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Use of Damping & Isolation for Seismic Qualification of Equipment for Increased Hazards

DOE/NRC Natural Phenomena Hazards Meeting

Why use Isolation and/or Damping?

- Isolation
  - Isolate equipment vibrations from the building structure
  - Decouple the equipment from the building structure to reduce seismic input motion by changing the fundamental frequency of the equipment
- Damping
  - Reduce floor accelerations felt by equipment within the structure

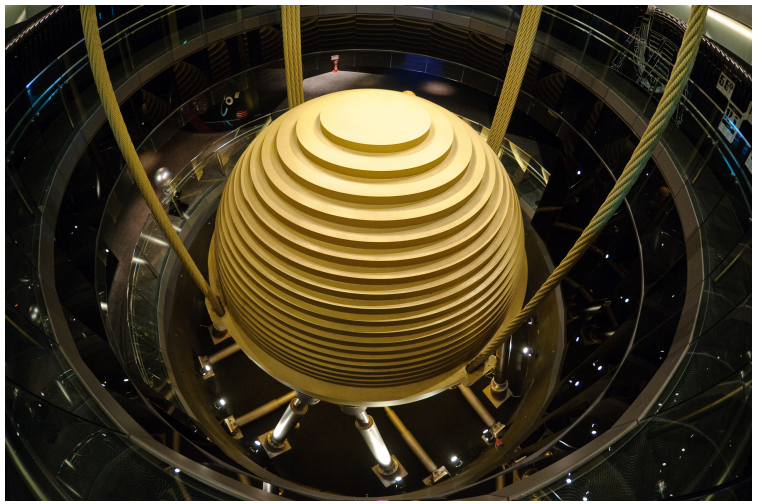
Pros & Cons of Isolation and Damping

- Isolation
  - Pros
    - If equipment has operational vibrations, isolation of some kind is likely already needed
  - Cons
    - If a component is typically rigid this could shift the fundamental frequencies into the flexible range of the spectra and experience higher accelerations and deflections
- Damping
  - Pros
    - Reduction in accelerations felt by the equipment
  - Cons
    - Difficult to implement on a component specific application

Types of Dampers

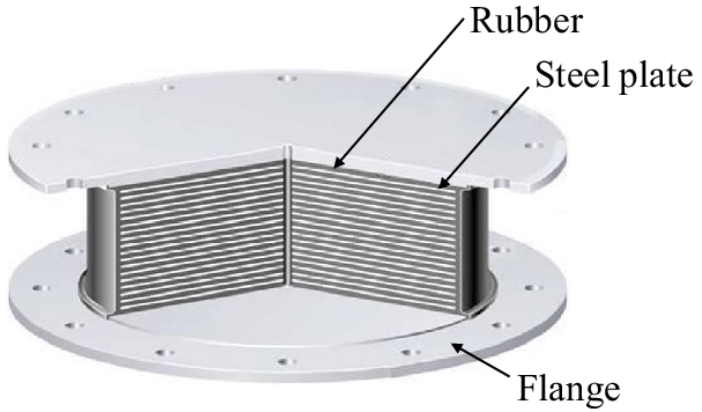
- Tuned Mass Dampers
- Fluid Viscous Dampers

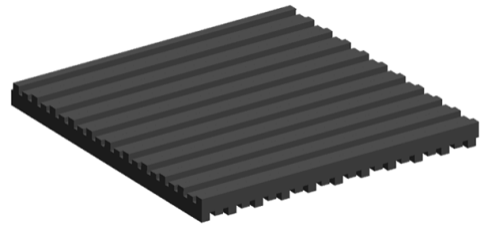
- Neither of these types of dampers are generally cost effective to be implemented for a specific piece of equipment
  - Best to be utilized for the global structure

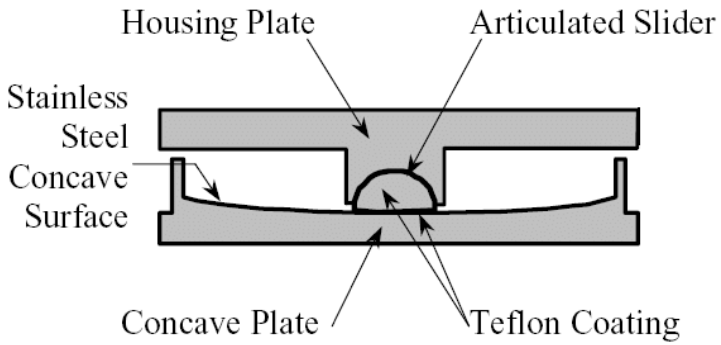


Types of Isolators

- Elastomeric
- Helical springs
- Wire rope isolators
- Friction pendulum bearing







Types of Isolators

- Elastomeric
  - Most common
  - Types: High damping rubber bearing (HDRB), Lead-rubber bearing, Low damping rubber (LDRB)bearing
- Helical springs
  - Common for equipment with vibration concerns
  - May not be as effective in damping lateral loads
  - Better temperature performance due to metal construction, fewer maintenance considerations
- Friction pendulum bearing
  - Not as feasible with equipment due to the cost
- Wire Rope Isolators
  - High damping ratios
  - Long product lifetime with limited creep effects
  - Drawbacks: Large deflections can occur without snubbers or isolator housings

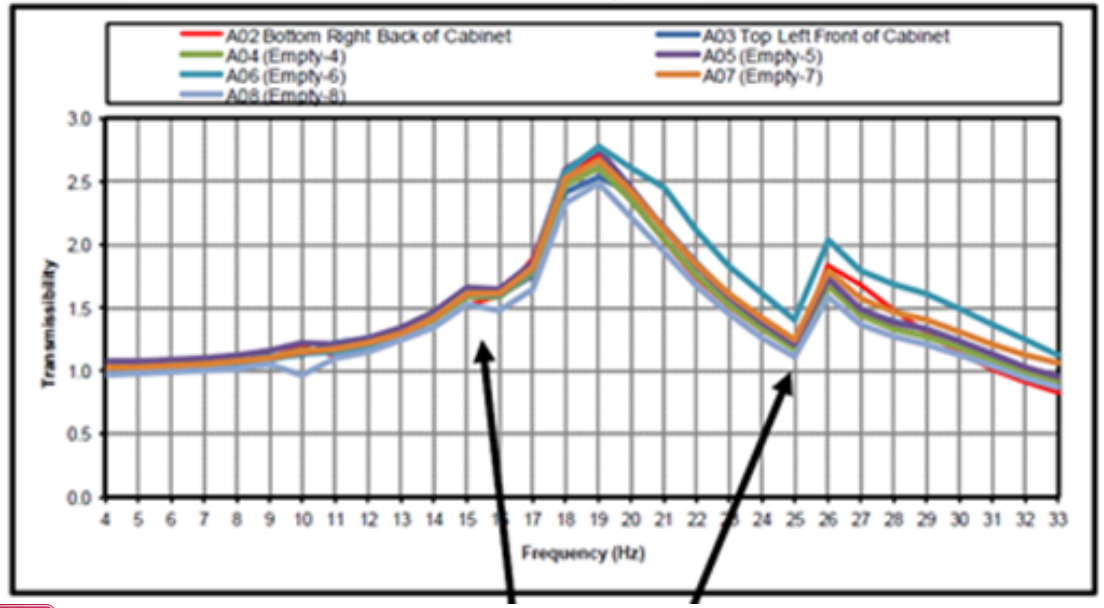
Wire Rope Isolators (WRI)

- How do they work?
  - WRIs utilize coulomb friction damping
  - The damping is generated when the cable strands slide across each other and generate heat and dissipate energy
  - Can increase damping further by applying a chemical cable wash to remove the remaining oils, lubricants, and hydrocarbons to increase the friction between the cables

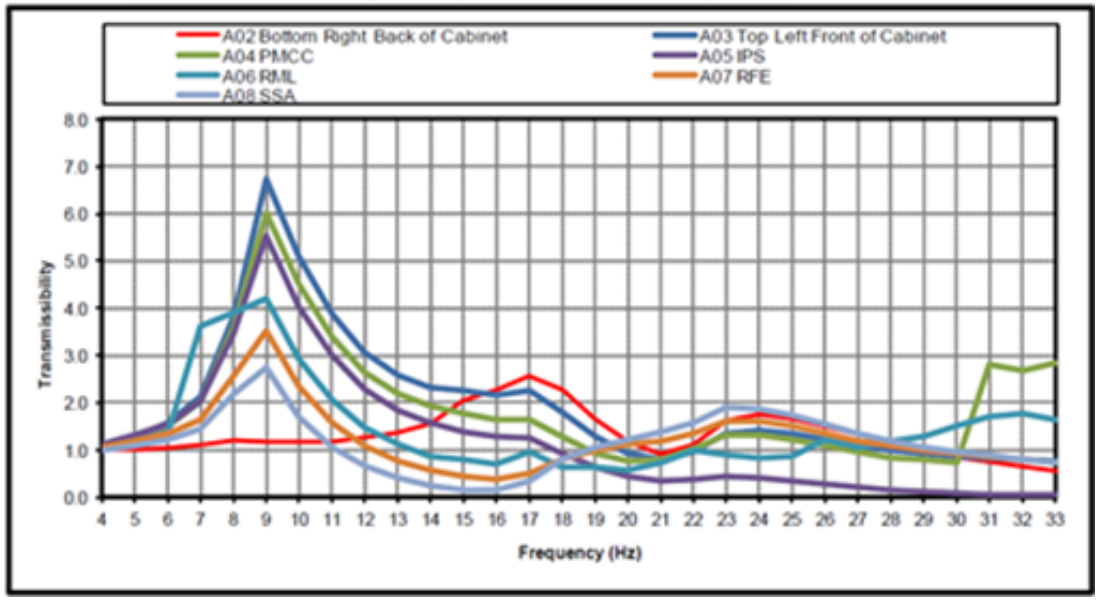
Wire Rope Isolators (WRI)

- Damping
  - Damping values calibrated by the manufacturer via vibration and shock testing
  - A product from Isolation Dynamics Corp. provides a high damping solution with WRIs having C/Cc of 0.15-0.20

C.2 Vertical Axis Variable Test Transmissibility Plots



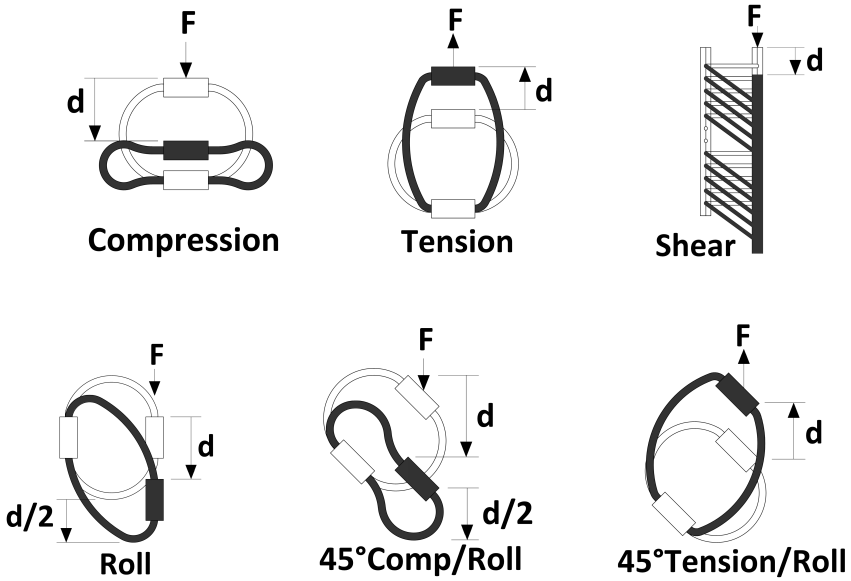
C.2 Side-to-Side Axis Exploratory Test Transmissibility Plots

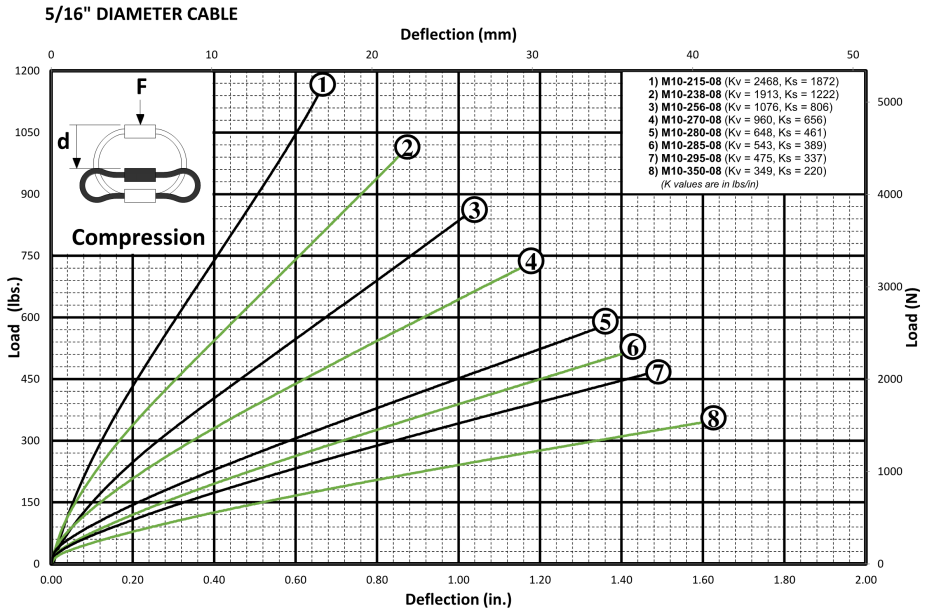


Test information provided by Eric Jansson, P.E. from Isolation Dynamics Corp.

Wire Rope Isolators (WRI)

- Stiffness Behavior
  - Vibration and Shock stiffnesses provided by manufacturer
    - Compression, Tension, Shear, Roll, Comp/Roll, and Tension/Roll





Test information provided by Eric Jansson, P.E. from Isolation Dynamics Corp.

Case Study

- Equipment has already been qualified via shake table testing or experience data to show continued operation after a seismic event
- Seismic hazard has increased beyond the original design basis and the component is no longer deemed acceptable

- Options:
  1. Retest to the higher level to show the system had higher capacity margin than previously considered
  2. Reduce the demands experienced by the equipment
     a) Isolation
     b) Damping

Case Study - Seismic Hazard Reevaluations

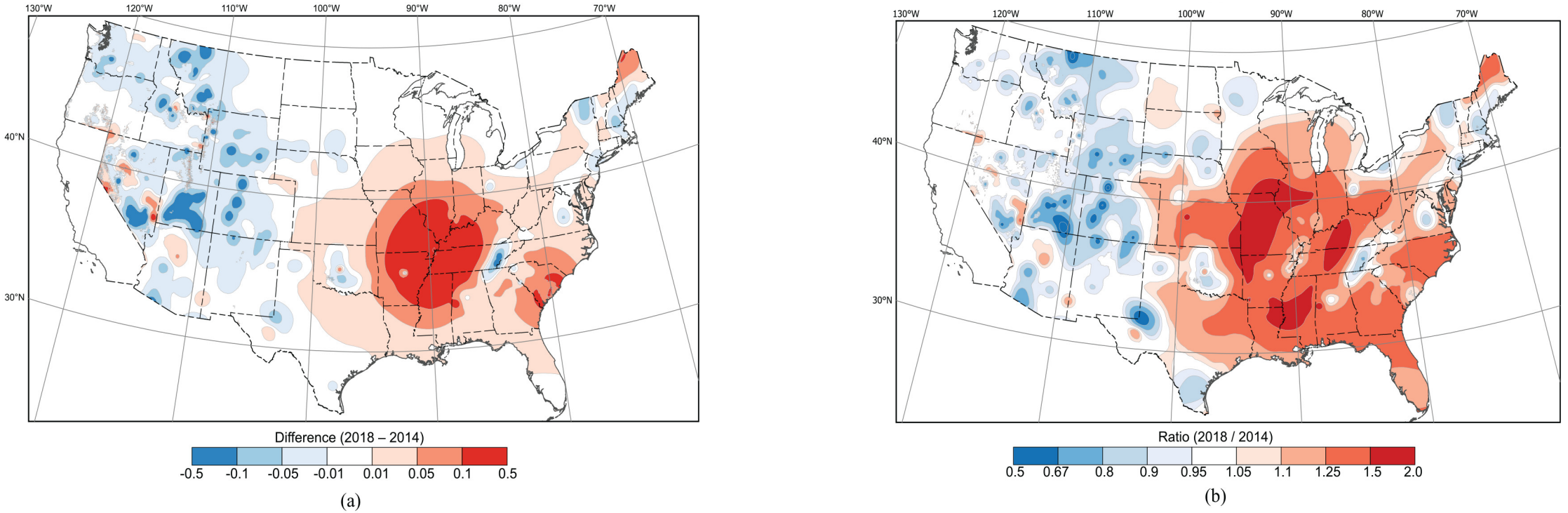


Figure 11. (a) Difference and (b) ratio maps showing comparisons between total mean hazard from the 2018 NSHM and the 2014 NSHM for the conterminous United States. Maps are for 0.2-s spectral acceleration, 2% probability of exceedance in 50 years, and NEHRP site class boundary B/C (V_{S30} = 760 m/s).

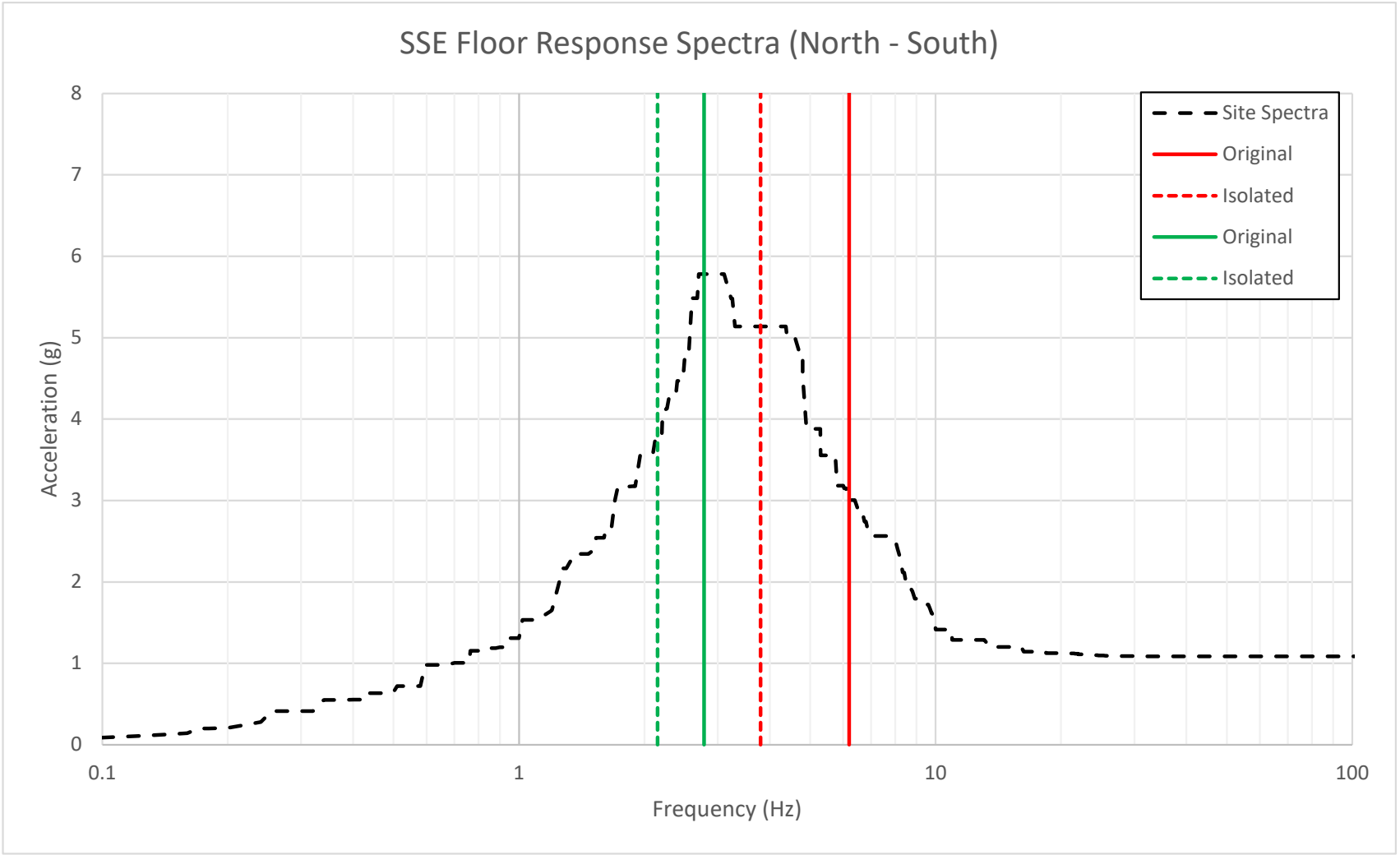
Petersen MD, Shumway AM, Powers PM, et al. The 2018 update of the US National Seismic Hazard Model: Overview of model and implications. *Earthquake Spectra*. 2020;36(1):5-41. doi:10.1177/8755293019878199

Case Study – Option 2a

- Solution: Use isolators

- Considerations:
  - Is the equipment already isolated?
  - Is isolation detrimental to the operability of the piece of equipment?
  - Where is the current fundamental frequency of the equipment on the spectra?
  - What would be the new fundamental frequency of the equipment on the spectra?
  - Are there any higher modes that need to be considered?

Case Study - Option 2a

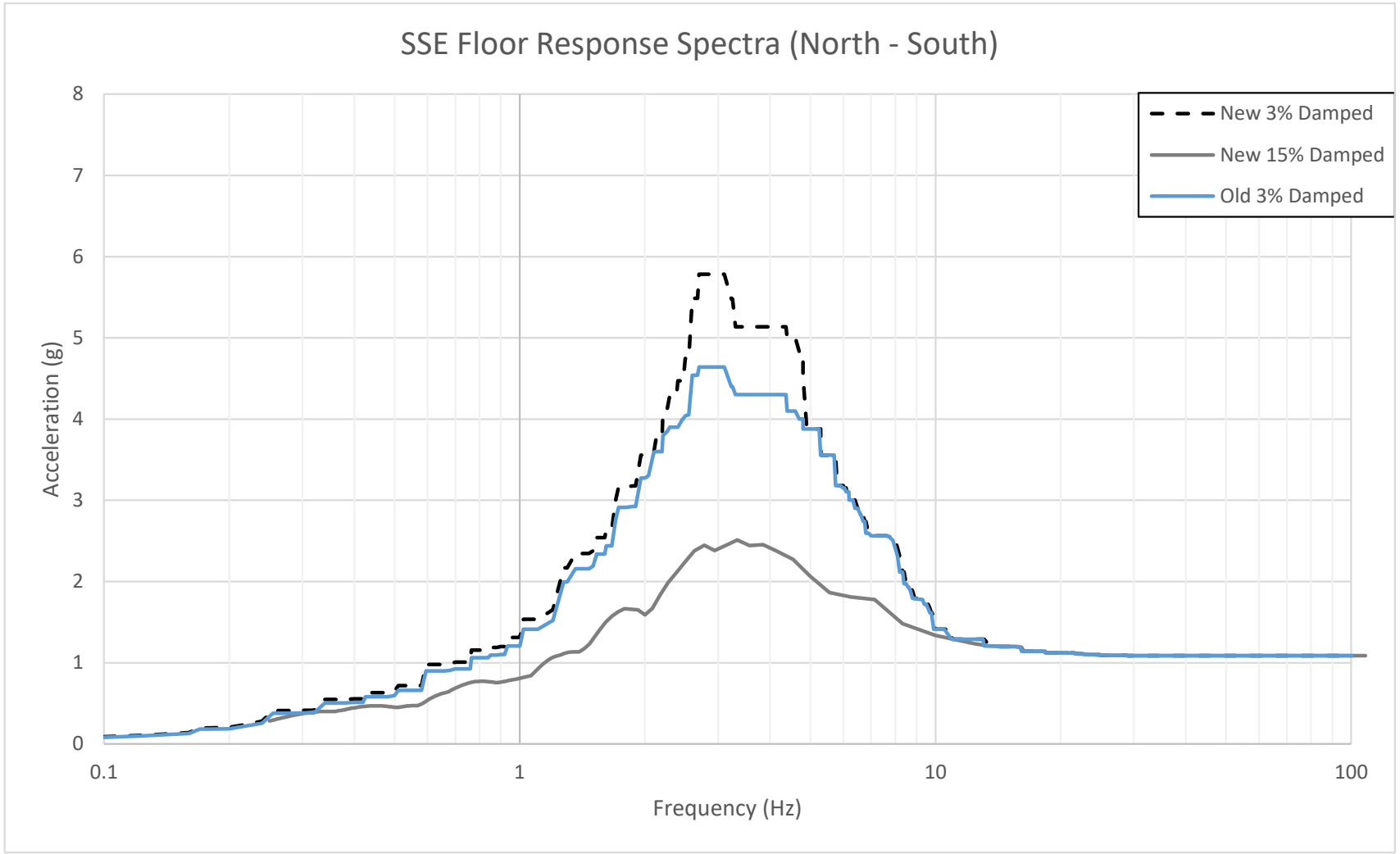


Case Study – Option 2b

- Solution: Use Wire Rope Isolators

- Considerations:
  - Is the equipment already isolated?
  - Is isolation detrimental to the operability of the piece of equipment?
  - Where is the current fundamental frequency of the equipment on the spectra?
  - What would be the new fundamental frequency of the equipment on the spectra?
  - Are there any higher modes that need to be considered?
  - Design restraints for larger deformations of the equipment
  - Design flexible connections to connected systems

Case Study - Option 2b



Case Study – Option 2b

- Procedure:
  - Acceleration time histories were generated to match the new 3% damped spectra using SeismoArtif software program
  - Input time histories into SeismoSignal software program evaluated at 15% damping (or alterative damping based on WRI manufacturer recommendations)
  - Compare new spectrum against the previously qualified spectra/capacity
  - Design snubber device to prevent excessive deformations

SeismoArtif and SeismoSignal are both developed by Seismosoft

Questions