Evaluation and Screening Process for High Frequency Sensitive Equipment

James Parello
Westinghouse Electric Company

Evaluation and Screening Process for High Frequency Sensitive Equipment

Background

- Central and Eastern United States (CEUS) plants on rock sites may exceed the Certified Seismic Design Response Spectra (CSDRS) for frequencies greater than 10 Hz
- EPRI White Paper, “Considerations for NPP Equipment and Structures Subjected to Response Levels Caused by High Frequency Ground Motions,” sent to the USNRC (March 2007)
  - Considerations for nuclear power plant (NPP) equipment and structures subjected to response levels caused by high frequency (HF) ground motions
  - Summarizes a significant amount of empirical and theoretical evidence as well as regulatory precedents
  - Conclusion - HF motions are non-damaging to virtually all types of NPP structures, systems, and components (SSCs) with the exception of potentially HF-sensitive components

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Background (Cont'd)

- Key Further Actions Requested by the USNRC
  - Identify potentially HF-sensitive components
  - Establish screening criteria
  - Develop evaluation methods
  - Recommend additional testing procedures as appropriate
- Recommended industry approach in EPRI White Paper, "Seismic Screening of Components Sensitive to High Frequency Vibratory Motions," sent to USNRC (June 2007)

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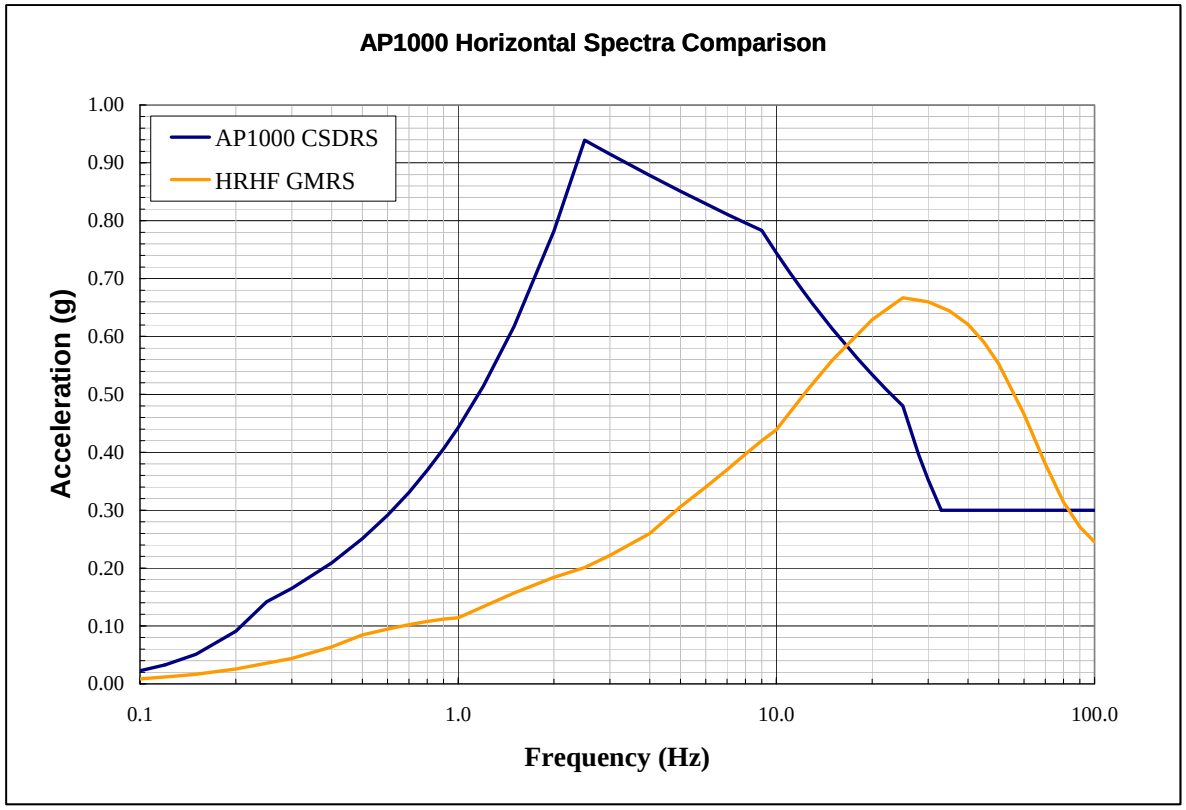

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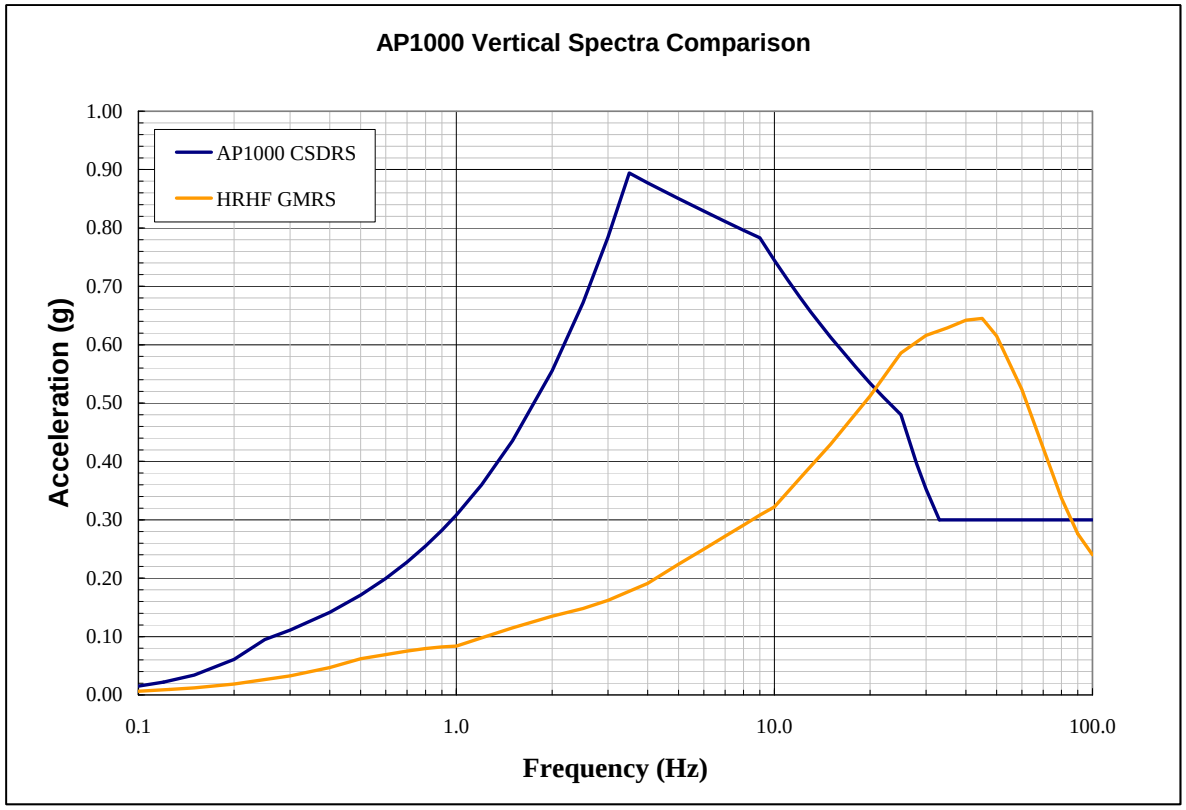

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Potential Failure Modes of HF-Sensitive Components

- Change of state
- Contact chatter
- Change in output or set-point
- Electrical connection discontinuity or intermediacy
- Mechanical connection loosening
- Mechanical misalignment/binding
- Cyclic strain effects
- Wiring not properly restrained
- Inadequately secured fasteners/connections

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Potentially HF-Sensitive Components

- Electro-mechanical relays (e.g., control relays, time delay relays, protective relays)
- Electro-mechanical contactors (e.g., motor control center (MCC) starters)
- Circuit breakers (e.g., molded case and power breakers – low and medium voltage)
- Auxiliary contacts (e.g., for molded case circuit breakers (MCCBs), fused disconnects, contactors/starters)
- Control switches (e.g., benchboard, panel, operator switches)

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Potentially HF-Sensitive Components (Cont'd)

- Transfer switches (e.g., low and medium voltage switches with instrumentation)
- Process switches and sensors (e.g., pressure/diff. pressure, temperature, level, limit/position, and flow) (calibration stability)
- Mechanical and trimmer potentiometers
- Digital/solid-state devices (connectors and connections)

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Evaluation Methods

- All safety-related components will be qualified to In-Structure Response Spectra (ISRS) developed from CDSRS
- Where site-specific ground motion response spectra (GMRS) exceed CDSRS in the HF region, an evaluate is performed to demonstrate HF-sensitive component acceptability
- Goal is to demonstrate that potential HF-sensitive safety-related components are acceptable or screened out for their application
- Acceptable methods for resolving HF concerns:
  - Review existing equipment qualification test data for adequate HF input motion
  - Review circuits containing potentially sensitive items for inappropriate system actions due to chatter or set point drifts
  - Perform screening test to identify any HF vulnerabilities

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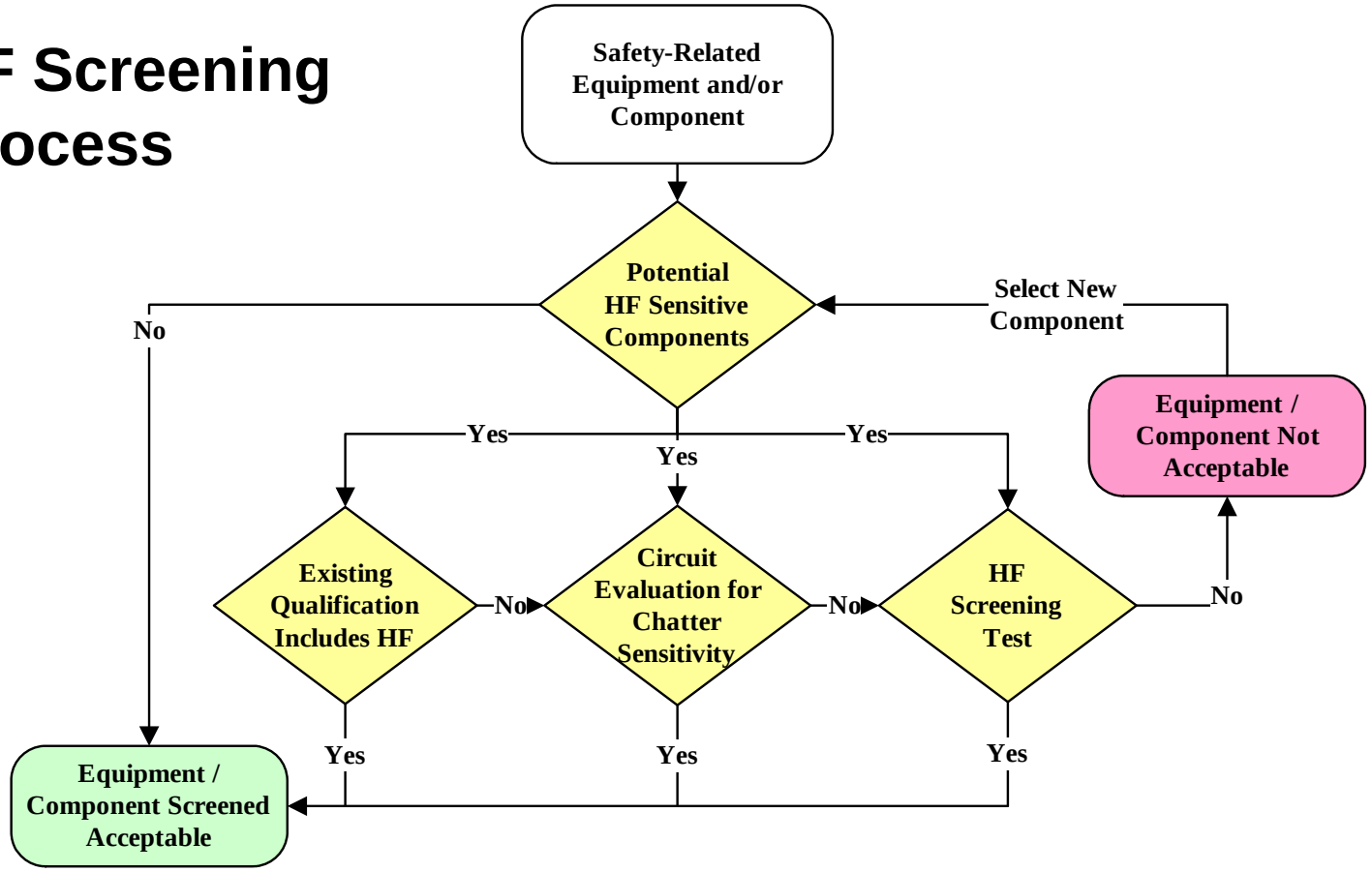
HF Screening Process



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HF (Vibration) Screening Test

- Screening Test (25Hz - 50Hz)
  - Sine sweep
  - Sine Beat dwell at 1/6 octave intervals
  - Random time history
- Input acceleration amplitudes sufficient to produce
  - 5g spectral response (5% damping) for floor mounted components
  - 15g spectral response (5% damping) for enclosure/rack mounted components
- Functional monitoring during testing to verify component acceptance

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Westinghouse HF Evaluation Process

- Comparative seismic analyses of typical structures housing safety-related electrical equipment
- Review of existing seismic test data for HF content and equipment performance
- Develop a screening process for HF-sensitive equipment and components
- Develop a methodology to address safety-related components sensitive to high frequency seismic excitation

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Comparative Seismic Analysis

- Purpose
  - Evaluate the effects of Hard Rock High Frequency (HRHF) seismic input on typical safety-related equipment structures
- Selection of Equipment and Finite Element Models
  - Typical equipment provided for nuclear power plants
  - Safety-related cabinet type equipment that may be sensitive to high frequency input
  - Use of existing finite element models validated on previous projects

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Comparative Seismic Analyses

- Conclusions:
  - Equipment exhibiting dominant natural frequencies below HRHF exceedance range or above 50 Hz do not require any additional treatment for HF seismic requirements
  - Equipment exhibiting dominant natural frequencies which coincide with the peak spectral acceleration of the HRHF SSE RRS will require additional HF evaluation to verify acceptability

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Review Existing Seismic Test Data

- Purpose
  - Determine if high frequency excitation is exhibited in 25 to 50 Hz frequency range during traditional low frequency seismic testing
- Selection of Seismic Test Programs
  - Typical equipment provided for commercial and nuclear power plant applications
  - Equipment functional monitoring during testing to verify component acceptance
  - Seismic test inputs were in compliance with IEEE Std 344-1987

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Review of Existing Seismic Test Data

- Conclusions:
  - Seismic test programs envelop HRHF SSE RRS up to 2g peak spectral acceleration (5% damping)
  - Supplemental HF testing when all of the following factors are present:
    - Equipment has potential high frequency failure modes,
    - HRHF SSE RRS peak region coincides with equipment dominant natural frequencies, and
    - HRHF SSE RRS is greater than 2g peak spectral acceleration (5% damping)

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Screening Process for HF-Sensitive Equipment

- HF-sensitive equipment are those safety-related equipment and components with potential failure modes involving change of state, chatter, signal change/drift, and connection problems
- HF-sensitive equipment are screened out or found acceptable for HRHF SSE RRS
- HF susceptibility requires all of the following factors to be present:
  - HRHF SSE RRS exceeds the AP1000 CSD SSE ISRS
  - Equipment dominant frequencies in the HF exceedance range
  - HRHF SSE RRS is greater than 2g peak spectral acceleration (5% damping)

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Evaluation Methodology for HF-Sensitive Equipment

Group No. 1

- Rugged equipment with dominant natural frequencies > 50 Hz
- Seismic qualification based on AP1000 CSD SSE ISRS is adequate and supplemental HF evaluation for HRHF SSE RRS is not required

Group No. 2

- Equipment dominant natural frequencies below the HRHF exceedance frequency range
- Seismic qualification based on AP1000 CSD SSE ISRS is adequate and supplemental HF evaluation for HRHF SSE RRS is not required

Group No. 3

- Equipment with dominant natural frequencies in HRHF exceedance range
- Seismic qualification based on AP1000 CSD SSE ISRS
- HF evaluation to verify acceptability is required

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Evaluation Methodology for HF-Sensitive Equipment (Cont'd)

- Evaluation of Group No. 3 Equipment
  - ➢ Perform review of HF-sensitive component safety functions and potential HF failure modes for SSE condition
    - Potential HF failure modes not impacting the ability of the equipment to perform its safety function are excluded
    - Potential failure modes associated with mounting, connections and fasteners, joints, and interface are considered to be acceptable based on seismic qualification per IEEE Std 344 to AP1000 CSD ISRS
  - ➢ Supplemental HF testing is not required for qualified equipment whose seismic level envelops the HRHF SSE RRS

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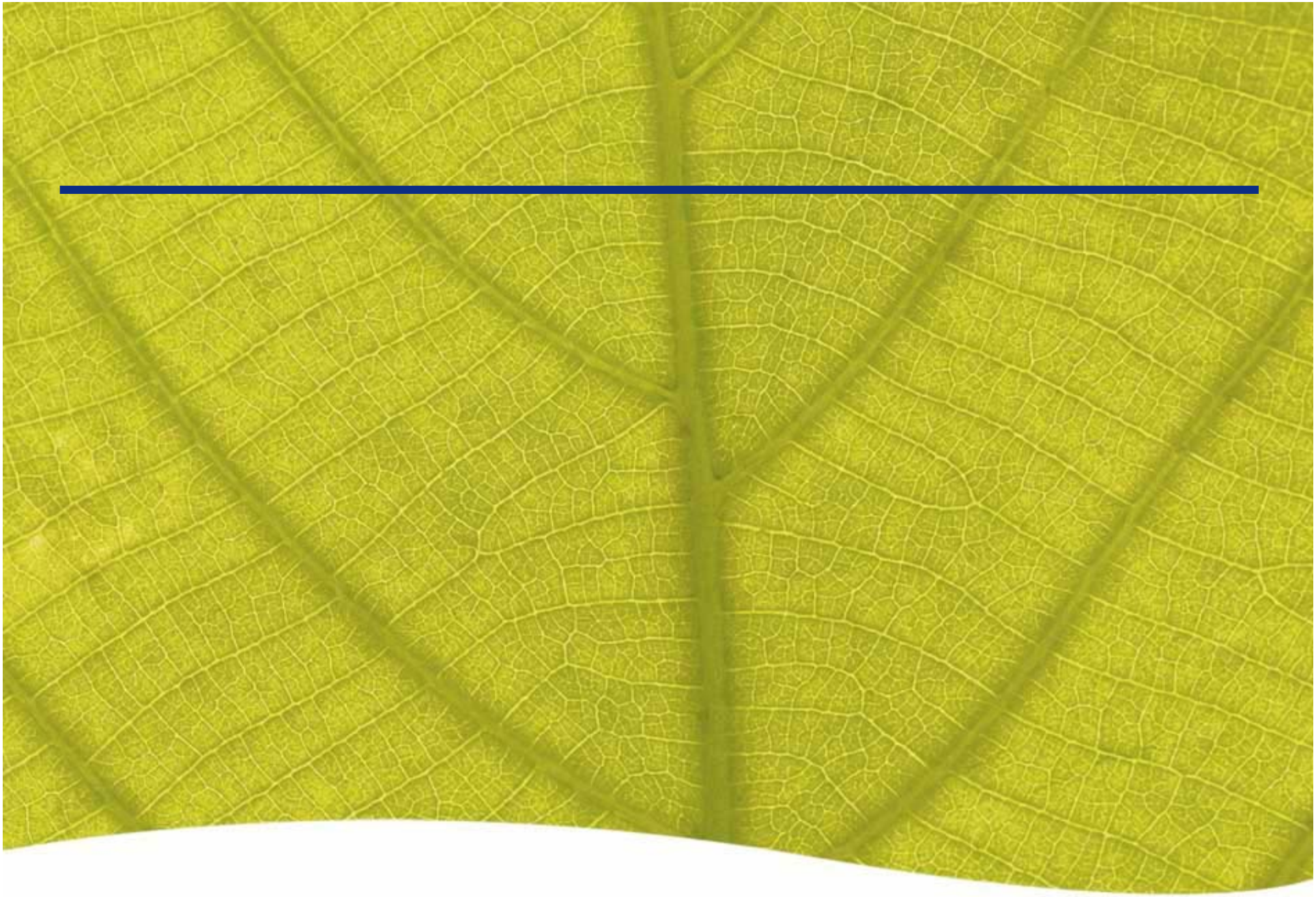
Evaluation Methodology for HF-Sensitive Equipment (Cont'd)

- Evaluation of Group No. 3 Equipment (Cont'd)
  - Supplemental HF testing is required when HRHF SSE RRS is greater than 2g peak spectral acceleration (5% damping)
  - Supplemental seismic testing is the preferred HF screening method when low frequency seismic testing does not envelop the HRHF SSE RRS



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