**Title:** Short Course on Seismic Ground Motion Development, Seismic Evaluation of Structures, Systems,
and Components, and Nuclear Equipment Qualification

**Potential PDH:** 24 **Code:** BTT038

**Description:**

This course addresses the requirements, regulations, methods and criteria for the environmental and seismic qualification of mechanical systems and components. The course is built around the regulatory requirements in SAR Sections 3.10 and 3.11; and Regulatory Guides 1 .73, 1.89, 1.100, and 1.122; ASME QME-1, IEEE-323, 344, and 382. The course addresses the role of analysis vs. testing, the sequence of tests to be conducted, and the documentation of the test specification and test report.

**Outline:**

Part I: Seismic Ground Motion Development, Seismic Evaluation of Structures, Systems, and Components

1. Development of Input Motions
   - Basics of Probabilistic Seismic Hazard Analysis (PSHA)
   - Hazard Curves
   - Uniform Hazard Spectra
   - Conditional Mean Spectra
   - Basics of Site Response Analysis
   - Terms and Concepts Associated with Site Response Analysis
     - CSDRS, FIRS, outcrop motions, performance based motions
   - Probabilistic vs. Deterministic Site Response Analysis
   - SHAKE
   - Random Vibration Theory
   - Introduction to Soil-Structure Interaction Analysis
     - Frequency Domain Approaches
     - Time Domain Approaches
   - Probabilistic vs. Deterministic Soil-Structure Interaction Analysis
   - When is Soil-Structure Interaction Necessary?
   - References

2. Seismic Evaluation of Structures
   - Equation of Motion for Seismic Excitation
   - Fundamental Ground Motion Equations
   - Linear Response History Analysis
   - Nonlinear Response History Analysis
   - Modal Analysis
   - Mode Superposition
   - Response Spectrum Analysis (RSA)
     - Definition of a Response Spectrum as the Maximum Response of a Series of SDOF Oscillators
     - Fundamental Equations for RSA

- o Relative vs. Absolute quantities
- o Relationship Between Peak Spectral Acceleration and Peak Ground Acceleration
- o Dual Interpretation of the Response Spectrum

• Bouncing Back and Forth Between the Time Domain and the Frequency Domain
• Selection of Damping
• Equivalent Static Analysis
• How to Choose an Appropriate Analysis Method
• References

3. Seismic Evaluation of Subsystems
• Definition and Generation of In-Structure Response Spectra (ISRS)
• Where to Define ISRS
• Treatment of Uncertainties in Generating ISRS
• When are ISRS Required?
• References

Part II: Nuclear Equipment Qualification

1. Seismic Qualification of Mechanical SSCs
• Regulatory Requirements
- o Hierarchy of Regulatory Requirements
- o 10CFR 50 Ap. A General Design Criterion 2
- o 10 CFR Part 50, Appendix S
- o SRP Section 3.2.1 Seismic Classification
- o Requirements of Standard Review Plan (SRP) 3.10
- o SRP 3.7.2 Seismic System Analysis
- o SRP 3.7.2 Seismic System Analysis
- o SRP 3.7.3 Seismic Subsystem Analysis
- o SRP 3.9.2 Dynamic Testing and Analysis of Systems, Structures, and Components
- o Reg. Guide 1.100 Seismic Qualification of Electric and Mechanical Equipment for Nuclear Power Plants.
- o Reg. Guide 1.29 Seismic Design Classification
- o Reg. Guide 1.60 Design Response Spectra for Seismic Design of Nuclear Power Plants
- o Reg. Guide 1.61 Damping Values for Seismic Design of Nuclear Power Plants
- o Reg. Guide 1.61 Damping Values for Seismic Design of Nuclear Power Plants
- o Reg. Guide 1 .73 Qualification Tests of Electric Valve Operators Inside the Containment of Nuclear Power Plants
- o Reg. Guide 1.92 Combining Modal Responses and Spatial Components in Seismic Response Analysis
- o Reg. Guide 1.122 Development of Floor Design Response Spectra for Floor-Supported Equipment or Components

• Codes and Standards
- o ASME III Seismic Design
- o ASME QME-1 Qualification of Active Mechanical Equipment Used in Nuclear Facilities
- o IEEE 323 and 344 Guide for Seismic Qual. of Class 1 Electric Equipment for Nuclear

Power
Generating Stations
- o IEEE 382 Random Input Motion Seismic Testing for Valve Actuators
- o SQUG GIP in QME and IEEE 344

- Implementation
  - o Specification for Seismic Analysis and Qualification
  - o Specification for Seismic Qualification by Testing
  - o Functional Requirements for Pumps and Valves
  - o What to do after a Tremor, North Anna Experience
  - o Reg. guide 1.97 Instrumentation for Light-Water-Cooled Nuclear Power Plants to Assess Plant and Environs
  - o Conditions During and following and Accident.
  - o Regulatory Guide 1.167 Restart of a Nuclear Power Plant Shut Down by a Seismic Event
  - o EPRI Report 3002000720 - Guidelines for Nuclear Plant Response to an Earthquake

2. Environmental Qualification of Mechanical SSCs

- Regulatory Requirements
  - o Hierarchy of Regulatory Requirements
  - o 10CFR 50 Ap. A General Design Criterion 4 Environmental and Dynamic Effects Design Bases
  - o 10 CFR 50.49, "Environmental Qualification of Electric Equipment Important to Safety for Nuclear Power Plants."
  - o SRP 3.11 Environmental Qualification of Mechanical and Electrical Equipment
  - o SRP 3.9.6 Functional Design, Qualification, and Inservice Testing Programs for Pumps, Valves
  - o SRP 3.6 Pipe Rupture Postulation

- Codes and Standards
  - o ASME QME-1 Qualification of Active Mechanical Equipment Used in Nuclear Facilities
  - o IEEE 323 Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations

- Implementation
  - o Bounding Environments inside Containment
  - o Specification for Environmental Qualification
  - o Functional Requirements for Pumps and Valve

**Instructor:**

Mr. George Antaki, PE, Fellow ASME, Becht Engineering, Aiken SC USA, has over 43 years of experience in design, qualification, fabrication, trouble-shooting, fitness-forservice, and repairs of ASME pressure equipment and piping systems. He is past vicechairman of API 579/ASME FFS joint committee, and past member of ASME PCC-2. He is currently member of several ASME Code

Committees, and a master instructor for ASME. He is the author of three textbooks on integrity and repairs of pressure equipment and piping systems.