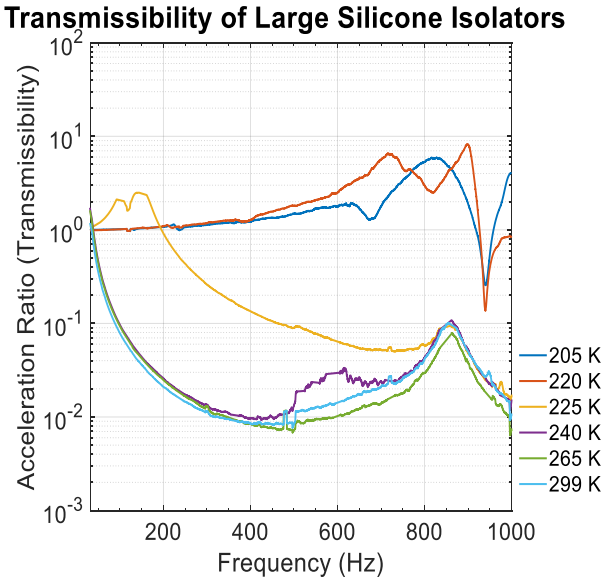
- Fluorosilicone sheets of 0.032”, 0.093” and 0.250” were tested
- Near 135 Hz, damping is in non-existent
- 0.250” sample shows marginally better performance
- Mode near 850 Hz attributed to stiffness of G10 standoffs

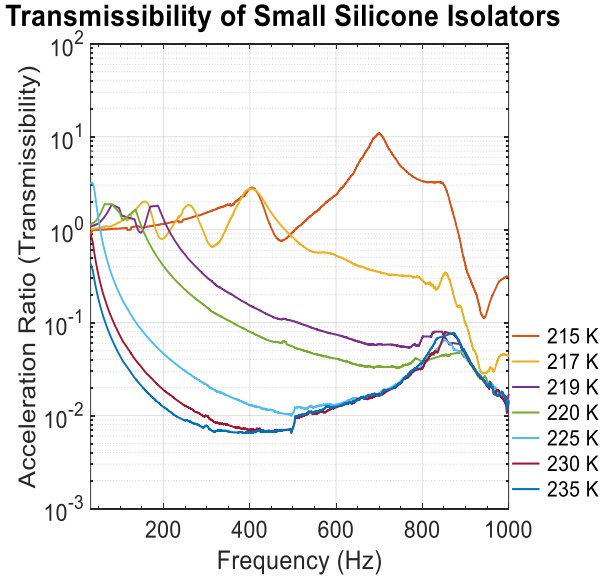


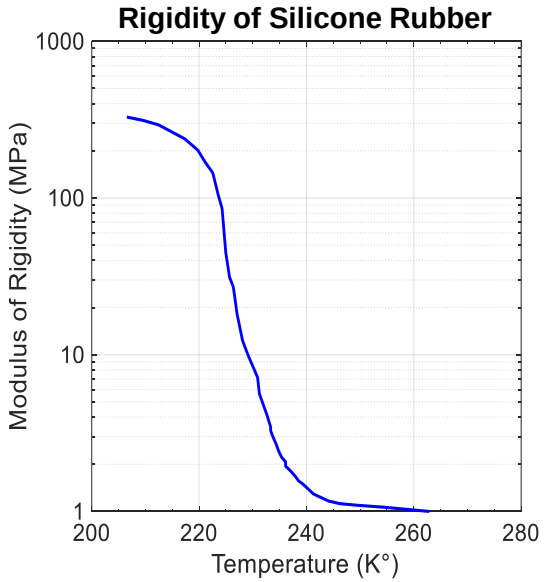


Results-Silicone Isolators

- These isolators are greatly affected by temperature
- Near 220 K the material undergoes a solid-solid phase change [1]
- System resonance near 850 Hz observed and could be affecting results at higher frequency
- Isolation is non-existent when material is below “melting” point.
- 850 Hz mode observed



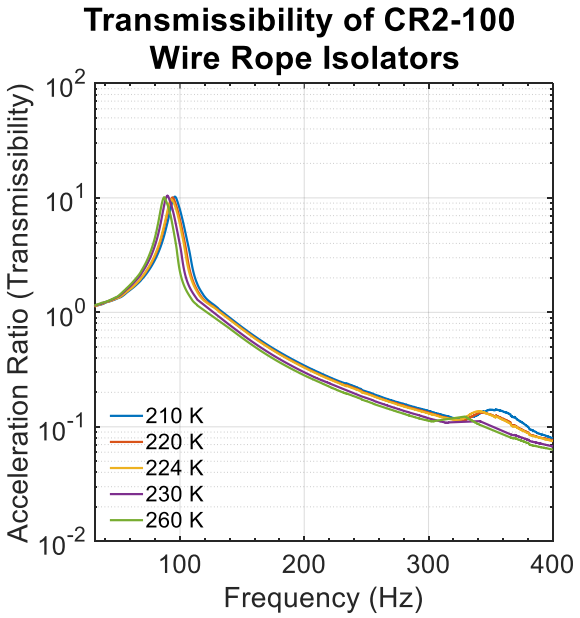


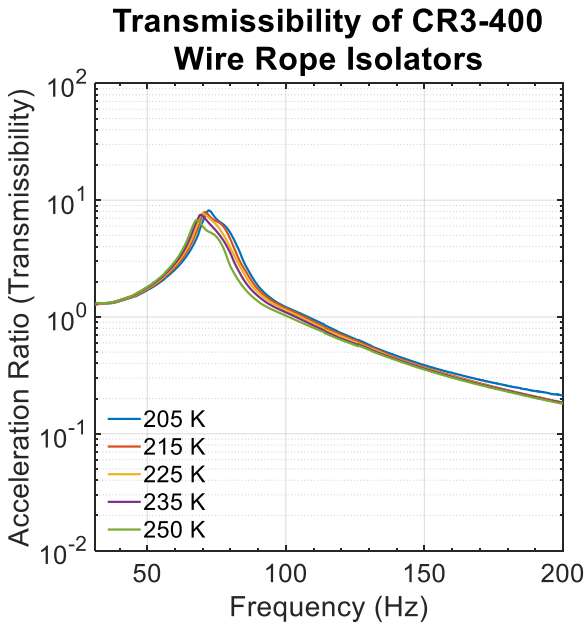


[1] Shin-Etsu Silicone, "Characteristic Properties of Silicone Rubber Compounds," August 2016

Results-Wire Rope Isolators

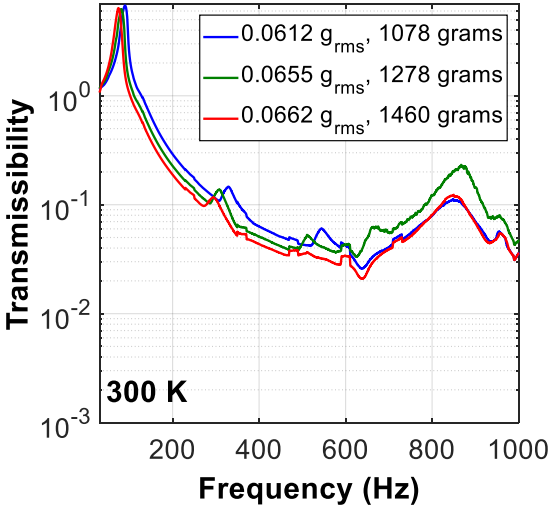
- Vibration is damped through rubbing and sliding of stainless steel twisted cable
  - Debris formation could be a concern
- No temperature dependence observed
- Data at higher frequencies is questionable due to system resonance at 850 Hz

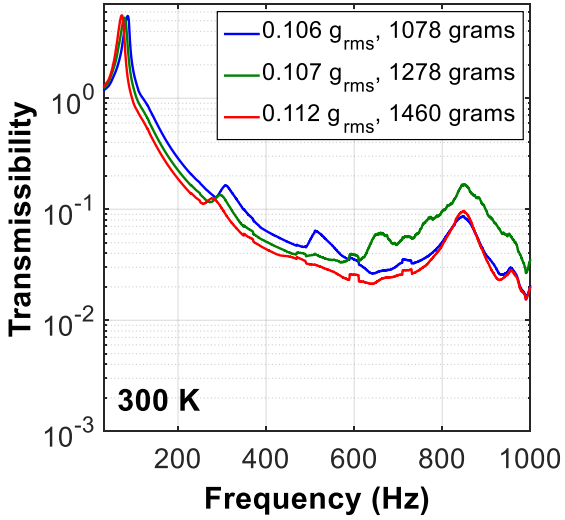


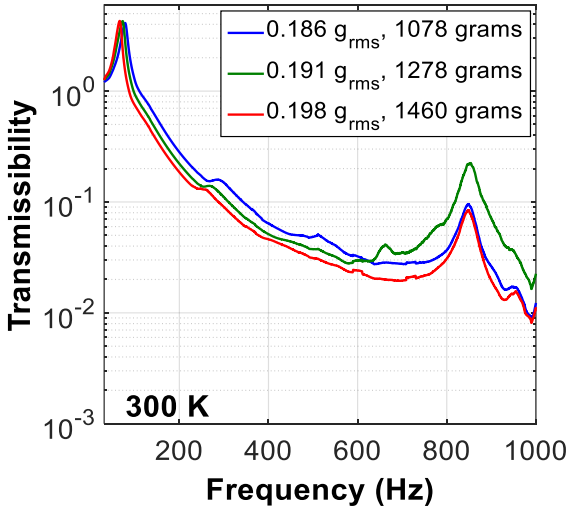


Results-Wire Rope Isolators-Parametric Study

- The CR2-100 isolators were tested parametrically with added mass and various input voltages to further investigate the modes of the test setup
  - Measurements made at room temperature
- 75 Hz resonance varies minimally with added mass
- 850 Hz resonance peak remains constant
  - Resonance is independent of test parameters
  - Clearly test setup resonance

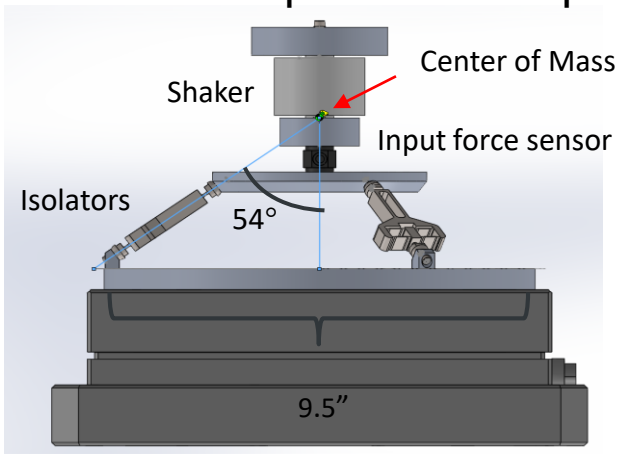


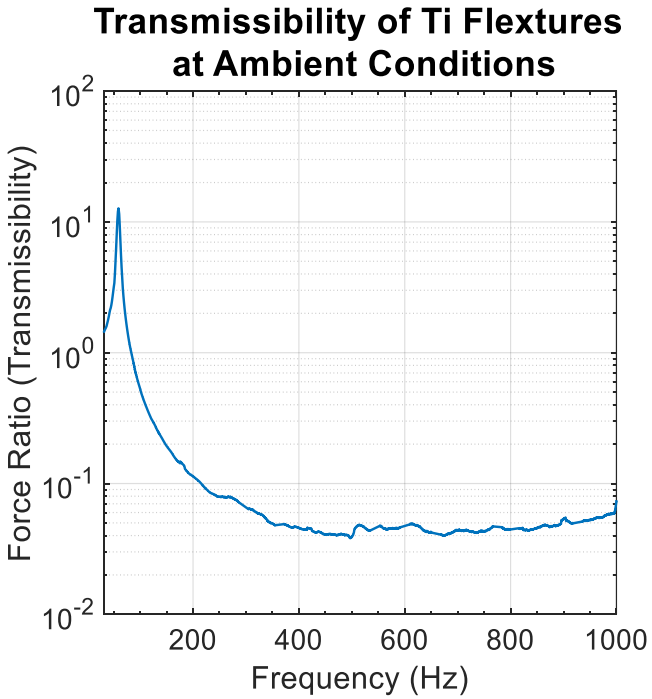




Titanium Flexures-Design

- A hexapod layout of temperature independent titanium flexures were designed to reduce amplitude by 10x at 135 Hz.
- In the test configuration, three flexures supported half the cooler mass
- Projected vectors of isolators meet at CM of Assembly
- Max transmissibility of 0.04 above 500 Hz and 0.25 at 135 Hz
- Performance independent of input force





Conclusions and Future Work

- Temperature dependence of elastomers make them poor materials for low temperature isolators
- Wire-rope isolators provided some damping, but a higher break frequency and slow roll off make them non-ideal
- Of the four materials tested the titanium flexures showed the most promise
  - Titanium flexures show similar trend in behavior to wire rope and can be designed and modelled easily to meet specification
  - For future applications custom flexures will be considered as a primary option
- JPL is currently evaluating the necessity for isolators on MISE
  - Ti flexures will undergo further analysis if implementation is necessary

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Backup

Results-Wire Rope Isolators-Parametric Study Bottom Plate

- Mass was also added to the bottom plate to determine dependence
  - Measurements made at room temperature
  - 75 Hz resonance constant
  - 850 Hz resonance significantly reduced due to added mass
    - Input acceleration reduced