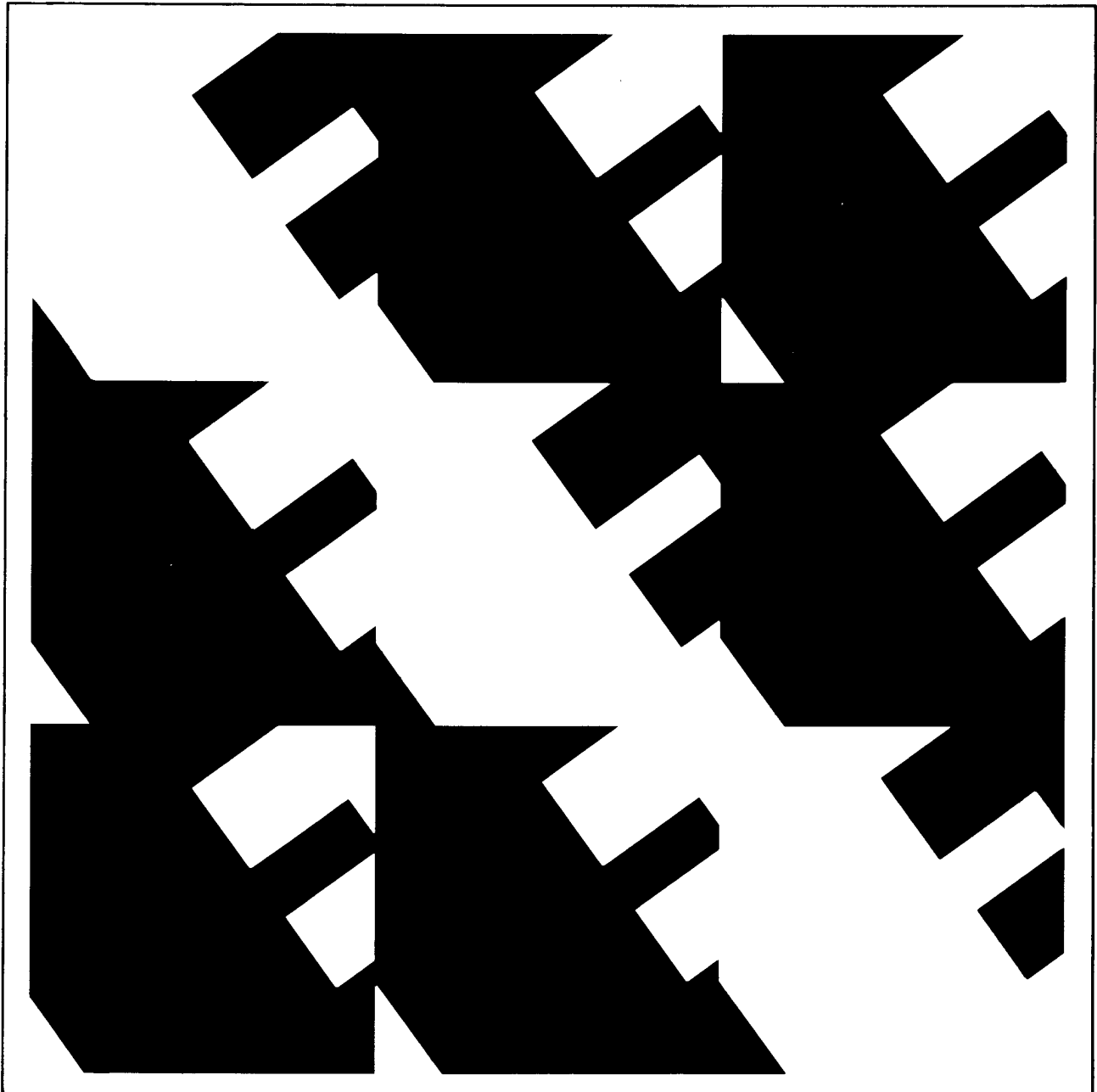


IEEE Standard for Qualification of Actuators for Power Operated Valve Assemblies with Safety-Related Functions for Nuclear Power Plants



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IEEE Standard for Qualification of Actuators for Power Operated Valve Assemblies with Safety- Related Functions for Nuclear Power Plants

Sponsor
**Nuclear Power Engineering Committee of the
IEEE Power Engineering Society
and
Committee on Qualification of Mechanical Equipment
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Foreword

(This Foreword is not a part of IEEE Std 382-1985, IEEE Standard for Qualification of Actuators for Power Operated Valve Assemblies with Safety-Related Functions for Nuclear Power Plants.)

Applicants for a construction permit or operating license for a nuclear generating station are required to provide assurance that systems, components, and structures are adequate for their service conditions to comply with the Code of Federal Regulations 10 CFR 50, Appendix B *Quality Assurance Criteria* and Criterion III *Design Control*. Each applicant has the responsibility to ensure that this or any other standard, if used, is pertinent to the application and that the integrated performance of the station is acceptable. Implementation of this standard requires the applicant to produce documentary evidence to ensure that the valve actuator can perform its intended function.

Typical design basis event conditions for principal reactor types are presented as one source of parameters for generic-type test. If the actual conditions of a specific application differ, it will be the obligation of the user to specify these actual conditions.

It is the responsibility of the user to ensure the acceptability of the methods, procedures, and specifications for the specific applications. A standard addressing design basis event (DBE) parameters is in preparation. When it is approved and published this standard will be revised accordingly.

The numerical values presented in this standard envelop current industry design with respect to radiation types and levels; seismic levels; temperature, pressure, humidity levels; post accident periods of operability; spray initiation and duration; and composition of environment may change in the future. The user is therefore cautioned to verify the suitability of these values for his application.

This standard was prepared by a joint ASME/IEEE Committee, organized at a meeting of ASME and IEEE representatives on August 14, 1974. Their task was to combine existing IEEE Std 382-1972 (ANSI N41.6) and ANSI 278.2, Draft 2, Part I, May 18, 1974, prepared by ANSI.

The primary objective of the Joint Committee was to develop a standard with requirements for qualification that would provide an acceptable level of assurance of functional operability for all types of valve actuators (electric, hydraulic, pneumatic, mechanical, etc). This qualification is based on tests that demonstrate valve actuator performance of its function under adverse conditions of thermal aging, pressure cycles, radiation aging; vibration, seismic motion, and DBE conditions of temperature; pressure, moisture, and (when appropriate) spray environment. Testing involves imposition of some of these conditions in combination and others individually, but all are equal to or greater than levels expected in service.

This standard is a revision of IEEE Std 382-1980, IEEE Standard for Qualification of Safety-Related Valve Actuators, national consensus for approval as an American National Standard as its purpose.

The Committee on Qualification Mechanical Equipment Used in Nuclear Power Plants was sponsored by ASME. The Joint Committee had the following membership:

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This standard was balloted by ANSI B16 and IEEE Nuclear Power Engineering Committee, reviewed, and approved by IEEE Standards Board and ASME Nuclear Power Codes and Standards Board.

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IEEE Standard for Qualification of Actuators for Power Operated Valve Assemblies with Safety-Related Functions for Nuclear Power Plants

Part I—Process

1. Scope and Purpose

This standard describes the qualification of all types of power-driven valve actuators, including damper actuators, for safety-related functions in nuclear power generating stations. This standard may also be used to separately qualify actuator components.

This standard establishes the minimum requirements for, and guidance regarding, the methods and procedures for qualification of power-driven valve actuators with safety-related functions. Part I describes the qualification process.

2. Definitions

aging. The effects of operational, environmental, and system conditions on equipment during a period of time up to, but not including design basis events, or the process of simulating these events.

air equivalent radiation dose. The energy that is absorbed per unit mass of air at the geometric center of the volume occupied by the specimen if it were replaced with air and a uniform flux were incident at the boundary of the volume, directed toward the center.

analysis. A course of reasoning showing that a certain result is a consequence of assumed premises.

auditable data. Information which is documented and organized in a readily understand-

able and traceable manner that permits independent verification of inferences or conclusions based on the information.

NOTE: Examples of information include product catalog information, dimensional drawings, bills of material, engineering specifications, performance specifications, installation and calibration instructions and manuals, maintenance manuals, test reports, and analyses.

Class 1E. The safety classification of the electric equipment and systems that are essential to emergency reactor shutdown, containment isolation, reactor core cooling, and containment and reactor heat removal, or otherwise essential in preventing significant release of radioactive material to the environment.

containment. The portion of the engineered safety features designed to act as the principal barrier, after the reactor system pressure boundary, to prevent the release, even under conditions of a reactor accident, of unacceptable quantities of radioactive material beyond a controlled zone.

design basis events (DBE). Postulated events (specified by the safety analysis of the station) used in the design to establish the acceptable performance requirements of the structures and systems.

design life. The time during which satisfactory performance can be expected for a specific set of service conditions.

NOTE: The time may be specified in real time, operating time, number of operating cycles, or other performance intervals, as appropriate.

generic actuator group. An actuator or family of actuators within a range of sizes with similar design principles, materials, manufacturing processes, limiting stresses, operating principles, and design margins.

installed life. The interval, from installation to removal, during which the equipment or component thereof may be subject to design service conditions and system demands.

margin. The difference between service conditions and the conditions used for equipment qualification.

motive power. The electric, fluid, air, nitrogen, or mechanical energy required to operate the actuator.

operating basis earthquake (OBE). The earthquake which could reasonably be expected to affect the plant site during the operating life of the plant. It is that earthquake which produces the vibratory ground motion for which those features of the nuclear power plant necessary for continued operation without undue risk to the health and safety of the public are designed to remain functional.

qualified life. The period of time, prior to the start of a design basis event, for which equipment was demonstrated to meet the design requirements for the specified service conditions.

NOTE: At the end of the qualified life, the equipment shall be capable of performing the safety function(s) required for the postulated-design basis and post-design basis events.

ratio set. A set of performance parameter values described by a range of numerical values whose boundaries have been established by doubling and halving the numerical mean value of a selected physical performance parameter.

required input motion (RIM). The input motion in terms of acceleration, velocity, and displacement expressed as a function of frequency that a device being tested shall withstand and still perform its intended function.

required response spectrum (RRS). The required response spectrum issued by the user or his agent as part of his specifications for proof testing, or artificially created to cover future applications. The RRS constitutes a requirement to be met.

response spectrum. A plot of the maximum response, as a function of oscillator frequency,

of an array of single-degree-of-freedom (SDOF) damped oscillators subjected to the same base excitation.

safe shutdown earthquake (SSE). That earthquake which produces the maximum vibratory ground motion for which certain structural systems and components are designed to remain functional. These structures, systems, and components are those necessary to ensure

(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

(3) The capability to prevent or mitigate the consequences of an accident which could result in potential offsite exposures comparable to the exposure guideline of CFR10 Energy [3],¹ Part 100, (Dec 5, 1973).

service conditions. Environmental, loading, power, and signal conditions expected as a result of normal operating requirements, expected extremes (abnormal) in operating requirements, and postulated conditions appropriate for the design basis events of the station.

test operating cycle. The movement of an actuator through its required operations travel under specified loading conditions, terminating with a return to the starting position.

test response spectrum (TRS). The response spectrum that is constructed using analysis or derived using spectrum analysis equipment based on the actual input test table motion to the device.

type test. Tests made on one or more sample actuators to verify adequacy of design and the manufacturing processes.

valve actuator. An electric, pneumatic, hydraulic, or electrohydraulic power-driven mechanism for positioning two-position or modulating valves, and dampers. Included are those components required to control valve action and to provide valve position output signals, as defined in the actuator specification.

zero period acceleration (ZPA). The acceleration which appears as a constant portion of a response spectrum in the highest frequency range. It is the maximum acceleration in the time history from which that response spectrum was developed.

¹ Numbers in brackets correspond to those of the references, Section 3 of this standard.

3. References

- [1] ANSI/IEEE Std 323-1983, IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations.²
- [2] ANSI/IEEE Std 344-1975 (R 1982), IEEE Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations.
- [3] CFR 10, Energy—Nuclear Regulatory Commission, Part 100, Dec 5, 1973.³

4. Introduction

4.1 General. Safety-system equipment in nuclear power stations shall be capable of performing satisfactorily under defined conditions, including postulated DBE. It is necessary to provide assurance that such equipment meets its performance requirements throughout its installed life. This is accomplished through a disciplined program of design, qualification, production quality control, installation, maintenance, and surveillance testing.

This standard applies only to the qualification portion of the above mentioned program.

Most actuators are designed and manufactured in generic design groups (families) which, although varying considerably in size, are made of similar materials and have similar design and manufacture. Individual actuators from these design groups can be applied to a wide range of applications. An independent qualification of each possible variation of design within each generic group is not practical. When a specific purchase request does exist, qualification shall be demonstrated with regard to that specific application.

Specific qualification requires demonstration that each actuator is a member of a generically qualified family and further that it will, when manufactured to meet an actuator specification, function as required for a particular application. However, if a particular actuator for which qualification is required cannot be related to a generically qualified actuator, the qualification test procedure shall be performed on a sample of that particular actuator.

² IEEE documents are available from IEEE Service Center 445 Hoes Lane, Piscataway, NJ 08854.

³ CFR publications are available from Superintendent of Documents, US Government Printing Office, Washington, DC 20402.

It is not the intent of this standard that a manufacturer shall perform generic qualification prior to receipt of an order for a specific application.

This standard divides the qualification process for actuators into the following three sequential steps:

- (1) Identification of the generic actuator group
- (2) Qualification testing of selected actuators in generic actuator group
- (3) Qualification of actuator for specific application

4.2 Requirements. Methods used for qualification include type testing, operating experience, and analysis. This standard requires that

- (1) Qualification of a generic actuator group shall be accomplished by type testing, supplemented as needed by analysis
- (2) Specific qualification for each application shall be accomplished by testing or analysis of generic group qualification data, operating experience, and additional testing when necessary.

In type testing sample actuators, a representative unit(s) manufactured in accordance with the manufacturer's quality control system and specifications for production units shall be subjected to environmental and operating cycles which simulate the intended service conditions and safety-related function for which they are to be qualified.

Documentation shall be provided as described in this standard.

5. Identification of the Generic Actuator Group

5.1 Generic Actuator Group Identification.

A generic actuator group from which sample actuators will be selected for type test shall be established and identified. Consideration shall be given to details including but not limited to design, materials, manufacturing processes, limiting stresses, deformation, deflections, operating principles, design margin.

Generic actuator group designs shall have the following common characteristics:

- (1) Identical type of actuator (electromechanical, pneumatic, hydraulic, mechanical, electrical, or any combination)
- (2) Functionally and geometrically similar

structural arrangements with the principal differences being overall size, weight, and ratings

- (3) Similar actuator mounting configuration and output drive method
- (4) Similar mounting of functional accessories
- (5) Similar internal control devices

5.2 Selection of Actuator Units for Type Testing. Due to the variation in types, sizes, and configurations of valve actuators, it is not practical for this standard to establish a fixed number of actuators to be tested in order to establish qualification. It is also impractical to require all actuators to be tested.

All actuators within a generic group will be qualified by analysis provided an appropriate number of units are type tested and a comparison by analysis is made between tested units and others. The number of units to be tested shall be based on an evaluation of the variations in physical and performance parameters that exist within the generic group; for example, thrust, torque, power, speed, materials, pressure, weight, dimension, inertia, and seismic moment.

NOTE: The relationship between generic actuator group and the specific application of an actuator is given in Part I, 7.3.

Appendix A describes a suggested procedure for selection of test units.

6. Qualification Testing of Selected Actuators in Generic Actuator Group

6.1 Type Test Parameter Values

6.1.1 Test Parameter Values. Parameter values to be used in qualification of a generic actuator group shall be obtained from one of the two sources described in 6.1.2 and 6.1.3.

6.1.2 Standard Sources. The standard qualification cases are defined in Part II. The test parameter values to be used in Part III, Section 8, are also shown in Part II. These values include environmental margins as stated in ANSI/IEEE Std 323-1983 [1]. In Part II, the values for the figures are based on composite service conditions, shown in Appendix B. These are a compilation of data obtained from the nuclear community at the time this standard was written. The thermal aging values for Part III, Section 2, are based on the rationale described in

Appendix C. The vibration testing and seismic simulation values for Part III, Sections 5 and 6, are based on the rationale described in Appendix D.

6.1.3 Other Sources. Test parameters other than (but in form comparable to) those in Part II may be developed. Margins, as required by ANSI/IEEE Std 323-1983 [1], shall be applied to service conditions to obtain parameter values.

6.2 Type Test Plan. A type test plan shall be prepared based on the requirements of this standard. The test plan shall contain the following information as a minimum:

- (1) Reference to this standard
- (2) Identification of the actuator(s) to be tested including the manufacturer, catalog identifications, and parts list and drawings for each actuator
- (3) Range and quality requirements of motive power source and control signal requirements, including quality of the actuating medium (such as cleanliness of an air supply or voltage ripple) which are critical to the proper functioning of the actuator
- (4) Mounting, connection, special orientation and interface requirements, cable and conduit entry points including pressure-seal type, and installation when required
- (5) Maintenance to be performed during the type test as related to the installed life maintenance program
- (6) The normal or rated performance specifications for the actuator(s) and accessory parts to be tested. These specifications shall include output characteristics and all the capabilities for which the actuator is to be qualified. For example, if it is intended to demonstrate that a limit switch in electric actuator or solenoid valve in pneumatic actuator function, this should be included in the listing
- (7) Qualified life objective
- (8) Safety-function capability to be demonstrated
- (9) Acceptable performance limits
- (10) Conditions which constitute test failure
- (11) Method of load simulation
- (12) Test procedure
- (13) A listing of environmental test parameters (see Part II). The variation of these parameters with time is to be specified by a table or graph similar to those shown in Part II. The listing shall indicate the variables to be mea-

sured and recorded and the frequency and accuracy of each measurement. These parameters may be classified as follows:

(a) *Thermodynamic Environment*. Temperature, pressure, moisture content (relative humidity)

(b) *Fluid Jet or Spray Environment*. Flow rate and duration jet or spray pattern, temperature, and chemical composition and pH of fluids injected into the test chamber

(c) *Seismic and Nonseismic Vibration Environment*. Frequency and amplitude or acceleration characteristics of vibrations

(d) *Radiological Environment*. Nuclear radiation type(s), energy spectra, exposure rates, and integrated dose levels

(e) *Input Power Source*. Electrical frequency, voltage, and current; hydraulic and pneumatic fluid type, quality, pressure, and flow rate

(f) *Electrical Characteristics*. Insulation resistance of electrical components

(g) *Mechanical Characteristics*. Torque, thrust, position, time and load profile from receipt of signal until stop of motion, and actuator fluid leakage

(h) *Auxiliary Function Measurement*. Function measurements confirming the capability of equipment included with the actuator but not necessary for its own operation. Measurements shall be taken that confirm the capability of the auxiliary equipment to handle rated load and provide the accuracy required by the test plan (for example, position-indicating devices)

(14) Any special requirements or conditions such as steam air mixture which may affect performance of the actuator during the test

6.3 Type Test Procedure

6.3.1 Installation for Tests. The test actuator(s) shall be selected as representative of production actuators and means shall be provided as required to permit testing in accordance with Part III. Electric, pneumatic, or hydraulic connections for motive power shall be provided as required. The same actuator(s) shall be used throughout the test. Orientation(s) shall be as required by the type test plan.

6.3.2 Test Sequence and Requirements. As applicable, the qualification type test shall be performed in sequence as follows:

(1) Baseline operability test. (See Part III, Section 1.)

(2) Normal thermal aging test. (See Part III, Section 2.)

(3) Normal pressurization cycle test. (See Part III, Section 3.)

(4) Normal radiation aging test. (See Part III, Section 4.)

(5) Vibration aging test. (See Part III, Section 5.)

(6) Seismic simulation test. (See Part III, Section 6.)

(7) DBE radiation exposure test. (See Part III, Section 7.) [Can be included in step (4).]

(8) DBE environment test. (See Part III, Section 8.)

(9) Operability test as in (1).

6.4 Inspection

6.4.1 Inspection of the test actuator(s) shall be performed prior to and upon completion of the qualification test series in accordance with a written test plan (see Part I, 6.2).

6.4.2 Pretest Inspection. Pretest inspection shall be performed according to the test plan prepared by the actuator manufacturer for such items as

- (1) Control settings
- (2) Securing of fasteners
- (3) Motive power-drive system
- (4) Test equipment calibration

6.4.3 Intermediate Inspection. To assist in evaluation of the test actuator, inspections including operability testing may be made at intermediate times during the qualification testing program.

Aside from any adjustments or other changes which are required to perform the various tests, no alterations, adjustments, or maintenance without suitable justification will be allowed other than those stipulated in the test plan without the qualification tests being reinitiated. Any such maintenance or adjustments shall be fully described and evaluated in the qualification report.

6.4.4 Post-Test Inspection. The test actuator shall be disassembled and inspected, and the condition of the actuator parts shall be recorded.

6.5 Acceptance Criteria. The actuator will have passed the type test if it performs the functions required by the type test plan described in 6.2.

6.6 Generic Actuator Group Design Modification. Any design modification made to a ge-