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RESEARCH INSTITUTE

New Plant Seismic Issues Resolution Program

High-Frequency Response Effects:
Component Screening

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HF Working Group

- Utilities
 - J. Richards, Duke
 - D. Moore, Southern Co.
 - R. Whorton, SCE&G
- EPRI
 - R. Kassawara
- Vendors (SEQ Specialists)
 - N. Burstein, AREVA
 - J. Gleason, GE
 - J. Parello, Westinghouse
- Test lab
 - G. Chapman, Trentec
- Consultants
 - K. Merz and G. Hardy, ARES
 - W. Schmidt, MPR
- Inputs from many others

Background

- CEUS plants on rock sites may exceed the CSDRS for frequencies greater than 10 Hz
- EPRI White Paper Sent to the USNRC (March 16, 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, which support the conclusion that such HF motions are non-damaging to virtually all types of nuclear power plant structures, systems, and components (SSCs) with the exception of potentially HF sensitive components
- Key Further Actions Requested by the USNRC
 - Identify potentially high-frequency sensitive components
 - Establish screening criteria
 - Develop evaluation methods
 - Recommend additional testing procedures as appropriate

Existing HF Test Data

- NPP safety-related active components have been seismically qualified by IEEE 344 random multi-frequency type tests for over 30 years with HF content present, e.g.
 - HF motion due to ball-joints and kinematic linkages of shake tables
 - Intentional HF, such as inclusion of concurrent BWR hydrodynamic response
- Existing qualification test data for a component can be used to demonstrate that such exceedances do not affect component function

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

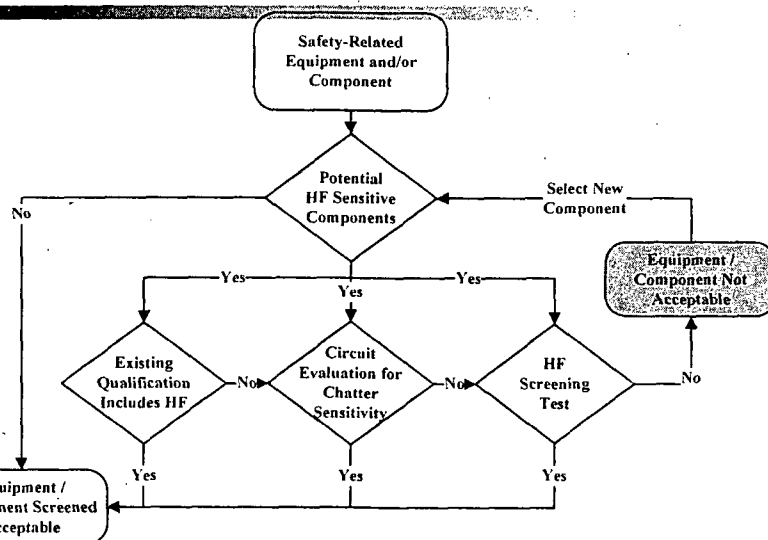
Potentially HF Sensitive Components

- 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)
- 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)

Evaluation Methods

- Acceptable methods for resolving HF concerns not already addressed by certified design qualification include:
 - Review existing equipment qualification test data for adequate HF input motion
 - Review circuits containing potentially sensitive items for inappropriate system actions due to intermediacy or set point drifts
 - Screening test to identify any HF vulnerabilities
- Goal is to demonstrate that potential HF vulnerabilities are not present

HF Screening Process



Screening Test Recommendations

- High-frequency motion between 25 and 50 Hz (octave interval, overlap with CD qualification frequency range < 33 Hz)
- Input amplitude related to representative screening spectral acceleration with test amplification associated with 5% damping [$SA=(Q)(A)$]
 - Sine Sweep (log or linear rate) ($Q_{ss}= 9-10$)
 - Sine Beat at 1/3 octave spacing [25, 31.5, 40, 50 Hz] (5 cycle/beat, $Q_{5sb}=5.56$)(10 cycle/beat, $Q_{10sb}=7.6$)
 - Band-limited White Noise ($Q_{bl}=\sqrt{10}$, pk factor=2.65)
 - Random Time History ($Q_r=\sqrt{10}= 3.2$, duration > 15 - 20 sec)

Screening Test Amplitude

- Screening test level is referenced to a representative HF spectral acceleration level which is used to screen for HF sensitivity.
- Screening level to be proposed by Industry based on the type of test:
 - Sine Sweep: $A=SA/Q_{ss}$, g
 - Sine Beat: $A=SA/Q_{sb}$, g
 - Band-limited White Noise: $PSD=(SA/Q_{bl}/pk)^2/(50-25)$, $grms^2/Hz$
 - Random Time History, $A=SA/Q_r$, g

Screening Test Amplitude (con't.)

- Representative screening spectral acceleration chosen as $SA = 5g$ (for base mounted components)
- In-cabinet mounted components may require consideration of additional amplification, $SA_{ic} = AF(SA)$
- Examples:
 - Sine Sweep, $SA=5g$, $Q_{ss}=10$, $A=5/10=0.5g$
 $AF=3.0$, $A_{ic}=3(0.5)=1.5g$
 - Sine Beat, $SA=5g$, $Q_{5sb}=5.56$, $A=5/5.56=0.90g$
 - Band-limited White Noise, $PSD=(5/3.16/2.65)^2/25$
 $0.14gmrs^2/Hz$
 - Random Time History, $SA=5g$, $Q_r=3.2$, $A=5/3.2=1.56g$

Summary of HF Screening Approach

- Components will be fully qualified for the Certified Seismic Design ISRS
- Any potentially HF-sensitive components will be screened, as discussed herein, to demonstrate that potential high frequency sensitivity is not present
- If existing test data is not available and a system and control logic review indicates that inadvertent change of state or intermediacy must be considered, then a high frequency screening test will be used to demonstrate lack of sensitivity to high frequency vibration in the 25-50 Hz range
 - Sine Sweep (fast linear rate, traditional log rate)
 - Sine Beat at 1/3 octave spacing
 - Band-limited White Noise
 - Random time history
- Function would be fully monitored during the screening test followed by post- test functional testing