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DRAFT REGULATORY GUIDE

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(Proposed Revision 3 of Regulatory Guide 1.100, dated June 1988)

SEISMIC QUALIFICATION OF ELECTRIC AND ACTIVE MECHANICAL EQUIPMENT AND FUNCTIONAL QUALIFICATION OF ACTIVE MECHANICAL EQUIPMENT FOR NUCLEAR POWER PLANTS

A. INTRODUCTION

This guide describes methods that the staff of the U.S. Nuclear Regulatory Commission (NRC) considers acceptable for use in seismic qualification of electric and active mechanical equipment and functional qualification of active mechanical equipment for nuclear power plants (NPPs).

For seismic qualification of electric and active mechanical equipment, the general requirements appear in Title 10, Part 50, "Domestic Licensing of Production and Utilization Facilities," of the *Code of Federal Regulations* (10 CFR Part 50) (Ref. 1) and 10 CFR Part 52, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants." (Ref. 2) Particular sections include General Design Criterion (GDC) 1, "Quality Standards and Records," GDC 2, "Design Bases for Protection Against Natural Phenomena," and GDC 4, "Environmental and Dynamic Effects Design Basis," of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50; Criterion III, "Design Control," Criterion XI, "Test Control," and Criterion XVII, "Quality Assurance Records," of

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This regulatory guide is being issued in draft form to involve the public in the early stages of the development of a regulatory position in this area. It has not received final staff review or approval and does not represent an official NRC final staff position.

Public comments are being solicited on this draft guide (including any implementation schedule) and its associated regulatory analysis or value/impact statement. Comments should be accompanied by appropriate supporting data. Written comments may be submitted to the Rulemaking, Directives, and Editing Branch, Office of Administration, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001; emailed to NRCREP@nrc.gov; submitted through the NRC's interactive rulemaking Web page at http://www.nrc.gov; faxed to (301) 415-5144; or hand-delivered to Rulemaking, Directives, and Editing Branch, Office of Administration, US NRC, 11555 Rockville Pike, Rockville, Maryland 20852, between 7:30 a.m. and 4:15 p.m. on Federal workdays. Copies of comments received may be examined at the NRC's Public Document Room, 11555 Rockville Pike, Rockville, MD. Comments will be most helpful if received by July 11, 2008.

Electronic copies of this draft regulatory guide are available through the NRC's interactive rulemaking Web page (see above); the NRC's public Web site under Draft Regulatory Guides in the Regulatory Guides document collection of the NRC's Electronic Reading Room at http://www.nrc.gov/reading-rm/doc-collections/; and the NRC's Agencywide Documents Access and Management System (ADAMS) at http://www.nrc.gov/reading-rm/adams.html, under Accession No. ML072620346.

Appendix B, “Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants,” to 10 CFR Part 50; and Appendix S, “Earthquake Engineering Criteria for Nuclear Power Plants,” to 10 CFR Part 50.

Section III, “Definitions,” of Appendix S to 10 CFR Part 50 states that the structures, systems, and components (SSCs) required to withstand the effects of the safe-shutdown earthquake (SSE) ground motion or surface deformation are those necessary to assure (1) the integrity of the reactor coolant pressure boundary; (2) the capability to shut down the reactor and maintain it in a safe-shutdown condition; or (3) the capability to prevent or mitigate the consequences of accidents that could result in potential offsite exposures comparable to the guideline exposures of 10 CFR 50.34(a)(1). Section IV(a)(1)(ii) of Appendix S to 10 CFR Part 50 requires that the NPP must be designed so that, if the SSE ground motion occurs, certain SSCs will remain functional and within applicable stress, strain, and deformation limits. In addition to seismic loads, the design of these safety-related SSCs must take into account applicable concurrent normal operating, functional, and accident-induced loads. Section IV (a)(1)(iii) of Appendix S to 10 CFR Part 50 requires that the safety functions of SSCs must be assured during and after the vibratory ground motion associated with the SSE ground motion through design, testing, or qualification methods.[1]

The general requirements for functional qualification of active mechanical equipment also appear in 10 CFR Part 50 and 10 CFR Part 52. In 10 CFR Part 50, particular sections include GDC 1, “Quality Standards and Records,” GDC 4, “Environmental and Dynamic Effects Design Basis,” GDC 14, “Reactor Coolant Pressure Boundary,” GDC 15, “Reactor Coolant System Design,” GDC 30, “Quality of Reactor Pressure Boundary,” GDC 37, “Testing of Emergency Core Cooling System,” GDC 40, “Testing of Containment Heat Removal System,” GDC 43, “Testing of Containment Atmosphere Cleanup Systems,” GDC 46, “Testing of Cooling Water Systems,” and GDC 54, “Piping Systems Penetrating Containment,” of Appendix A to 10 CFR Part 50, as well as Criteria III, XI, and XVII of Appendix B to 10 CFR Part 50.

The NRC issues regulatory guides to describe to the public methods that the staff considers acceptable for use in implementing specific parts of the NRC regulations, to explain techniques that the staff uses in evaluating specific problems or postulated accidents, and to provide guidance to applicants. Regulatory guides are not substitutes for regulations and compliance with them is not required.

This regulatory guide contains information collection requirements covered by 10 CFR Part 50 and 10 CFR Part 52, and that the Office of Management and Budget (OMB) approved under OMB control numbers 3150-0011 and 3150-0151. The NRC may neither conduct nor sponsor, and a person is not required to respond to, an information collection request or requirement unless the requesting document displays currently valid OMB control numbers.

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[1] Appendix S to 10 CFR Part 50 applies to applicants for a design certification or combined license pursuant to 10 CFR Part 52 or a construction permit or operating license pursuant to 10 CFR Part 50 after January 10, 1997. However, the earthquake engineering criteria in Section VI, “Application to Engineering Design,” of Appendix A, “Seismic and Geologic Siting Criteria for Nuclear Power Plants,” to 10 CFR Part 100, “Reactor Site Criteria,” continue to apply for either an operating license applicant or holder with a construction permit issued before January 10, 1997.

B. DISCUSSION

Background

The NRC issued Revision 2 of Regulatory Guide 1.100, “Seismic Qualification of Electric and Mechanical Equipment for Nuclear Power Plants,” (Ref. 3) in June 1988. With a few exceptions and clarifications, it endorsed the Institute of Electrical and Electronics Engineers (IEEE) Std 344-1987, “IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations,” (Ref. 4) and extended the application of that standard to the seismic qualification of mechanical equipment. In extending the application of IEEE Std 344-1987 to mechanical equipment, the NRC staff recognized differences in seismic qualification methods for electric equipment[2] (including instrumentation and control (I&C) components) and mechanical equipment. Specifically, Revision 2 of this regulatory guide stated that seismic qualification of mechanical equipment by analysis is permitted when such equipment can be modeled to adequately predict its response. Revision 2 also stated that the American Society of Mechanical Engineers (ASME) was developing a standard for seismic qualification of mechanical equipment and, upon publication of that standard the NRC staff would review it for suitability for endorsement by a revision of this regulatory guide.

In 1994, the ASME issued a standard, ASME QME-1-1994, “Qualification of Active Mechanical Equipment Used in Nuclear Power Plants.” (Ref. 5) The ASME QME-1 covers both seismic qualification and functional qualification of active mechanical equipment. The ASME subsequently revised and reissued the standard in 1997, 2000, and 2002, with the last revision issued in November 2007 as ASME QME-1-2007 (Ref. 6). Furthermore, the IEEE updated IEEE Std 344-1987 and issued it as IEEE Std 344-2004 (Ref. 7) in June 2005.

The NRC developed this regulatory guide (i.e., Revision 3) to endorse, with exceptions and clarifications, the IEEE Std 344-2004 and the ASME QME-1-2007. (This is the first time the NRC is endorsing ASME QME-1). Specifically, Sections B.1 and C.1 of this regulatory guide endorse, with exceptions and clarifications, the entire IEEE Std 344-2004 and Section QR, “General Requirements,” and Nonmandatory Appendix QR-A, “Seismic Qualification of Active Mechanical Equipment,” of ASME QME-1-2007 for the seismic qualification of electric and active mechanical equipment, respectively. Sections B.2 and C.2 of this regulatory guide endorse, with exceptions and clarifications, Section QR and the remaining sections of ASME QME-1-2007 (except Nonmandatory Appendix QR-A) for the functional qualification of active mechanical equipment. The ASME QME-1 defines active mechanical equipment as “Mechanical equipment containing moving parts, which, in order to accomplish its required function as defined in Qualification Specification, must undergo or prevent mechanical movement. This includes any internal components or appurtenances whose failure degrades the required function of the equipment.”

1. Seismic Qualification of Electric and Active Mechanical Equipment

The major change from IEEE Std 344-1987 to IEEE Std 344-2004 is the update and expansion of Clause 10, “Experience,” which describes the use of experience data as a method for seismic qualification of Class 1E electric equipment (including I&C components). Experience data include earthquake

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2 Hereafter in this regulatory guide, the term “electric equipment” means an assembly of electric and electronic components designed and manufactured to perform specific functions, and the term “electric component” or “electronic component” means items from which the equipment is assembled (e.g., resistors, capacitors, wires, connectors, microprocessors, switches, springs, and instrumentation and control items).

experience data and test experience data. Nonmandatory Appendix QR-A to ASME QME-1-2007, which has been updated and expanded from Nonmandatory Appendix QR-A to ASME QME-1-2002, also includes the use of experience data as a method for seismic qualification of active mechanical equipment.

The use of earthquake experience data for seismic qualification of electric and mechanical equipment has its origin in the NRC research program associated with Unresolved Safety Issue (USI) A-46, "Seismic Qualification of Mechanical and Electric Equipment in Operating Nuclear Power Plants." In 1980, the NRC staff raised a safety concern that licensees had not conducted the seismic qualification of electric and mechanical equipment in some older vintage NPPs (i.e., plants with construction permit applications docketed before about 1972) in accordance with the licensing criteria for seismic qualification of equipment acceptable at that time (i.e., IEEE Std 344-1975 (Ref. 8) and Regulatory Guide 1.100, Revision 1, (Ref. 9) issued August 1977). Therefore, equipment in the older vintage NPPs may not have been adequately qualified to ensure its structural integrity and/or proper functionality in the event of an SSE ground motion. As a result, the NRC established the USI A-46 program in December 1980 and, in February 1987, issued Generic Letter (GL) 87-02, "Verification of Seismic Adequacy of Mechanical and Electric Equipment in Operating Reactors, Unresolved Safety Issue (USI) A-46," (Ref. 10) to address this safety concern. The NRC staff categorized approximately 70 NPP units in the United States as "USI A-46 plants."

In 1982, the Seismic Qualification Utility Group (SQUG) undertook the development of an earthquake experience and a test experience database to address USI A-46. Because of the scarcity and low intensity level of earthquakes to which U.S. NPPs were exposed, the SQUG and its contractors performed a pilot study to determine the feasibility of using actual earthquake experience data from nonnuclear plants located worldwide (e.g., fossil-fueled power plants, substations, petrochemical plants) and existing test experience data from domestic NPPs to evaluate the performance of electric and mechanical equipment in those facilities to infer the susceptibility of similar NPP equipment to seismic loads. The SQUG concluded, and the NRC agreed, that the use of experience data was feasible for the purpose of verifying equipment seismic adequacy for the older vintage USI A-46 plants.

Large uncertainties exist in the seismic qualification of equipment as a class on the basis of earthquake experience data because (1) it is difficult to compile a credible earthquake experience database (e.g., estimation of ground and floor earthquake excitations used in the earthquake experience database); (2) the inclusion rules and exclusion rules (termed "prohibited features" in IEEE Std 344-2004) of equipment in the database may not be complete; (3) the similarity between equipment in fossil/petrochemical plants in the database and those in NPPs is difficult to establish; and, most importantly, (4) generally there is no credible information from the earthquake experience database to provide assurance of the proper functionality of certain active electric equipment during earthquakes. Active electric equipment is the equipment that must either undergo a change of state or prevent a change of state in order to accomplish its required functions. The NRC staff is particularly concerned about the use of earthquake experience data for seismic qualification of active electric equipment that may inadvertently change state during an earthquake such that its intended safety functions are not performed during and/or after an earthquake. Examples of such active electric components are certain types of relays, contactors, circuit breakers, switches, sensors, and potentiometers.

The NRC has three concerns regarding the use of test experience data for the seismic qualification of electric equipment. First, it is difficult to quantify the damage potential of equipment under testing since it depends on the combination of input motion and the equipment item exhibiting a particular malfunction. The resonant frequency corresponding to a given malfunction is mostly unknown, and this frequency for each item of equipment of the same class can differ significantly. There could be multiple malfunction mechanisms for components and subcomponents that need to be considered in comparing the test response spectra (TRS) and the required response spectra (RRS). Therefore, an equipment capacity factor has to be considered to cover the uncertainties in high-level testing for an equipment class. Second, the technologies and designs of certain electric components (such as certain types of relays and microprocessor-based components) have undergone significant changes since the NRC issued Revision 2 of this regulatory guide, as a result of the more prevalent use of digital I&C components in place of the traditional analog I&C components. Some solid-state relays and microprocessor-based components are quite fragile in terms of withstanding earthquake excitations. The staff considers the use of test experience data from the old-vintage electric components of this type for the seismic qualification of the new generation of such electric components to be inappropriate and unacceptable. Third, since no new NPPs were built after the early 1980s, a number of manufacturers for electric or active mechanical equipment are no longer in business, and the appropriateness of using the test experience of old equipment made by manufacturers no longer in business for the seismic qualification of modern equipment designs made by different manufacturers is highly questionable.

The NRC staff has two other concerns as well. The NRC staff has a concern regarding electric and active mechanical equipment exposed to harsh environments, aging, and earthquakes. In such cases, the NRC staff does not find it acceptable to use experience data (earthquake or test experience data) for seismic qualification of equipment. The test sample shall be subjected to simulated operating-basis earthquake (OBE) and SSE seismic vibrations in accordance with IEEE Std 344-2004.

Another NRC staff concern is the high-frequency earthquake ground motion for certain plant sites. Recent studies related to the early site permit applications at certain hard-rock-based plants along the east coast of the United States indicated that the site-specific spectra may exceed the certified design spectra of those new plants in the high-frequency range (20 hertz (Hz) and above). This exceedance cannot always be eliminated, even with incoherency added to the soil-structure interaction analyses. As a result of the high-frequency ground motion, the seismic input to SSCs may also contain high-frequency excitations. For operating boiling-water reactor (BWR) plants, the seismic qualifications of some safety-related electric and active mechanical equipment were performed using IEEE-344-type tests with intentional high-frequency contents to account for concurrent BWR hydrodynamic loads. However, the vast majority of existing seismic qualification tests used input frequencies up to only 33 Hz, although the TRS may have shown a zero period acceleration (ZPA) up to 100 Hz. Ball joints and kinematics linkages of the shake tables generated these inadvertent high frequencies, which the NRC staff considers to be noise signals that may not have the proper frequency content with sufficient energy to be compatible with the amplified region of the RRS at high frequencies. Therefore, any attempt to use such past test experience data for the seismic qualification of high-frequency-sensitive equipment or fragile components in such plants clearly is not appropriate. When new seismic qualification tests are planned for equipment in such plants, the formulation of the test input waveforms should properly consider this high-frequency ground motion concern.

2. Functional Qualification of Active Mechanical Equipment

The ASME QME-1-2007 describes requirements and guidelines for qualifying active mechanical equipment used in NPPs. The foreword to the standard indicates that the standard may be applied to future NPPs or existing operating NPP component replacements, modifications, or additions, as determined by regulators and the NPP licensees. The ASME QME-1-2007 provides functional qualification guidance for nonmetallic parts, dynamic restraints, pumps, and valves. The following sections and appendices of ASME QME-1-2007 provide the functional qualification guidance for this active mechanical equipment—(1) Section QR, (2) Nonmandatory Appendix QR-B, "Guide for Qualification of Nonmetallic Parts," (3) Section QDR, "Qualification of Dynamic Restraints," and its Nonmandatory Appendices QDR-A, "Functional Specification for Dynamic Restraints," QDR-B, "Restraint Similarity," and QDR-C, "Typical

Values of Restraint Functional Parameters," (4) Section QP, "Qualification of Active Pump Assemblies," and its Nonmandatory Appendices QP-A, "Pump Specification Checklist," QP-B, "Pump Shaft-Seal System Specification Checklist," QP-C, "Pump Turbine Driver Specification Checklist," QP-D, "Pump Similarity Checklist," and QP-E, "Guidelines for Shaft-Seal System Material and Design Consideration," and (5) Section QV, "Functional Qualification Requirements for Active Valve Assemblies for Nuclear Power Plants," and its Mandatory Appendix QV-1, "Qualification Specification for Active Valves." The major change from ASME QME-1-2002 to ASME QME-1-2007 in terms of the functional qualification of mechanical equipment is a complete rewrite of Section QV and the new Mandatory Appendix QV-1.

In the 1980s and 1990s, operating experience at NPPs revealed a number of weaknesses in the initial design, qualification, testing, and performance of motor-operated valves (MOVs). For example, some engineering analyses used in the original sizing and setting of MOVs were found to predict inadequately the thrust and torque required to open and close valves under design-basis conditions. Similarly, some testing methods used to measure valve stroke times under zero differential-pressure and flow conditions were found not to detect deficiencies that could prevent MOVs from performing their safety functions under design-basis conditions. Both regulatory and industry research programs later confirmed weaknesses in the performance of MOVs. Such programs included extensive NRC research to study the performance of MOVs under various flow, temperature, and voltage conditions, and a nuclear-industry-sponsored program by the Electric Power Research Institute (EPRI) to develop a computer methodology to predict the performance of MOVs under a wide range of operating conditions.

Responding to weaknesses found in the initial design, qualification, testing, and performance of MOVs, the NRC issued GL 89-10, "Safety-Related Motor-Operated Valve Testing and Surveillance," (Ref. 11) in June 1989, which requested licensees to (1) ensure the capability of MOVs in safety-related systems to perform their intended functions by reviewing MOV design bases; (2) verify MOV switch settings initially and periodically; (3) test MOVs under design-basis conditions when practicable; (4) improve evaluations of MOV failures and necessary corrective action; and (5) trend MOV problems. The NRC staff evaluated various MOV NPP programs through onsite inspections of the design-basis capability of safety-related MOVs.

In support of the regulatory activities to ensure MOV design-basis capability, the NRC conducted a research program to test several MOVs under normal flow and blowdown conditions. The NRC summarized the results of this MOV research program in Information Notice (IN) 90-40, "Results of NRC-Sponsored Testing of Motor-Operated Valves," (Ref. 12) dated June 5, 1990. The testing revealed that (1) more thrust was required to operate gate valves than predicted by standard industry methods; (2) some valves were internally damaged under blowdown conditions and their operating requirements were unpredictable; (3) static and low-flow testing might not predict valve performance under design-basis flow conditions; (4) during valve opening strokes, the highest thrust requirements might occur at unseating or in the flow stream; (5) partial valve stroking did not reveal the total thrust required to operate the valve; (6) torque, thrust, and motor operating parameters were needed to fully characterize MOV performance; and (7) reliable use of MOV diagnostic data requires accurate equipment and trained personnel.

To assist NPP licensees in responding to GL 89-10, the EPRI developed the MOV Performance Prediction Methodology (PPM) to determine dynamic thrust and torque requirements for gate, globe, and butterfly valves based on first principles of MOV design and operation. The EPRI described the methodology in Topical Report TR-103237, Revision 2, "EPRI MOV Performance Prediction Program," (Ref. 13) issued in April 1997. The EPRI MOV PPM program included the development of improved methods for the prediction and evaluation of system flow parameters; gate, globe, and butterfly valve performance; and motor-actuator rate-of-loading effects (load-sensitive behavior). The EPRI conducted numerous valve tests to provide data for the development and validation of the valve performance models and methods, including flow loop testing, parametric flow loop testing of butterfly valve disk designs, and in situ MOV testing. The NRC staff issued a safety evaluation (SE) in March 1996 (Ref. 14) accepting the EPRI MOV PPM with certain conditions and limitations. The NRC staff also issued supplements to the SE in February 1997 (Ref. 15), in April 2001 (Ref. 16), and in September 2002 (Ref. 17) to address updates to the EPRI MOV PPM. The NRC staff alerted licensees to lessons learned from the EPRI MOV program in IN 96-48, "Motor-Operated Valve Performance Issues," (Ref. 18) dated August 21, 1996.

In September 1996, the NRC issued GL 96-05, "Periodic Verification of Design-Basis Capability of Safety-Related Motor-Operated Valves," (Ref. 19) to provide recommendations for ensuring the capability of safety-related MOVs to perform their design-basis functions over the long term. In response to GL 96-05, the NPP owners' groups developed an industrywide Joint Owners' Group (JOG) program on MOV periodic verification to obtain benefits from sharing information among licensees on MOV performance. Following an interim MOV program and extensive dynamic MOV testing at NPPs, in February 2004, the JOG submitted to the NRC the Topical Report MPR-2524, Revision 0, "Joint Owners' Group Motor Operated Valve Periodic Verification Program Summary," (Ref. 20) providing long-term recommendations for the periodic verification of MOVs to be implemented by licensees as part of their commitments to GL 96-05. The NRC staff completed an SE on its evaluation of the JOG topical report in September 2006 (Ref. 21)

In the late 1990s, the NRC conducted research to study the performance of alternating current (ac)-powered MOV motor actuators manufactured by Limitorque Corporation under various temperature and voltage conditions. For the Limitorque ac-powered motor-actuator combinations tested, the research indicated that (1) actuator efficiency might not be maintained at the "run" efficiency published by the manufacturer; (2) degraded voltage effects can be more severe than predicted by the square of the ratio of actual to rated motor voltage; (3) some motors produce more torque output than predicted by their nameplate rating; and (4) temperature effects on motor performance appeared consistent with the Limitorque guidance. The NRC documented its study of ac-powered MOV output in NUREG/CR-6478, "Motor-Operated Valve (MOV) Actuator Motor and Gearbox Testing," (Ref. 22) issued in July 1997. The nuclear industry also evaluated the output capability of ac-powered MOVs at several plants. In response to the new information on ac-powered MOV performance, Limitorque provided updated guidance in its Technical Update 98-01, "Actuator Output Torque Calculation," (Ref. 23) issued in May 1998, and Supplement 1, issued in July 1998, for the prediction of ac-powered MOV motor actuator output. The NRC alerted licensees to the new information on ac-powered MOV output in Supplement 1 to IN 96-48 (Ref. 24), dated July 24, 1998.

Following the NRC review of ac-powered MOV performance, the NRC conducted research to study the performance of Limitorque direct current (dc)-powered MOV motor actuators under various temperature and voltage conditions. For the Limitorque dc-powered motor-actuator combinations tested, the research indicated that (1) the ambient temperature effects were more significant than predicted; (2) the use of a linear voltage factor needs to consider reduced speed, increased motor temperature, and reduced motor output; (3) the stroke-time increase is significant for some dc-powered MOVs under loaded conditions; and (4) the actuator efficiency may fall below the published "pullout" efficiency at low speed and high load conditions. The NRC documented this research in NUREG/CR-6620, "Testing of DC-Powered Actuators for Motor-Operated Valves," (Ref. 25) issued in May 1999. In June 2000, the Boiling Water Reactor Owners' Group forwarded to the NRC the Topical Report NEDC-32958, "BWR Owners' Group DC Motor Performance Methodology—Predicting Capability and Stroke Time in DC Motor-Operated Valves," (Ref. 26) issued in March 2000. In August 2001, the NRC issued Regulatory Issue Summary 2001-15, "Performance of DC-Powered Motor-Operated Valve Actuators," (Ref. 27) to inform licensees of the availability of improved industry guidance for predicting dc-powered MOV actuator performance.

Through an extensive effort spanning over many years, the ASME QME Standards Committee revised Section QV in ASME QME-1 to incorporate the lessons learned from the MOV operating experience and research programs for the functional qualification of all power-operated valves. The NRC staff participated in the activities of the ASME QME Standards Committee and its subcommittees during the revision of ASME QME-1. The staff presents its regulatory positions on ASME QME-1-2007 in Section C of this regulatory guide.

C. REGULATORY POSITION

1. Seismic Qualification of Electric and Active Mechanical Equipment

1.1 <u>Regulatory Positions on IEEE Std 344-2004</u>

1.1.1 *General NRC Staff Positions*

The IEEE Std 344-2004 is, in general, acceptable to the NRC staff for the seismic qualification of (1) electric equipment in new NPPs and (2) new addition or replacement electric equipment in operating NPPs, subject to the following provisions:

a. Rigorous seismic qualification by analysis, testing, or combined analysis and testing, as described in Clauses 7, 8, and 9 of the IEEE Std 344-2004, are acceptable methods for seismic qualification of electric equipment.

b. The use of experience data (earthquake or test experience data) for seismic qualification of electric equipment is subject to review by the NRC staff in areas such as (1) the credibility and completeness of the compilation of the experience database; (2) the inclusion rules and exclusion rules (termed "prohibited features" in IEEE Std 344-2004) for electric equipment in the experience database; (3) the justification used to demonstrate similarity among the member items in a reference equipment class and the similarity between electric equipment in the experience database and those in the NPP to be seismically qualified; (4) the justification used to demonstrate the reference equipment class functionality during and after the earthquake; and (5) the credibility of similarity among member items of a reference equipment class if a generic reference equipment class is proposed. As described in Clause 9.3 of IEEE Std 344-2004, similarity should include similarity in physical, functional, and dynamic characteristics between electric equipment in the experience database and those in the NPP to be seismically qualified, as well as similarity between seismic excitation noted in the experience database and the required seismic excitation for the electric equipment in the NPP to be seismically qualified.

c. The NRC staff does not generally find it acceptable to use experience data (earthquake or test experience data) for seismic qualification for (1) certain active electric components that may inadvertently change state during an earthquake such that they do not consistently perform their intended safety functions during and/or after an earthquake, such as certain types of relays, contactors, circuit breakers, switches, sensors, and potentiometers; (2) fragile electronic components, such as solid-state relays and microprocessors-based components; and (3) electric equipment, such as battery chargers, inverters, relay and control panels, switchgear, and motor control centers. The electric equipment mentioned in (3) above generally consists of enclosures constructed of metal frames with metal panels that contain some of the components described in (1) and (2) above, and the response and performance of these components (and therefore the performance of the equipment) under earthquake loadings in general are sensitive to their locations and the type of mountings in such equipment.

d. If the licensee proposes to use test experience data to perform seismic qualification, the licensee should submit for staff review and approval the details of the test experience database, including applicable implementation procedures, to assure the structural integrity and functionality of the in-scope electric equipment. Supporting documentation for equipment identified in the database should confirm that such equipment will remain functional during and after the equivalent effect of five postulated occurrences of OBE and one SSE in combination with other relevant static and dynamic loads.

e. For electric equipment exposed to harsh environments, aging, and earthquakes, the NRC staff does not find it acceptable to use experience data (earthquake or test experience data) for seismic qualification of equipment. The test sample shall be subjected to simulated OBE and SSE seismic vibrations in accordance with IEEE Std 344-2004.

f. The NRC staff does not generally find it acceptable to restrict the frequency range of testing up to 33 Hz. The frequency range should be continued beyond 33 Hz, in accordance with the RRS of a specific plant.

g. For certain hard-rock-based plants, the site-specific spectra may exceed the certified design spectra in the high-frequency range. This guide refers to this phenomenon as the high-frequency ground motion concern. As a result of the high-frequency ground motion, the seismic input to SSCs may also contain high-frequency excitations. For operating BWR plants, the seismic qualifications of some safety-related electric equipment were performed using IEEE-344-type tests with intentional high-frequency contents to account for concurrent BWR hydrodynamic loads. However, the vast majority of existing seismic qualification tests used input frequencies up to only 33 Hz. These past test experience data are therefore not acceptable for the seismic qualification of high-frequency-sensitive equipment or fragile components. Furthermore, credit should not be taken for the inadvertent high frequencies present in some of the IEEE-344-type seismic qualification tests of equipment in the past, which may have shown the ZPA of the TRS to be up to 100 Hz. Ball joints and kinematics linkages of the shake tables could have generated these inadvertent high frequencies, and the NRC staff considers them to be noise signals that may not have the proper frequency content with sufficient energy to be compatible with the amplified region of the RRS at high frequencies.

h. If new seismic qualification tests are planned for equipment in plants with the high-frequency ground motion concern, the test input waveforms should be properly formulated to address this concern. In order for the TRS to be valid for such plants, the adequacy of the frequency content and the stationarity of the frequency content of the synthesized input waveforms used for the tests should be demonstrated. The frequency content of the Fourier transform of the test waveform or the frequency content of the power spectral density of the test waveform must be compatible with the amplified portion of the RRS. The Annex B, "Frequency Content and Stationarity," to the IEEE 344-2004 provides guidelines on frequency content and stationarity.

i. Electric equipment should be qualified with five one-half SSE events followed by one full SSE event (SECY-93-087) (Ref. 28) even if the OBE of a plant is defined to be one-third of SSE or less. Alternatively, a number of fractional peak cycles equivalent to the maximum peak cycle for five one-half SSE events may be used in accordance with Annex D, "Test Duration and Number of Cycles," to IEEE Std 344-2004, when followed by one full SSE.

j. The IEEE Std 344-2004 recommended no damping values. The damping values listed in Table 6 of NRC Regulatory Guide 1.61, Revision 1, "Damping Values for Seismic Design of Nuclear Power Plants," (Ref. 29) issued in March 2007, are recommended. These damping values are the updated values currently acceptable to the NRC staff.

1.1.2 *Specific NRC Staff Positions*

The following are specific NRC staff positions, including exceptions and clarifications, on IEEE Std 344-2004:

a. Clause 10.2.3.1 and Clause 10.3.3.1 (Experience—Attributes of Equipment Class)

The NRC staff will review, in detail, the attributes of the equipment for establishing the inclusion rules that constitute the earthquake or test experience reference equipment class as described in

Clause 10.2.3.1 or Clause 10.3.3.1, respectively, to determine the acceptability of similarity arguments to define a reference equipment class.

To avoid addressing fatigue failure at low-cycle loads from earthquakes by simply considering it as a prohibited feature (Clause 10.2.3.1(b)) does not demonstrate successful equipment functionality under OBEs as required by the NRC regulations delineated in 10 CFR Part 100 (Ref. 30), Appendix S to 10 CFR Part 50, or 10 CFR Part 52. Earthquake experience data or test data are needed to demonstrate that all electric equipment in the reference equipment class, including the enclosed or attached devices or subassemblies, performed successfully (structural integrity and specified functionality) under the equivalent of five OBE and one SSE loadings.

b. Clause 10.2.3.3 (Experience—Reference Equipment Class Functionality)

Detailed information about the justification used to demonstrate the reference equipment class functionality during and after the earthquake should be submitted for NRC review and approval.

c. Clause 10.2.4 (Earthquake Experience Data—Qualification of Candidate Equipment)

The use of a median-centered horizontal in-structure response spectrum as the RRS for the candidate equipment is not acceptable. In-structure response spectra should be developed in accordance with the licensing basis and NRC guidance described in the latest revision of Regulatory Guide 1.122, "Development of Floor Design Response Spectra for Seismic Design of Floor-Supported Equipment or Components." (Ref. 31)

d. Clause 10.3.2 (Test Experience Data—Test Experience Spectra (TES))

i. The use of the frequency-by-frequency mean of the successful TRS is not adequate to define TES. When using test experience data, an equipment capacity factor has to be considered to obtain an equivalent confidence level for performance and to cover the uncertainties in high-level testing for an equipment class. The acceptable equipment capacity factor is 1.4 for TES (Refs. 32 and 33).

   Therefore, the NRC takes exception to the existing second sentence in the first paragraph of Clause 10.3.2. Instead, the following is acceptable to the NRC:

   > The TES shall be the frequency-by-frequency mean divided by 1.4 of the response spectra from successful tests without malfunction.

ii. The second paragraph of Clause 10.3.2 is not appropriate. The position acceptable to the NRC staff is the one stated in Section C.1.1.1.i of this regulatory guide.

e. Clause 10.3.3 (Test Experience Data—Characterization of Reference Equipment Class)

Clause 10.3.3 cites an example that significant natural frequencies of the reference equipment class would lie within approximately one-third octave. This will not provide an adequate range of significant natural frequencies of the reference equipment in a class. Instead of one-third octave, one-sixth octave should be used.

f. Clause 10.3.3.2 (Test Experience Data—Number of Independent Items for Reference Equipment Class)

Justification should be provided to show the adequacy of using a minimum of five independent items to define a reference equipment class for test experience.

g. Clause 10.3.4 (Test Experience Data—Qualification of Candidate Equipment)

The use of a median-centered horizontal in-structure response spectrum as the RRS for the candidate equipment is not acceptable. In-structure response spectra should be developed in accordance with the licensing basis and NRC guidance described in the latest revision of Regulatory Guide 1.122.

h. Clause 10.4.2 (Experience—Limitations)

The list of limitations for the use of earthquake- or test-experience-based methods for seismic qualification of equipment as described in Clause 10.4.2 may not be complete. The list should be expanded to include additional limitations as a result of new findings from testing new equipment or new studies.

i Annex C (Fragility Testing)

An example of determining the fragility level to single-frequency transient excitation of the equipment is to subject it to any single-frequency excitation such as sine-beat motion. The frequency range of the test excitation should be continued beyond 33 Hz, in accordance with the RRS of a specific plant.

j. Annex D (Test Duration and Number of Cycles)

Figure D.2 is used to determine the equivalent number of fatigue cycles for a given filtered frequency and duration. Currently, IEEE Std 344-2004 does not develop guidance beyond 40 Hz. Therefore, justification should be provided for applications beyond 40 Hz.

k. Annex E (Statistically Independent Motions)

A coherence function of less than 0.5 and an absolute value of the correlation coefficient function of less than 0.3 are not acceptable.

The NRC positions on the numerical values for the coherence function and the correlation coefficient function for defining statistically independent motions are the same as in Reference 34, particularly the following:

i. For the coherence function, numerical values ranging from 0.0 to a maximum of 0.3 and an average of approximately 0.2 are acceptable.
ii. An absolute value of less than 0.16 for the correlation coefficient function is acceptable.

1.2 <u>Regulatory Positions on ASME QME-1-2007</u>

1.2.1 General NRC Staff Positions

In the discussion of the seismic qualification of some active mechanical equipment, ASME QME-1-2007 references IEEE Std-344-1987 (as addressed in NRC Regulatory Guide 1.100, Revision 2) or

Nonmandatory Appendix QR-A. Such references appear in several sections of ASME QME-1-2007, such as Section QP-6400 for pumps, and Sections QV-7450 and QV-7650 for valves. The NRC staff finds these acceptable if they are applied consistent with the NRC staff positions delineated in this regulatory guide (Revision 3) and other relevant NRC regulatory documents.

The NRC staff finds Nonmandatory Appendix QR-A to ASME QME-1-2007 acceptable, in general, for seismic qualification of (1) active mechanical equipment in new NPPs; and (2) new addition or replacement active mechanical equipment in operating NPPs. However, the NRC staff acknowledges the statement in Section QR-A7500 that the section on test-experience-based qualification is currently not available in ASME QME-1-2007 and will be added in a later issue of the standard. In addition, the NRC has the following regulatory positions, including exceptions and clarifications, on Nonmandatory Appendix QR-A of ASME QME-1-2007:

a. In endorsing the use of ASME QME-1-2007, the staff noticed that several appendices are designated as either nonmandatory or mandatory (e.g., Nonmandatory Appendix QR-A; Nonmandatory Appendix QR-B; Nonmandatory Appendices QDR-A, QDR-B, and QDR-C; Nonmandatory Appendices QP-A, QP-B, QP-C, QP-D, and QP-E; and Mandatory Appendix QV-1). The staff position is that, once the user commits to the use of ASME QME-1-2007 for its qualification of active mechanical equipment in NPPs, the criteria and procedures delineated in those appendices then become the requirements for its qualification program, unless the deviations are justified.

b. Rigorous seismic qualification by analysis or testing, as described in Sections QR-A7100 and QR-A7200 of ASME QME-1-2007, is an acceptable method for seismic qualification of active mechanical equipment.

c. The ASME Class 1, 2, and 3 active mechanical equipment should meet the requirements in the ASME Boiler and Pressure Vessel Code (hereafter referred to as the ASME Code), Section III (Ref. 35). The NRC staff recommends that a future revision of ASME QME-1 add this position to (1) Section QR-6000, "Qualification Specification," as item (j); and (2) Section QR-A7440, "Qualification of Candidate Equipment," as item (g).

d. The NRC staff will review the use of earthquake experience data for seismic qualification of active mechanical equipment in areas such as (1) the credibility and completeness of the compilation of the experience database; (2) the inclusion rules and exclusion rules for active mechanical equipment in the experience database; (3) the justification used to demonstrate similarity among the member items in a reference equipment class and the similarity between active mechanical equipment in the experience database and those in the NPP to be seismically qualified; (4) the justification used to demonstrate the functionality of candidate equipment during and after the earthquake; and (5) the credibility of similarity among member items of a reference equipment class if a generic reference equipment class is proposed. As described in Section QR-A7300 of ASME QME-1-2007, similarity should include similarity in physical, functional, and dynamic characteristics between mechanical equipment in the experience database and those in the NPP to be seismically qualified, as well as similarity between seismic excitation documented in the experience database and the required seismic excitation for the mechanical equipment in the NPP to be seismically qualified.

e. If the licensee proposes to use test experience for seismic qualification, the licensee should submit for staff review and approval the details of the test experience database, including applicable implementation procedures, to assure the structural integrity and functionality of the in-scope mechanical equipment. Supporting documentation for equipment identified in the database should confirm that such equipment will remain functional during and after the equivalent effect of five postulated occurrences of an OBE and one SSE in combination with other relevant static and dynamic loads.

f. The NRC staff does not generally find it acceptable to restrict the frequency range of testing up to 33 Hz. The frequency range should be continued beyond 33 Hz, in accordance with the RRS of a specific plant.

g. For certain hard-rock-based plants, the site-specific spectra may exceed the certified design spectra in the high-frequency range. This guide refers to this phenomenon as the high-frequency ground motion concern. As a result of the high-frequency ground motion, the seismic input to SSCs may also contain high-frequency excitations. For operating BWR plants, the seismic qualification of some safety-related active mechanical equipment were performed using IEEE-344-type tests with intentional high-frequency contents to account for concurrent BWR hydrodynamic loads. However, the vast majority of existing seismic qualification tests used input frequencies up to only 33 Hz. These past test experience data are therefore not acceptable for the seismic qualification of high-frequency-sensitive equipment or fragile components. Furthermore, credit should not be taken for the inadvertent high frequencies present in some of the IEEE-344-type seismic qualification tests of equipment in the past, which may have shown the ZPA of the TRS to be up to 100 Hz. Ball joints and kinematics linkages of the shake tables could have generated these inadvertent high frequencies, and the NRC staff considers them to be noise signals that may not have the proper frequency content with sufficient energy to be compatible with the amplified region of the RRS at high frequencies.

h. If new seismic qualification tests are planned for active mechanical equipment in plants with the high-frequency ground motion concern, the test input waveforms should be properly formulated to address this concern. For the TRS to be valid for such plants, the adequacy of the frequency content and the stationarity of the frequency content of the synthesized input waveforms used for the tests should be demonstrated. The frequency content of the Fourier transform of the test waveform or the frequency content of the power spectral density of the test waveform should be compatible with the amplified portion of the RRS. The Annex B to IEEE 344-2004 provides guidelines on frequency content and stationarity.

i. For active mechanical equipment exposed to harsh environments, aging, and earthquakes, the staff does not find it acceptable to use experience data (earthquake or test experience data) for seismic qualification of equipment. The test sample shall be subjected to simulated OBE and SSE seismic vibrations in accordance with IEEE Std 344-2004.

j. Active mechanical equipment should be qualified with five one-half SSE events followed by one full SSE event (SECY-93-087) even if the OBE of a plant is defined to be one-third of SSE or less. Alternatively, a number of fractional peak cycles equivalent to the maximum peak cycle for five one-half SSE events may be used in accordance with Annex D to IEEE Std 344-2004 when followed by one full SSE.

1.2.2 *Specific NRC Staff Positions*

The following are specific NRC staff positions, including exceptions and clarifications, on ASME QME-1-2007:

a. Section QR-A6200 (Damping)

Instead of the damping values listed in Table QR-A6210-1, the damping values listed in Tables 1 to 6 of NRC Regulatory Guide 1.61, Revision 1, are recommended. These damping values are the updated values currently acceptable to the NRC staff.

b. Section QR-A6300 (Seismic Qualification Requirements—Required Response Spectrum)

The Section QR-A6300 states that "For in-line active mechanical equipment qualified in accordance with QR-A7400 (Earthquake Experience-Based Qualification), the RRS is typically the building filtered response spectrum at the distribution system support attachments to the building." The use of the building filtered response spectrum at the distribution system support attachments to the building as the RRS for the in-line equipment may not be adequate. The RRS for in-line active mechanical equipment should account for the potential motion amplification of the distribution system.

c. Section QR-A7331 (Qualification by Similarity—Excitation)

The Section QR-A7331 states that "a conservative composite excitation may be generated by extrapolations or interpolations of data whose parameters are not identical but are justifiable. Likewise, excitation whose spectral content are significantly different may be used to generate lower-level composite estimates, providing that an account is taken of possible multi-axis response or cross-axis coupling, or both." The licensee should provide detailed information, justifying this statement, to the NRC staff for review and approval.

d. Section QR-A7421 (Earthquake Experience-Based Qualification—Attributes of Equipment Class)

The NRC staff will review, in detail, the attributes of the equipment for establishing the inclusion rules that constitute the earthquake experience reference equipment class as described in Section QR-A7421 to determine the acceptability of similarity arguments to define a reference equipment class.

Section QR-A7421 also states the following:

> "Prohibited features should include any attributes that would contribute to fatigue failure from low cycle loads. The rules of this section apply to active mechanical equipment that may undergo 5 OBE's or aftershocks and one SSE resulting in 60 full range stress cycles during plant life. If a component contains items which could experience a fatigue failure from low cycle loads (less than 60 full range stress cycles), it shall be evaluated in accordance with Section QR-A6800."

The NRC regulations delineated in 10 CFR Part 100, Appendix S to 10 CFR Part 50, and 10 CFR Part 52 require the demonstration of successful equipment functionality under OBEs.

e. Section QR-A7423 (Functionality during Earthquake)

Detailed information about the justification used to demonstrate the reference equipment class functionality during and after the earthquake should be submitted for NRC review and approval.

f. Section QR-A7431 (Earthquake Experience-Based Qualification—Inherently Rugged Active Mechanical Equipment)

To justify the active mechanical equipment class as an "inherently rugged active mechanical equipment" class, the licensee should provide, for NRC review, information regarding the operational or shipping loads as compared to the expected seismic loads that the equipment could be subjected to, and the explicit design standards applied to this equipment class. Detailed information regarding the simplified and reduced rules, including the technical justification and data for characterizing the inherently rugged active mechanical equipment class and the procedure for defining the seismic capacity for this equipment class (i.e., the earthquake experience spectrum), should also be provided to the NRC staff for review.

g. Section QR-A7432 (Earthquake Experience-Based Qualification—Limitations)

The limitations for the use of an earthquake-experience-based method of seismic qualification of equipment, as described in Section QR-A7432, may not be a complete list. The list should be expanded to include additional limitations as a result of new findings from testing of new equipment or new studies.

h. Section QR-A7440 (Earthquake Experience-Based Qualification—Qualification of Candidate Equipment)

The use of a median-centered horizontal in-structure response spectrum as the RRS for the candidate equipment is not acceptable. In-structure response spectra should be developed in accordance with the licensing basis and NRC guidance described in the latest revision of Regulatory Guide 1.122.

i. Section QR-A8330 (Qualification Report—Earthquake Experience-Based Qualification Documentation)

All ASME Class 1, 2, and 3 active mechanical equipment should comply with the ASME Code, Section III, requirements. The NRC staff recommends adding the following item to a future revision of ASME QME-1:

> (f) compliance with the ASME Code, Section III, requirements for ASME Class 1, 2, and 3 active mechanical equipment.

j. Attachment C to Nonmandatory Appendix QR-A (Qualification of Pumps and Valves Using Natural Earthquake Experience Data)

Attachment C to Nonmandatory Appendix QR-A is based on the guidelines developed by the SQUG for USI A-46 plants. The provisions in the SQUG guidelines rely heavily on earthquake experience data that the staff considered reasonable for verification of existing equipment seismic adequacy, and the qualification of new and replacement equipment in older vintage USI A-46 plants only. The NRC staff has not accepted these SQUG guidelines for the seismic qualification of equipment in plants other than USI A-46 plants. The provisions outlined in Section QR-A7400, including the NRC staff's positions noted in Sections C.1.2.1 and C.1.2.2 of this regulatory guide, are acceptable for the seismic qualification of active mechanical components. In addition, contrary to the provisions in Section QR-A7400, the introduction to Attachment C states that the data have not been developed to conclusively demonstrate that pumps and valves function properly during earthquakes. Therefore, Attachment C in its current form does not fully comply with the requirements in 10 CFR Part 100. Attachment C also contains an error in Section C-2. The equipment frequency restriction should be greater than 8 Hz instead of less than 8 Hz.

2. Functional Qualification of Active Mechanical Equipment

2.1 Regulatory Positions on ASME QME-1-2007

2.1.1 *General NRC Staff Positions*

In general, the NRC staff finds ASME QME-1-2007 acceptable for the functional qualification of (1) active mechanical equipment in new NPPs; and (2) new addition or replacement of active mechanical equipment in operating NPPs, subject to the following provisions:

a. Appendices

In endorsing the use of ASME QME-1-2007, the staff acknowledged that several appendices are designated as either nonmandatory or mandatory (e.g., Nonmandatory Appendix QR-A; Nonmandatory Appendix QR-B; Nonmandatory Appendices QDR-A, QDR-B, and QDR-C; Nonmandatory Appendices QP-A, QP-B, QP-C, QP-D, and QP-E; and Mandatory Appendix QV-1). The NRC staff's position is that, once the user commits to the use of ASME QME-1-2007 for its qualification of active mechanical equipment in NPPs, the criteria and procedures delineated in those appendices then become mandatory and are the requirements for its qualification program. Justification must be provided for any deviations, which will be subjected to NRC staff review and approval.

b. Nonmandatory Appendix QR-B

This appendix recommends a methodology and describes the documentation that should be available in a user's files to demonstrate the qualification of nonmetallic parts, materials, or lubricants. It addresses the steps for the user of the active mechanical equipment to follow to qualify and maintain qualification of the nonmetallic material that is part of the active mechanical equipment. The NRC staff considers Nonmandatory Appendix QR-B to provide a reasonable approach to the qualification of nonmetallic material in active mechanical equipment.

c. Sections QDR and QP

The NRC staff considers Sections QDR and QP to provide a reasonable approach to the qualification of dynamic restraints and active pump assemblies, respectively. These sections have not changed from those in ASME QME-1-2002, and they still adequately document the state of the art of the nuclear industry in the qualification of dynamic restraints and active pump assemblies.

d. Section QV

The revision to ASME QME-1 reflects valve performance information obtained from nuclear industry programs and NRC's research since the development of ASME QME-1 in the 1980s. With the active involvement of industry personnel and the NRC staff in the development of ASME QME-1-2007, only a few NRC staff exceptions and clarifications are necessary in this guide for Section QV, as described in Section C.2.1.2 of this regulatory guide below.

2.1.2 *Specific NRC Staff Positions*

a. The definition of "valve assembly" in Section QV-4000, "Definitions," refers to power-operated valves. The NRC staff considers the power actuators for valve assemblies to include all types of power actuators, such as motor, pneumatic, hydraulic, solenoid, and other drivers.

b. The Section QV-6000, "Qualification Specification," states that the owner or owner's designee is responsible for identifying the functional requirements for a valve assembly, and that these requirements shall be provided in a qualification specification prepared in accordance with Mandatory Appendix QV-1. The NRC staff considers Mandatory Appendix QV-1 to be a necessary part of the implementation of Section QV of ASME QME-1-2007. For example, Mandatory Appendix QV-1 provides the definitions of QV Category A and B valve assemblies used in Section QV of ASME QME-1-2007.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the NRC's plans for using this draft regulatory guide. No imposition or backfit is intended or approved in connection with its issuance.

The NRC has issued this draft guide to encourage public participation in its development. The NRC will consider all public comments received in development of the final guidance document. Except in those cases in which an applicant or licensee proposes or has previously established an acceptable alternative method for complying with specified portions of the NRC's regulations, the methods described in the active guide will be used in evaluating compliance with the regulations as discussed in this guide for license applications, license amendment applications, and exemption requests.

REGULATORY ANALYSIS

1. Statement of the Problem

The NRC issued Revision 2 of Regulatory Guide 1.100 in June 1988 to endorse (with exceptions and clarifications) IEEE Std 344-1987 and to describe acceptable methods for complying with the NRC's regulations governing the seismic qualification of NPP electric (including I&C components) and active mechanical equipment that is important to safety. Since the issuance of Revision 2 of Regulatory Guide 1.100 in 1988, two consensus standards, IEEE Std 344-2004 and ASME QME-1-2007, have been revised and issued in 2005 and 2007, respectively. With some exceptions and clarifications, this regulatory guide (Revision 3) endorses these two consensus standards and describes methods that the NRC staff considers acceptable in the areas of seismic qualification of electric and active mechanical equipment and functional qualification of active mechanical equipment.

2. Objective

The objective of the regulatory action is to update the NRC's guidance in the area of seismic qualification of electric and active mechanical equipment and functional qualification of active mechanical equipment.

3. Alternatives Approaches

The NRC staff considered the following alterative approaches:

- Do not revise Regulatory Guide 1.100.
- Update Regulatory Guide 1.100.

3.1 Alternative 1: Do Not Revise Regulatory Guide 1.100

Under this alternative, the NRC would not revise Regulatory Guide 1.100 and licensees would continue to rely on the current version (Revision 2), which is based on technology developed in the 1980s. Since then several newer developments that have improved the engineering understanding have been incorporated in updated standards. This alternative is considered the baseline or "no-action" alternative.

3.2 Alternative 2: Update Regulatory Guide 1.100

Under this alternative, the NRC would update Regulatory Guide 1.100 to reference the two latest consensus standards (see above) and to describe the NRC's positions on these two consensus standards. The staff has identified the following potential benefits associated with adopting alternative 2:

- Licensees would have NRC guidance on the use of the latest IEEE and ASME consensus standards related to the seismic qualification of electric and active mechanical equipment and functional qualification of active mechanical equipment.
- Regulatory efficiency would be improved by reducing uncertainty on acceptable methods to follow and by encouraging consistency in the seismic qualification of electric and active mechanical equipment and the functional qualification of active mechanical equipment. The NRC reviews would be facilitated because licensee submittals would be more predictable and consistent.
- Both the NRC and the nuclear industry would realize cost savings. From the NRC's perspective, relative to the baseline, the agency will incur one-time minimal incremental cost to issue the revised regulatory guide. However, the NRC should also realize cost savings associated with the review of licensee submittals; the ongoing cost savings associated with these reviews should more than offset the one-time cost.
- The updated regulatory guide will clarify for the industry the NRC positions on the two standards. The NRC staff expects that industry will realize a net savings by the efficiencies (e.g., fewer follow-up questions and revisions) associated with each licensee submission.

4. Conclusion

Based on this regulatory analysis, the staff recommends that the NRC revise Regulatory Guide 1.100. The staff concludes that the proposed action will clarify the NRC positions on the two standards related to seismic qualification of electric and active mechanical equipment and functional qualification of active mechanical equipment. The staff also concludes that no adverse effects are associated with revising Regulatory Guide 1.100.

REFERENCES

1. 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," U.S. Nuclear Regulatory Commission, Washington, DC.[3]

2. 10 CFR Part 52, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants," U.S. Nuclear Regulatory Commission, Washington, DC.

3. Regulatory Guide 1.100, Revision 2, "Seismic Qualification of Electric and Mechanical Equipment for Nuclear Power Plants," U.S. Nuclear Regulatory Commission, Washington, DC, June 1988.[4]

4. IEEE Std 344-1987, "IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers, Inc., New York, NY, January 1987.[5]

5. ASME QME-1-1994, "Qualification of Active Mechanical Equipment Used in Nuclear Power Plants," American Society of Mechanical Engineers, New York, NY, June 1994.[6]

6. ASME QME-1-2007, "Qualification of Active Mechanical Equipment Used in Nuclear Power Plants," American Society of Mechanical Engineers, New York, NY, November 2007.

7. IEEE Std 344-2004, "IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers, Inc., New York, NY, June 2005.

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3 All NRC regulations listed herein are available electronically through the Electronic Reading Room on the NRC's public Web site, at http://www.nrc.gov/reading-rm/doc-collections/cfr/. Copies are also available for inspection or copying for a fee from the NRC's Public Document Room (PDR) at 11555 Rockville Pike, Rockville, MD; the mailing address is USNRC PDR, Washington, DC 20555; telephone (301) 415-4737 or (800) 397-4209; fax (301) 415-3548; and e-mail PDR@nrc.gov.

4 All regulatory guides listed herein were published by the U.S. Nuclear Regulatory Commission. Most are available electronically through the Electronic Reading Room on the NRC's public Web site, at http://www.nrc.gov/reading-rm/doc-collections/reg-guides/. Active guides may also be purchased from the National Technical Information Service (NTIS) on a standing order basis. Details on this service may be obtained by contacting NTIS at 5285 Port Royal Road, Springfield, VA 22161, online at http://www.ntis.gov, by telephone at (800) 553-NTIS (6847) or (703) 605-6000, or by fax at (703) 605-6900. Copies are also available for inspection or copying for a fee from the NRC's Public Document Room (PDR) at 11555 Rockville Pike, Rockville, MD; the mailing address is USNRC PDR, Washington, DC 20555-0001; telephone (301) 415-4737 or (800) 397-4209; fax (301) 415-3548, and e-mail PDR@nrc.gov.

5 Copies of Institute of Electrical and Electronics Engineers (IEEE) standards may be purchased from IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854; telephone (800) 678-4333. Purchase information is available through the IEEE Web-based store at http://www.ieee.org.

6 Copies of American Society of Mechanical Engineers (ASME) standards may be purchased from ASME, Three Park Avenue, New York, NY 10016-5990; telephone (800) 843-2763. Purchase information is available through the ASME Web-based store at http://www.asme.org/Codes/Publications/.

8. IEEE Std 344-1975, "IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers, Inc., New York, NY, 1975.

9. Regulatory Guide 1.100, Revision 1, "Seismic Qualification of Electric and Mechanical Equipment for Nuclear Power Plants," U.S. Nuclear Regulatory Commission, Washington, DC, August 1977.

10. Generic Letter 87-02, "Verification of Seismic Adequacy of Mechanical and Electric Equipment in Operating Reactors, Unresolved Safety Issue (USI) A-46," U.S. Nuclear Regulatory Commission, Washington, DC, February 1987.[7]

11. Generic Letter 89-10, "Safety-Related Motor-Operated Valve Testing and Surveillance," U.S. Nuclear Regulatory Commission, Washington, DC, June 1989.

12. Information Notice 90-40, "Result of NRC-Sponsored Testing of Motor-Operated Valves," U.S. Nuclear Regulatory Commission, Washington, DC, June 1990.[8]

13. Topical Report TR-103237, Revision 2, "EPRI MOV Performance Prediction Program," and Addenda 1 and 2, nonproprietary versions, Electric Power Research Institute, Palo Alto, CA, April 1997.[9]

14. Safety Evaluation, "Safety Evaluation on EPRI MOV Performance Prediction Methodology," U.S. Nuclear Regulatory Commission, Washington, DC, March 1996.

15. Safety Evaluation Supplement, "Supplement to Safety Evaluation on EPRI MOV Performance Prediction Methodology," U.S. Nuclear Regulatory Commission, Washington, DC, February 1997.

16. Safety Evaluation Supplement, "Supplement 2 to Safety Evaluation on EPRI MOV Performance Prediction Methodology," U.S. Nuclear Regulatory Commission, Washington, DC, April 2001.

17. Safety Evaluation Supplement, "Supplement 3 to Safety Evaluation on EPRI MOV Performance Prediction Methodology," U.S. Nuclear Regulatory Commission, Washington, DC, September 2002.

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7 All generic letters (GLs) listed herein were published by the U.S. Nuclear Regulatory Commission and are available electronically through the Electronic Reading Room on the NRC's public Web site, at http://www.nrc.gov/reading-rm/doc-collections/gen-comm/gen-letters/. Copies are also available for inspection or copying for a fee from the NRC's Public Document Room at 11555 Rockville Pike, Rockville, MD; the mailing address is USNRC PDR, Washington, DC 20555-0001; telephone (301) 415-4737 or (800) 397-4209; fax (301) 415-3548; and e-mail PDR@nrc.gov.

8 All information notices (INs) listed herein were published by the U.S. Nuclear Regulatory Commission and are available electronically through the Electronic Reading Room on the NRC's public Web site, at http://www.nrc.gov/reading-rm/doc-collections/gen-comm/info-notices/. Copies are also available for inspection or copying for a fee from the NRC's Public Document Room at 11555 Rockville Pike, Rockville, MD; the mailing address is USNRC PDR, Washington, DC 20555; telephone (301) 415-4737 or (800) 397-4209; fax (301) 415-3548; and e-mail PDR@nrc.gov

9 Copies of the listed Electric Power Research Institute (EPRI) standards and reports may be purchased from EPRI, 3420 Hillview Ave., Palo Alto, CA 94304; telephone (800) 313-3774; fax (925) 609-1310.

18. Information Notice 96-48, "Motor-Operated Valve Performance Issues," U.S. Nuclear Regulatory Commission, Washington, DC, August 1996.

19. Generic Letter 96-05, "Periodic Verification of Design-Basis Capability of Safety-Related Motor-Operated Valves," U.S. Nuclear Regulatory Commission, Washington, DC, September 1996.

20. Topical Report MPR-2524, "Joint Owners' Group Motor Operated Valve Periodic Verification Program Summary," Joint Owners' Group, February 2004.

21. Final Safety Evaluation, "Final Safety Evaluation on Joint Owners' Group Program on Motor-Operated Valve Periodic Verification," U.S. Nuclear Regulatory Commission, Washington, DC, September 2006.

22. NUREG/CR-6478, "Motor-Operated Valve (MOV) Actuator Motor and Gearbox Testing," U.S. Nuclear Regulatory Commission, Washington, DC, July 1997.[10]

23. Technical Update 98-01, "Actuator Output Torque Calculation," Limitorque Corporation, Lynchburg, VA, May 1998, and Supplement 1, July 1998.

24. Information Notice 96-48, Supplement 1, "Motor-Operated Valve Performance Issues," U.S. Nuclear Regulatory Commission, Washington, DC, July, 1998.

25. NUREG/CR-6620, "Testing of DC-Powered Actuators for Motor-Operated Valves," U.S. Nuclear Regulatory Commission, Washington, DC, May 1999.

26. Topical Report NEDC-32958, "BWR Owners' Group DC Motor Performance Methodology—Predicting Capability and Stroke Time in DC Motor-Operated Valves," Boiling Water Reactor Owners' Group, March 2000.

27. Regulatory Issue Summary 2001-15, "Performance of DC-Powered Motor-Operated Valve Actuators," U.S. Nuclear Regulatory Commission, Washington, DC, August 2001.[11]

28. SECY-93-087, "Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor (ALWR) Designs," ADAMS ML No: ML003708021, U.S. Nuclear

[10] All NUREG-series reports listed herein were published by the U.S. Nuclear Regulatory Commission. Most are available electronically through the Electronic Reading Room on the NRC's public Web site, at http://www.nrc.gov/reading-rm/doc-collections/nuregs/. Copies are also available for inspection or copying for a fee from the NRC's Public Document Room (PDR) at 11555 Rockville Pike, Rockville, MD; the mailing address is USNRC PDR, Washington, DC 20555; telephone (301) 415-4737 or (800) 397-4209; fax (301) 415-3548; and e-mail PDR@nrc.gov. In addition, copies are available at current rates from the U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20402-9328, telephone (202) 512-1800, or from the National Technical Information Service (NTIS), at 5285 Port Royal Road, Springfield, VA 22161, online at http://www.ntis.gov, by telephone at (800) 553-NTIS (6847) or (703) 605-6000, or by fax at (703) 605-6900.

[11] All regulatory issue summaries (RISs) listed herein were published by the U.S. Nuclear Regulatory Commission and are available electronically through the Electronic Reading Room on the NRC's public Web site, at http://www.nrc.gov/reading-rm/doc-collections/gen-comm/reg-issues/. Copies are also available for inspection or copying for a fee from the NRC's Public Document Room at 11555 Rockville Pike, Rockville, MD; the mailing address is USNRC PDR, Washington, DC 20555; telephone (301) 415-4737 or (800) 397-4209; fax (301) 415-3548; and e-mail PDR@nrc.gov.

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29. Regulatory Guide 1.61, Revision 1, “Damping Values for Seismic Design of Nuclear Power Plants,” U.S. Nuclear Regulatory Commission, Washington, DC, March 2007.

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32. Michael W. Salmon and Robert P. Kennedy, “Meeting Performance Goals by Use of Experience Data,” UCRL-CR-120813, prepared for Lawrence Livermore National Laboratory and U.S. Department of Energy, Existing Facilities Project Steering Group and Technical Review Team, Livermore, CA, December 1994.[12]

33. ASCE/SEI 43-05, “Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities,” Section 8.3.2, American Society of Civil Engineers, Reston, VA, January 2005.[13]

34. ASME Boiler and Pressure Vessel Code, Section III, Division 1, Article N-1213.1 of Nonmandatory Appendix N, “Dynamic Analysis Methods,” American Society of Mechanical Engineers, New York, NY, 2004.

35. ASME Boiler and Pressure Vessel Code, Section III, “Rules for Construction of Nuclear Power Plant Components,” American Society of Mechanical Engineers, New York, NY, 2007.

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12 The report can be accessed by the public from the Internet Web site http://www.osti.gov/bridge/servlets/purl/101081-bmPSJ9/webviewable/101081.pdf

13 Copies of American Society of Civil Engineers (ASCE) standards may be purchased from ASCE Publications, 1801 Alexander Bell Drive, Reston, VA 20191; telephone (800) 548-2723. Purchase information is available through the ASCE Web-based store at http://pubs.asce.org/books/.