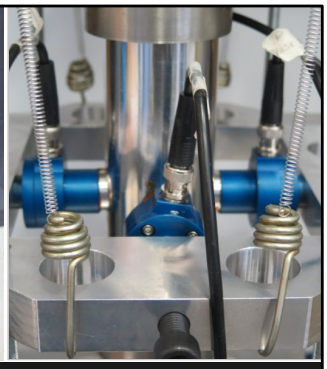
Vibration comparison from different seismic requirements



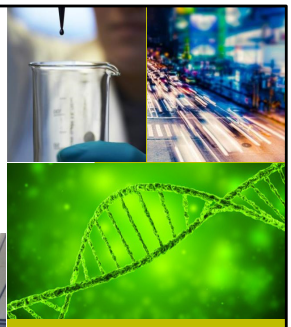
RISE Research Institutes of Sweden
Martin Olofsson
Chemistry & Applied Mechanics

RISE Research Institutes of Sweden

- State-owned research institute with a mission to be a strong innovation partner to corporations and society
- 2700 employees offer unique expertise in a wide range of knowledge and application fields (1/3 with a PhD)
- 100 testbeds and demonstration facilities

Short facts about RISE Applied Mechanics

- 50 researchers, engineers, technicians and admin staff
- Node for solid and structural mechanics inside RISE
- Large experimental & simulation capabilities
- Unique capacity for accredited seismic testing



Example of load frame for material testing

Max force 1.2 MN

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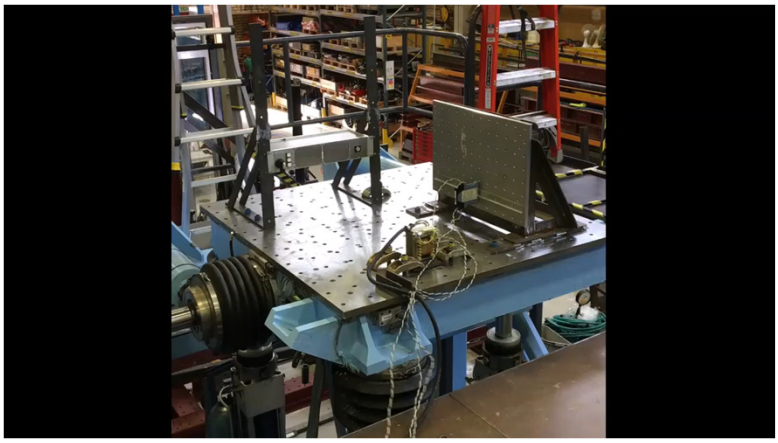
Seismic qualification of safety-critical systems and equipment

- RISE performs seismic testing of
  - Nuclear power plant equipment
  - Electricity transmission systems
  - Telecom and network equipment
  - RISE has a PLC system for detection of contact bounce in relays or switches
- Rigorous standards framework exists
  - IEC, IEEE, Telcordia
- Other products also have demand
  - Bulding and interior components



Accredited test methods

▪ IEEE Std 693:2005	IEEE Recommended Practice for Seismic Design of Substations
▪ IEEE Std 344:2013	IEEE Standard for Seismic Qualification of Equipment for Nuclear Power Generating Stations
▪ IEC 60980:1989	Recommended practices for seismic qualification of electrical equipment of the safety system for nuclear generating stations
▪ IEC 60068-2-57:2013	Test Ff: Vibration – Time-history and sine-beat method
▪ IEC 60068-3-3:2019	Supporting documentation and guidance - Seismic test methods for equipment
▪ IEC 60255-21-3:1993	Vibration, shock, bump and seismic tests on measuring relays and protection equipment - Section 3: Seismic tests
▪ Telcordia GR-63-CORE	NEBS™ Requirements: Physical Protection

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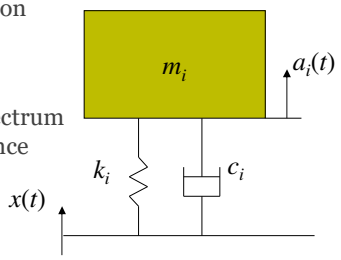
Seismic vibration severity

- Triaxial vibration with uncorrelated random, multi-frequency time series
  - Biaxial and single-axis testing is acceptable in most cases.
  - Random multi-frequency is motivated by the random nature of earthquake vibration
  - Alternatives are allowed, like sine sweep or sine beats
  - Measured true earthquake records not suitable

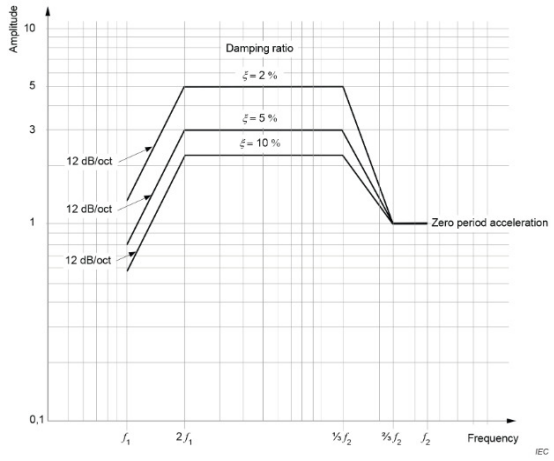
- Test vibration requirement is always described as shock response spectrum (RRS)
  - Vertical vibration can have different RRS than horizontal vibration
  - A test run is always about 30 s. Full power during at least 20 s.

principle for response spectrum
simple model of a resonance



Generalized RRS according to IEC 60068-2-57

- Guidance for the development of an RRS in the situation where environmental conditions are not well known or when equipment is qualified for multiple applications
- When using 5 % damping, which is a suggested default value, the strong part of the RRS has an amplitude that is three times the Zero Period Acceleration (ZPA).
- The RRS becomes unique when a ZPA value for the test signal is specified, together with suggested frequency range of 1-35 Hz (f_1-f_2).

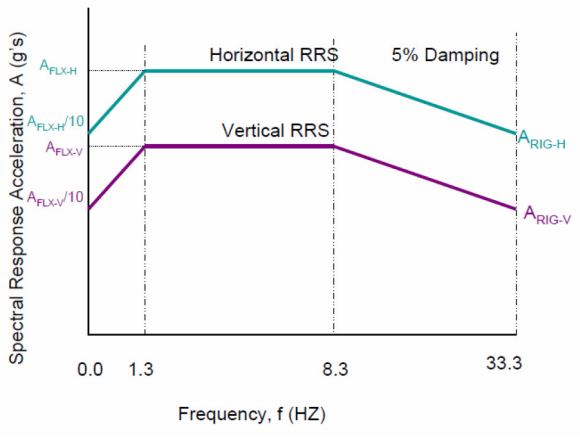


Generalized RRS according to ICC-ES AC156

- American standard for nonstructural building components
- The RRS shall be defined using a damping value equal to 5 percent of critical damping. The strong part of the RRS is never higher than 1.6 times the design spectral response acceleration, as defined by the International Building Code,

$$S_{DS} = 2/3 * F_a * S_S$$

- S_{DS} ranges from 0 g to 2 g and the maximum response acceleration of the RRS is 3.2 g, for the two horizontal dimensions. The vertical RRS has two-thirds of the amplitude of the horizontal RRS.



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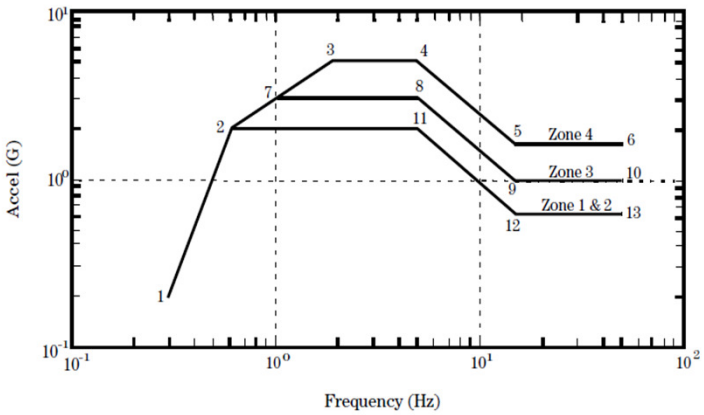
F_a is an acceleration-based site coefficient with a maximum value of 1 and S_S values are assigned based upon geographic location, probability, and severity of seismic activity and ranges from 0% to 300% of the gravitational acceleration.

Specific RRS according to GR-63-CORE

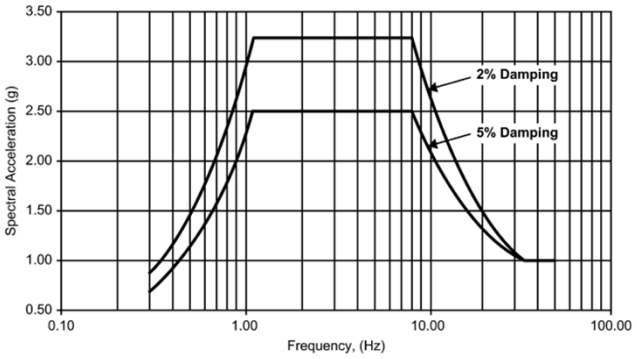
- Telcordia GR-63-CORE is developed in America for Telecom and Network equipment. Original version was created by the Bell company. It is now managed by Telcordia – an Ericsson company.
- Seismic risk zone 4 is often used to make the qualification universal. RRS has 5 g in the strong part (2-5 Hz).
- Corresponding time record VERTEQII, has been synthesized from several typical earthquakes and for different building and soil site conditions.
- Single axis testing is instructed

Figure 5-18 Required Response Spectra



High performance level RRS from IEEE std 693

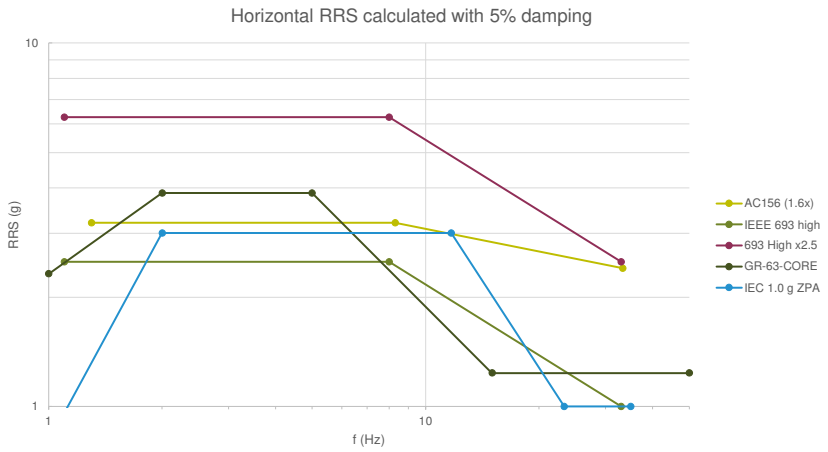
- High performance level is toughest and mostly used, in IEEE std. 693, with RRS level at 2.5 g in the strong part (1.1-8.0 Hz) and 1.0 g ZPA.
- Vertical RRS is 80% of above
- For installations with flexible support structure, equipment shall be qualified to 2.5 × RRS to count for potential dynamic amplification of the input acceleration
- Only triaxial testing is recognized in the current 2018 issue



Why are requirements different?

- One can question use of different descriptions for the same target earthquake
- However,
  - different applications may have installations that amplify vibrations differently
  - testing shall be conservative, but need for safety margin may be different

RRS comparison



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Handling of multiple requirements

- Different requirements and different vibration severities are likely for the qualification testing of a product, from different markets or customers
- In this case, there are two options for making successful qualification that covers for several requirements:
  1. An envelope of all RRS representing the individual requirements is made, which comes with an over-testing penalty
  2. Testing needs to be performed according to each standard or requirement, in sequence

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Thank you!

- Welcome to have a look a shake table, at the RISE Applied Mechanics lab