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AMERICAN NATIONAL STANDARD

Functional Qualification Requirements for Power Operated Active Valve Assemblies for Nuclear Power Plants

ANSI B16.41 - 1983

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FOREWORD

(This Foreword is not a part of American National Standard, Functional Qualifications Requirements for Power Operated Active Valve Assemblies for Nuclear Power Plants, ANSI B16.41.)

This Standard is one of a series of power plant equipment standards provided to assure that equipment will function as specified. The Standard was developed under sponsorship of the American Society of Mechanical Engineers (ASME). Its development was initiated by the American National Standards Committee N45 on Reactor Plants and Their Maintenance. In October, 1972, the N45 Committee established a task force to prepare a series of standards to assure that valves would function as specified. In 1974, the task force was reassigned to American National Standards Committee B16 and designated Subcommittee H.

Power operated active valve assemblies are required to perform their functions under specified operating conditions. It is the purpose of the series of standards on active valves to provide requirements for:

(1) the preparation of Functional Specifications;

(2) the qualification of the design of valves, actuators, and the combination thereof (valve assemblies) by test and analysis for the intended service; and

(3) production testing of valve assemblies manufactured for specific applications.

The purpose of the foregoing is to provide assurance that the valve assemblies in service will function as required under all specified operating conditions. Only those conditions considered to uniquely affect the operability of valve-actuator combination (as opposed to either the valve or actuator alone) are developed within ANSI B16.41. Integrity of the pressure retaining boundary of the valve, covered by codes developed by the ASME Boiler and Pressure Vessel Committee, is excluded from the scope of this Standard.

The first standard to be issued in the series is ANSI N278.1-1975, which covers the preparation of Functional Specifications.

This Standard provides a method for qualification of power operated active valve assemblies that will provide an acceptable level of assurance of functional operability. This qualification is based on tests demonstrating the ability of the valve assembly to perform its function under extreme adverse conditions of pressure, mechanical loading, flow dynamics, temperature, and vibration. The testing involves imposition of certain of these conditions in combination, and others individually, all exceeding maximum levels expected in service. It is recognized that in the extremity of certain adverse plant events involving need for valve operation, loading combinations not specifically tested in this qualification may be imposed on valves. The adverse effects of such combinations have been considered by the Committee, and it has been concluded that this qualification will provide a high degree of assurance of functional operability for all such combinations.

It is recognized that in testing a complete series of valves of a given type, for example NPS 6, 8, 10, 12, 14, 16, 18, 20, 24, 28, 32, and 36 valves, all Class 600 gate valves, much of the test time, work, and expense will be unproductive, in that no useful information will be produced by the later tests. If the various sizes are uniformly designed and proportioned, it will be expected that all valves will perform uniformly in the tests. Conversely, if on the test of the first valve a specific design weakness is discovered, similar weakness will be found in all the other valve sizes.

It has been proposed that in such case, if for example, an 8 in. valve and 18 in. valve were tested successfully, it should be possible to infer from such results that all the other valves, none being less than half or more than double the size of a valve that *was* actually tested, should be qualified as to acceptable design, provided such untested designs can be shown to be, in fact, geometrically similar to the test-qualified sizes.

Such generic qualification is considered to be potentially acceptable, subject to due consideration of the degrees of variation from exact geometric similarity of two valves of different size, and the possibility of scale factors, such as changing relativity between surface roughness vs. length dimensions, having some unanticipated adverse effect on functional performance. In the absence of clear, demonstrable practical limits on extrapolation of functional design qualification, the Committee has made it obligatory for a determination to be made by the plant owner or his designee (ultimately by the licensing agency) that design qualification "by proxy" will be acceptable in each individual case, as a condition for the use of the candidate qualification method.

In this Standard, provision has been made for such qualification, with the expectation that generic qualification *will be* a practical way to maximize the cost-effectiveness of the design qualification process. References in this Standard to "Parent" and "Candidate" valve assemblies are addressing this undertaking. The Term "Parent" is intended to be understood in the family sense, that is, as the elder in a family of generic offspring having strong resemblance to the parent.

The "Candidate" is the nominee for family membership until it is shown that the rules of Annex J are satisfied *and* the Candidate is accepted as Qualified by the owner or his designee.

In recognition of this external control on the candidate qualification process, Annex J is identified as supplementary information which is not an integral part of this Standard. It should *not* be inferred that the Guidance provided in Annex J is optional in the candidate qualification process, but rather that the candidate qualification process is nonmandatory and subject to specific acceptance in each individual case by the owner or his designee.

Annexes A through H and K are integral parts of the body of the proposed Standard which, for reasons of convenience, are placed after the main text. Annex J provides supplementary information that is not an integral part of the Standard.

Approval for the 1983 revision to this Standard was granted by ANSI on January 6, 1983.

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AMERICAN NATIONAL STANDARD

FUNCTIONAL QUALIFICATION REQUIREMENTS FOR POWER OPERATED ACTIVE VALVE ASSEMBLIES FOR NUCLEAR POWER PLANTS

1 SCOPE

1.1 This Standard establishes the requirements for functional qualification of power operated active valve assemblies for nuclear power plants. It is not intended that this Standard be applied to power operated relief valves and self-operated valves such as check and pressure relief valves. It is the responsibility of the plant owner or his designee to identify those active valves which require qualification under this Standard and to identify the functional qualification requirements, as associated with Annexes A through H, which shall be met.

1.2 Functional qualification of a parent valve assembly consists of testing as specified herein to demonstrate that a valve assembly can perform its required function under test conditions. Annex J is a guide to provide functional qualification of a candidate valve assembly by analyses that demonstrate design similarity to a parent valve assembly. Any use of Annex J for qualification of a candidate valve for a specific application in a nuclear power plant shall be the responsibility of the plant owner or his designee.

1.3 Qualification testing, inspecting, and reporting as specified herein shall be performed in accordance with the applicable requirements of ANSI/ASME NQA-1 or its equivalent.

1.4 A Functional Qualification Report(s) is required to document compliance with this Standard. An Application Report(s) is required to document qualification of a valve assembly for a specific nuclear plant application.

2 REFERENCES

The standards or codes referenced in this Standard are listed in Annex K. The text of this Standard indicates whether use of a referenced standard or code is mandatory or reference is for information only.

3 DEFINITIONS

The following definitions are provided to assure a uniform understanding of selected terms as they are used in this Standard.

aging—the cumulative effect of operating cycles and environmental and system conditions imposed on the valve assembly

application report—documentation for a specific application showing that the required pressure ratings, qualification loading levels, and operating condition capabilities are equaled or exceeded by the corresponding pressure ratings, qualification loadings, and operating condition capabilities shown in the Functional Qualification Report(s)

cold working pressure—the valve pressure rating at 100°F (38°C)

design life—the time or operating cycles (or both) for which satisfactory performance is required

Functional Qualification Report—documentation of tests or analyses (or both) performed in accordance with this Standard

maximum motive power—the electrical, fluid, or mechanical power provided when voltage or actuator pressure is at the highest value for which the valve assembly is to be qualified

minimum motive power—the electrical, fluid, or mechanical power provided when voltage or actuator pressure is at the lowest value for which the valve assembly is to be qualified

motive power—the electrical, fluid, or mechanical power required to operate the valve assembly

normal motive power—the electrical, fluid, or mechanical power provided when voltage or actuator pressure is at its normal or nominal value

operating cycle—the movement of a valve closure member through its full stroke under defined operating conditions, terminating with a return to the starting position

power operated active valve assembly—a valve assembly that must perform a mechanical motion to fulfill its function through the application of motive power

valve assembly—a valve-actuator combination including those functional accessories which are directly mounted thereon:

(a) *test valve assembly*—a valve assembly selected for qualification testing

(b) *parent valve assembly*—a test valve assembly which has been qualified by all appropriate testing required by this Standard

(c) *candidate valve assembly*—a valve assembly to be qualified by:

(1) analyses that demonstrate design similarity with the parent valve assembly; or

(2) analyses as described in (1) above in combination with appropriate testing of the candidate valve assembly

(d) *qualified candidate valve assembly*—a valve assembly which has been qualified in accordance with the definition above

4 FUNCTIONAL SPECIFICATION

The functional requirements for a valve assembly shall be provided in a specification prepared in accordance with ANSI N278.1-1975.

5 FUNCTIONAL QUALIFICATION REQUIREMENTS

Functional qualification shall be demonstrated by tests, by analyses, or by a suitable combination thereof, based on the requirements provided herein and corresponding operating requirements in the Functional Specification. Qualification of the valve-actuator is established by conformance with IEEE-382. As applicable, the functional qualification shall demonstrate the following:

(a) Valve sealing capability

(b) Cold cyclic operability

(c) Hot cyclic operability

(d) Operability under maximum pipe reaction end-loading

(e) Operability during and after loading representative of the maximum seismic incident

(f) Operability during and after vibratory disturbances

(g) Flow interruption capability

(h) Adequacy of the materials of construction to survive environmental and aging effects

5.1 Qualification of Parent Valve Assemblies

Qualification of a parent valve assembly in accordance with this Standard demonstrates that the parent valve assembly will perform its function for the individual test conditions and qualifies the parent valve assembly design for operating conditions shown in the Functional Qualification Report. Functional Qualification Tests qualify the valve assembly for the test orientation(s).

5.1.1 Test Plan. A Test Plan shall be prepared with appropriate inspection and test record forms to define test objectives, test fluids, test instrumentation, conditions of the test, orientation, permissible maintenance or adjustments, and acceptance criteria. Where prequalified parts of the valve assembly (i.e., valve-actuator, etc.) are utilized as part of the valve assembly qualification, the Test Plan shall reference the report upon which such prequalification is based.

5.1.2 Testing

5.1.2.1 Installation for Tests. A test valve assembly shall be selected as representative of the production valves and shall be supported as required to permit testing in accordance with the applicable Annex. Electric, pneumatic, or hydraulic connections for motive power shall be provided as required.

5.1.2.2 Orientation. Orientation shall be as required by the Test Plan.

5.1.2.3 Test Sequence and Requirements. The applicable tests in the following test groupings shall be conducted in accordance with the referenced Annexes and in the group sequence listed below on the same test valve assembly. Individual tests within a numerical grouping may be conducted in any sequence or in any combination with other tests within that numerical grouping.

Group 1
(a) Leakage (Annex A)
(b) Cold cyclic (Annex B)

Group 2
(a) Hot cyclic (Annex C)
(b) End loading (Annex D)
(c) Exploratory Vibration (Annex E)
(d) Vibration Endurance (Annex H)
(e) Seismic (Annex F)
(f) Flow interruption capability (Annex G)

Group 3: Cold cyclic (Annex B)

Group 4: Leakage (Annex A)

5.1.2.4 Environmental and Aging Effects. Valves covered by this Standard are characterized by the use of metal for all components which provide the pressure containing boundaries and operating load bearing or transmitting functions. The use of nonmetallic materials is confined to applications involving substantially total confinement in compressure loadings, as in stem seal packing and in joint sealing gaskets. The use of metal in valve components provides basic assurance against loss of operability from environmental and aging effects, such as radiation, elevated environmental temperature, and impinging chemical sprays. Qualification of plastic and elastomeric materials requires exposure to aging radiation and thermal environments which are equivalent to the maximum for which the valve is to be qualified. This radiation and thermal aging shall be performed as specified in IEEE-382, followed by tests of the aged specimens to demonstrate that the specimens are capable of performing their required function. The sequential testing program required by this Standard provides assurance that the valve assembly can function under a wide range of operating conditions. Periodic inservice testing prescribed by the ASME Code, Section XI, may provide assurance that aging does not unacceptably affect valve assembly operability during normal plant service conditions.

5.1.3 Inspection

5.1.3.1 Inspections of the test valve assembly shall be performed prior to and upon completion of the qualification test series in accordance with a written Test Plan (see 5.1.1).

5.1.3.2 Pretest Inspection. Pretest inspection shall be performed according to the Test Plan for such items as the following:
(a) Control settings
(b) Securing of fasteners
(c) Motive power drive system
(d) Test equipment calibration

5.1.3.3 Intermediate Inspection. To assist in evaluation of the test valve assembly, inspections may be made at intermediate times during the qualification testing program. If some condition is exhibited during the sequence of the testing which requires maintenance or adjustment of a part, acceptance of the test must be evaluated according to the limitations of the Test Plan. Aside from any adjustments or other changes which are required to perform the various tests, no alterations, adjustments, or maintenance are 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 Functional Qualification Report.

5.1.3.4 Post-test Inspection. The test valve shall be disassembled and inspected after completion of the group of tests of 5.1.2.3. Significant damage and changes shall be recorded and evaluated and be included in the Functional Qualification Report described in 5.1.4.

5.1.4 Reports

5.1.4.1. A Functional Qualification Report shall be prepared for each parent valve assembly qualified in accordance with this Standard. This report shall provide complete identification of the valve by type, size, pressure rating, actuator, and other data as appropriate, including qualification Test Plan, test results, and inspections. Any specific limitations that restrict qualification shall be stated.

5.1.4.2 The Functional Qualification Report shall contain a summary of the parameters established by the functional qualification testing and analysis. Each Functional Qualification Report shall be certified to be correct and complete and to be in compliance with this Standard, by one or more Registered Professional Engineers representing the organization responsible for the functional qualification.

5.2 Qualification of Candidate Valve Assemblies

Qualification of a candidate valve in accordance with this Standard is based on the individual test conditions for the parent valve and the guidance for qualification of candidate valve assemblies given in Annex J. Any use of Annex J for qualification of a candidate valve for a specific application in a nuclear power plant shall be the responsibility of the plant owner or his designee. It is the objective of the following qualification requirements to verify that the candidate valve will perform its intended function and that it qualifies for the operating conditions shown in the Functional Qualification Report.

5.2.1 Requirements

A candidate valve assembly shall satisfy the functional qualification requirements specified in 5.1. This may be accomplished by similarity analysis or by a combination of testing and similarity analyses in accordance with Annex J. The testing or analysis shall show that the qualification of the parent valve assembly constitutes a valid basis for conclusion that the design of the candidate valve assembly is of at least equivalent adequacy for its intended function.

5.2.2 Candidate Valve Testing

Any testing that is required for candidate valve qualification shall be performed in accordance with the appropriate Annex (A through J) of this Standard.

5.2.3 Reports

The Functional Qualification Report for a qualified candidate valve assembly shall contain the following, as applicable:

(a) a summary of the functional parameters;
(b) the Test Plan;
(c) test results;
(d) inspection reports for the parent valve assembly (assemblies) and for the candidate valve assembly;
(e) an explanation of how conformance with the requirements of 5.1.2.3 is achieved, including explanation of all items treated as "not applicable;" and
(f) the analyses used to show that the candidate valve assembly satisfies the requirements of this Standard for design similarity with the parent valve assembly.

Each Functional Qualification Report shall be certified to be correct and complete, and to be in compliance with this Standard, by one or more Registered Professional Engineers representing the organization responsible for the functional qualification.

6 APPLICATION REPORT

The suitability of a valve assembly that has been qualified in accordance with this Standard to meet the requirements of a Functional Specification for a specific application shall be documented in an Application Report. The Application Report shall be certified to be correct and complete, and to be in compliance with this Standard, by one or more Registered Professional Engineers.

ANNEX A
VALVE LEAKAGE TEST

This Annex is an integral part of American National Standard B16.41, and is placed following the main text for convenience.

A1 SCOPE

The valve leakage test establishes, by measurement, the mainseat valve leakage rate and, by observation or measurement, the packing leakage rate of the test valve.

A2 LEAKAGE CLASSIFICATION

Classification of valves relative to mainseat leakage is provided in ANSI N278.1-1975.

The initial valve leakage test establishes the base line performance of the valve being tested. Leakage rates measured subsequent to other tests in the qualification test series shall be recorded in the Functional Qualification Report for comparison with the initial test and to establish a basis to verify the valve application.

A3 TEST SETUP REQUIREMENTS

A3.1 The test valve assembly shall be installed in a fixture that will permit control of the pressurization of both the upstream and downstream flow ports. Motive power connections shall be functionally equivalent to an actual installation. Orientation of the valve assembly shall be as required to satisfy the provisions of 5.1.2.2. Provision shall be made to measure mainseat leakage and, the packing leakage as set forth in A.4.1 and A.4.2, respectively.

A3.2 The test working fluid may be water (that may contain a corrosion inhibitor), steam, air, or an inert gas, whichever is appropriate to the test.

A3.3 Both the rated pressure for the valve and the maximum rated seat sealing differential pressure shall be defined in the Functional Qualification Report (the pressure used in these tests determines the qualification pressure rating). A higher test pressure may be selected to establish margin for the downward qualification of candidate valves similar to the parent valve being tested. In addition, the valve is to be identified as bidirectional or unidirectional, in which case the direction of pressurization is defined.

A4 TEST CONDUCT

A4.1 For measurement of mainseat leakage, a valve closure shall be effected by the actuator using minimum motive power, and with the test assembly at its rated test pressure. Pressure on one side of the closure shall be relieved to establish a differential pressure in the direction resulting in the most adverse seating condition for bidirectional valves. For example, a globe valve shall be tested with pressure under the disk, unless the valve is restricted to unidirectional service only in the reverse direction. Leakage shall be collected from the low pressure side of the closure or otherwise measured by appropriate means. The test shall be a minimum of 5 min or a longer period deemed adequate to establish the leakage rate.

NOTE: For double disk gate valves, differential pressure may be applied to the bonnet cavity and leakage rates measured for each mainseat.

A4.2 Packing leakage shall be observed at cold working pressure with the valve in the partially open position. For valves without leakoff connections, packing leakage shall be observed and the leak rate estimated. For valves with lantern rings and leakoff connections, leakage at the leakoff connections shall be measured and recorded. For valves utilizing diaphragms or bellows to achieve zero stem leakage, and that also utilize back-up packing, the packing test shall be performed with the diaphragm or bellows removed or with pressure equalized on both sides of the diaphragm or bellows. The initial packing leakage test shall be performed after fully cycling the test valve assembly 10 times. The leakage rate test duration shall be adequate to determine the leakage rate, but no less than 5 min.

ANNEX B
COLD CYCLIC TEST

This Annex is an integral part of American National Standard B16.41, *and is placed following the main text for convenience.*

B1 SCOPE

The cold cyclic test demonstrates the capability of a test valve assembly to open and close under adverse combinations of motive power and system pressure with the assembly at room temperature not exceeding 100°F (38°C). The basis for qualification is the maximum time to open and/or close the valve.

B2 TEST SETUP REQUIREMENTS

The test valve assembly shall be installed in a fixture as specified in A3.

B3 TEST CONDUCT

B3.1 An initial test run shall be made consisting of one full operating cycle utilizing normal motive power. With the valve open, the fixture is pressurized at the rated test pressure and a valve closure initiated and timed. One side of the closure is then depressurized to establish the rated differential operating pressure in the most adverse direction for opening the valve. An opening is then initiated and timed. Differential pressure need not be maintained after the test valve assembly is unseated.

B3.2 The second test series consists of three full operating cycles performed with the test fixture depressurized utilizing the maximum motive power for actuation. Each half cycle of the operation shall be timed.

B3.3 The third test series consists of three full operating cycles utilizing minimum motive power. The sequence for performance of the testing is the same as for B3.1.

ANNEX C
HOT CYCLIC TEST

This Annex is an integral part of American National Standard B16.41, and is placed following the main text for convenience.

C1 SCOPE

The hot cyclic test demonstrates capability of a test valve assembly to open and close under adverse combinations of motive power and system pressure with the assembly operated at a qualification temperature in excess of 100°F (38°C). The basis for qualification is the maximum time to open and the maximum time to close the valve.

C2 QUALIFICATION REQUIREMENT

The test is required only when the valve assembly is to be qualified for operation at a fluid temperature exceeding 200°F (93°C), except that for valves having components made of plastic or elastomeric materials which operate at temperatures exceeding 100°F (38°C), testing is required for qualification.

C3 TEST SETUP REQUIREMENTS

The test valve assembly shall be installed in a fixture as specified in A3. Provision shall be made for regulating the working fluid temperature and timing of the valve operation.

C4 TEST CONDUCT

C4.1 An initial test run shall be made consisting of one full operating cycle utilizing normal motive power. With the valve open, the fixture is pressurized to the rated test pressure and the working fluid temperature is raised to the qualification temperature level. The valve metal temperature shall reach approximately steady state conditions before initiation of operation. A valve closure is then made and timed. One side of the closure is then depressurized to establish the rated differential operating pressure across the valve in the most adverse direction for opening the valve. An opening is then initiated and timed. Differential pressure need not be maintained after the test valve assembly is unseated.

C4.2 The second test series consists of three full operating cycles using minimum motive power for valve actuation. The sequence for each cycle of operation is the same as for C4.1.

C4.3 The final test run is begun with the valve open, the text fixture pressurized at the rated test pressure, and the rated temperature established at steady state condition. A valve closure is initiated using the maximum motive power and the closure timed. With the valve closed, the test fixture shall be allowed to cool to steady state equilibrium with ambient air, no higher than 100°F (38°C). One side of the closure is depressurized to establish the rated differential operating pressure across the valve in the most adverse direction for opening the valve. An opening cycle is then performed using minimum motive power for actuation, and the opening timed. Differential pressure need not be maintained after the test valve assembly is unseated.

ANNEX D
PIPE REACTION END LOADING QUALIFICATION TEST

This Annex is an integral part of American National Standard B16.41, and is placed following the main text for convenience.

D1 SCOPE

The pipe reaction end loading test demonstrates the operability of the valve assembly after being subjected to pipe end loading forces for which the valve is to be qualified.

D2 QUALIFICATION REQUIREMENTS

The end loading qualification test shall be applicable only to valve assemblies whose application involves significant imposed end loading reactions (e.g., a valve without significant loading is a drain valve with piping attached to one end only).

D3 MAGNITUDE OF THE END LOADING MOMENT

The valve manufacturer determines the magnitude of the end loading force for the valve qualification. The test loading to be applied shall be at least equal to the moment $F_b S$, as defined in NB-3500.[1] The values of S and SMYS used shall be those of ASME Code, Class 1, materials. The test loading may be increased, if desired, to qualify candidate valves whose size, pressure ratings, and/or dimensional parameters may require downward adjustments of the qualified end loading force. The loading test bending moment shall be greater than that for which the test valve assembly is to be qualified by a factor equal to the ratio:

$$\frac{\text{Actual test bar yield strength of body material} \times G_b \text{ based on measured dimensions}}{\text{SMYS of body material} \times G_b \text{ based on minimum drawing dimensions}}$$

where SMYS is the specified minimum yield strength, and G_b is the section modulus as defined in NB-3500.[1]

D4 TEST OPERATING PRESSURE

The minimum test operating pressure is the 100°F (38°C) pressure rating selected for qualification of the valve assembly. A higher pressure may be designated to permit qualification of candidate valves requiring downward adjustment from the parent valve pressure rating. The test operating pressure shall be greater than that for which the test valve assembly is to be qualified by a factor equal to the ratio:

$$\frac{\text{Actual test bar yield strength of body material}}{\text{SMYS of body material}}$$

D5 TEST SETUP REQUIREMENTS

The test valve assembly shall be installed in a fixture as specified in A3 with end pieces capable of transmitting the test end loading. The test arrangement may be such that a constant moment is applied over the entire length of the valve body and the valve body subjected to at least the normal axial tensile forces produced in the end closures by the simultaneous application of full test pressure. Alternative arrangements which impose shear loadings and variable moments over the length of the valve body are acceptable provided the moment is at least equal to the minimum required at any point in the valve body. The test moment shall be applied in the plane and mode most likely to adversely affect test valve assembly operability. For most gate and globe valves this is normally considered to be in the plane of the stem and pipe center lines, and tending to close the bonnet bore.

[1] References identified by NB refer to Subsection NB of Section III of the ASME Boiler and Pressure Vessel Code.

D6 TEST CONDUCT

D6.1 With the valve in the open position, the test operating pressure is established in the valve assembly, and while pressure is maintained, the test loading moment is applied to the valve assembly. The test loading moment is then reduced to 2/3 of the original value and the test pressure is also reduced to 2/3 of the initial pressure or to the maximum rated pressure, whichever is greater. A valve closure cycle is then effected using minimum motive power. The closure time shall be observed and recorded. Following closure, a valve leakage test is conducted in accordance with A4.

D6.2 With test loading moment at the same value as for the valve closure operation, a valve opening is made utilizing minimum motive power with maximum closure differential pressure, for which the test valve assembly is to be qualified and applied in the direction producing the greatest resistance to the valve opening. Differential pressure need not be maintained after the test valve assembly is unseated. During this operation the opening time shall be observed and recorded.

D7 EXEMPTION

Valves installed in piping by bolting between pipe flanges and having a cylindrical cross section (except for through holes for bolting and entrance of the valve stem) of such proportions that the length of the valve parallel to the pipe run is equal to or less than the inside diameter of the valve are exempt from this qualification test.

ANNEX E
EXPLORATORY VIBRATION TEST

This Annex is an integral part of American National Standard B16.41, and is placed following the main text for convenience.

E1 SCOPE

The exploratory vibration test shall be used to determine the fundamental frequency of the test valve assembly. The exploratory vibration test described in this Annex requires the use of a shake table.[1] The fundamental frequency determined by this test is used to identify the test assembly as flexible or rigid, as required by Annex F.

E2 TEST SETUP REQUIREMENTS

E2.1 The test valve assembly shall be mounted on a shake table utilizing a suitable fixture.

E2.2 The assembly shall be filled with fluid (see A3.2), but pressurization is not required.

E2.3 The shake table shall be capable of inducing sinusoidal vibration as required in E3.

E2.4 Suitable instrumentation shall be provided to at least measure frequency and acceleration of the valve body and of the actuator.

E2.5 The stroke position shall be determined by preliminary test so as to produce to lowest natural frequency for the valve assembly.

E3 EXPLORATORY VIBRATION TEST

The test valve assembly shall be given an exploratory vibration test over a range of frequencies[2] from 5 Hz to the maximum frequency to be qualified in each of three mutually perpendicular axes. In no case shall the maximum vibration frequency be less than 40 Hz.

Vibration shall be essentially sinusoidal with amplitudes to produce an applied acceleration of 0.2 g minimum. Exploratory vibration shall be performed by a sweep of the full frequency range to be qualified at a rate not exceeding one octave per minute. Resonance is defined as actuator response at a frequency at which the acceleration response of the actuator exceeds the test acceleration value by a factor of three or greater. Response measurements shall be made in the direction of input and two other mutually perpendicular axes. Each test frequency, in each axis at which resonance occurs, shall be recorded.

[1] Other methods of exploratory vibration testing are in preparation.

[2] If desired, the frequency range for test of a parent valve may be extended to aid in qualification of a candidate valve. Fundamental frequency calculations shall be made for the parent and candidate valve assemblies, with all such calculations being made using the same method. The fundamental frequencies (fn) thus calculated shall be used to determine the required vibration test range as follows:

from:

$$\frac{\text{(fn) Parent Valve}}{\text{(fn) Max. Any Candidate Valve}} \times 5\ \text{Hz}$$

to:

$$\frac{\text{(fn) Parent Valve}}{\text{(fn) Min. Any Candidate Valve}} \times 40\ \text{Hz (or maximum frequency qualified)}$$

If the above computation produces a frequency range requirement for the candidate valve with limits outside the actual test range of the parent valve, the candidate valve must be qualified by an exploratory vibration test through required frequency range.

ANNEX F
SEISMIC LOADING TEST

This Annex is an integral part of American National Standard B16.41, and is placed following the main text for convenience.

F1 SCOPE

The seismic test demonstrates the operability of a test valve assembly when subjected to a loading representative of the selected seismic load qualification level.

F2 QUALIFICATION REQUIREMENT

F2.1 The qualification test method shall be based on whether the test valve assembly is flexible (i.e., has a fundamental frequency less than 33 Hz) or rigid (i.e., has a fundamental frequency greater than or equal to 33 Hz) in its least rigid axis. If the test valve assembly has a fundamental frequency less than 33 Hz, identified as a resonance as defined in E3 (Vibration Test), it shall be seismically qualified by test in accordance with the applicable requirements of IEEE-382 and the seismic load testing procedures of this Annex are not applicable. If the test valve assembly has a fundamental frequency of 33 Hz or greater, the procedure of this Annex is applicable.

F2.2 Seismic qualification of the valve-actuator shall have been established in accordance with IEEE-382.

F2.3 Functional accessories shall be rigidly attached to the valve assembly. The accessories that have not been qualified as part of the actuator shall be seismically qualified in accordance with IEEE-382. During the seismic qualification, the accessories shall be operationally checked and monitored during testing to assure that no malfunction occurs.

F3 MAGNITUDE OF THE SEISMIC LOADING

The valve manufacturer determines the magnitude of the loading required to simulate the effect of the "g" value of seismic acceleration for which the test valve assembly is to be qualified. This is calculated considering the mass supported from the valve body in the valve assembly. Torsional as well as bending effects shall be considered. More than one calculation may be required if various orientations of the valve assembly are to be qualified. These values are the qualification seismic loadings.

The test seismic load shall be obtained by upward adjustment of the qualification seismic load such that the highest calculated test yield strength utilization of yoke, yoke clamp, or yoke bolting shall be equal to or greater than the highest calculated qualification yield strength utilization of any of these elements, where:

(a) the test yield strength utilization is the calculated primary membrane plus bending stress due to test seismic load, test pressure, and actuator and yoke dead weight load divided by the actual test bar yield strength; and

(b) the qualification yield strength utilization is the calculated primary membrane plus bending stress due to qualification seismic load, qualification pressure, and actuator and yoke dead weight load divided by the specified minimum yield strength.

If desired, the test seismic loading may be increased to permit qualification of candidate valve assemblies whose dimensional parameters may require downward adjustment of the seismic qualification rating.

F4 TEST OPERATING PRESSURE

The test operating pressure is the same as in D4.

F5 TEST SETUP REQUIREMENTS

The test valve shall be installed in a fixture with suitable provisions for imposing the static test load(s).

The test load(s) shall be applied in a direction producing maximum loading in the least rigid plane of the actuator mounting (causing greatest deflection under load). The test load(s) shall be applied to the yoke-actuator structure such that the resulting forces, moments, and torque acting on the yoke-actuator structure in the region from the actuator mounting flange to the valve body are at least equal to the calculated forces and moments that result from the application of uniform seismic acceleration [simulated by the test load(s)] to the valve assembly.

F6 TEST CONDUCT

With the valve in the open position, test operating pressure is established in the valve assembly, and while pressure is maintained, the test seismic loading force(s) shall be applied to deflect the valve assembly. The deflection at the center of gravity of the yoke-actuator structure in the direction of the application of the load(s) relative to the valve body shall be measured and recorded. The test pressure is now relaxed to the rated operating pressure and the seismic loading to the qualification seismic load. With these levels, a cold cyclic test series is performed according to B3.

ANNEX G
FLOW INTERRUPTION CAPABILITY TEST

This Annex is an integral part of American National Standard B16.41, and is placed following the main text for convenience.

G1 SCOPE

The flow interruption capability test is a demonstration of the valve assembly capability to close against substantial flow. See Annex J, J4 for modeling rules.

G2 TEST SETUP REQUIREMENTS

The test valve assembly shall be installed in a pipe run connected to a reservoir to supply the required flow and simulate the desired operating fluid conditions. Instrumentation shall be provided to simultaneously record the valve travel and upstream and downstream pressures. Supplementary instrumentation shall be provided to measure flow or permit calculation of flow during the closure part of the cycle.

G3 TEST CONDUCT

Prior to initiation of flow, the working fluid conditions shall be raised to the pressure and temperature for which the valve is to be qualified. Also, with the valve in the open position, the valve body shall be heated by circulation of steam or other suitable means so that the seat area is at the approximate test temperature. The timing of flow initiation and closure initiation shall be such that during closure of the final 10% of the valve flow area the differential pressure is at least equal to the maximum pressure rating for which the valve is to be qualified. The valve closure is to be effected using the minimum motive power qualification level for actuation. Immediately following completion of the valve closure, an observation shall be made of the seat leakage under full differential pressure.

ANNEX H
ENDURANCE TEST

This Annex is an integral part of American National Standard B16.41, and is placed following the main text for convenience.

H1 SCOPE

The endurance test demonstrates the effects of a vibratory environment on the valve assembly. The test is intended to induce an arbitrary but reasonable level of vibratory excitation in the valve assembly representative of normal plant induced vibration. It is not intended to be a qualification test in itself nor a test to any specific plant environment.

H2 TEST SET-UP REQUIREMENTS

H2.1 The test valve assembly shall be mounted on a shake table utilizing a suitable fixture.

H2.2 The assembly shall be filled with fluid (see A3.2), but pressurization is not required.

H2.3 Electrical, hydraulic, or pneumatic connections shall be attached to the actuator in accordance with the manufacturer's recommended method.

H2.4 The shake table shall be capable of inducing sinusoidal motion as required in H3.1.

H2.5 Suitable means of measurement of vibration frequency and acceleration shall be assured.

H3 TEST CONDUCT

H3.1 Sinusoidal motion shall be applied by exposing the valve assembly to 0.5 g or such reduced acceleration necessary at low frequencies to not exceed 0.025 in. double amplitude with the frequency sweeping from 5 to 100 to 5 Hz at a rate of 2 octaves per minute. Ninety minutes of vibration shall be applied along each orthogonal axis. Modulating valve assemblies shall be operated continuously at between 20% and 80% stroke.

H3.2 The input motion to the valve assembly shall be monitored and controlled using accelerometers located on the test fixture adjacent to the mounting surface of the valve assembly.

H3.3 At the conclusion of the endurance test for each axis, with the assembly vibrating at 33 Hz, the valve shall be operated to perform one full operating cycle in accordance with B3.3, except that pressurization of the valve assembly is not required. The cycle time shall be observed and recorded.

ANNEX J
GUIDANCE FOR QUALIFICATION OF CANDIDATE VALVE ASSEMBLIES

This Annex is not part of American National Standard B16.41.
It is included for supplementary guidance and its use is subject to the conditions stated in 5.2.

J1 SCOPE

This Annex contains guidelines for a method intended to demonstrate functional qualification of a candidate valve assembly. The procedure is based on analysis to illustrate a degree of design similarity between a candidate valve assembly and a parent valve assembly. Depending upon the degree of design similarity, qualification of a candidate valve assembly can be demonstrated by analysis or a combination of analysis and testing.

J2 REQUIREMENTS

J2.1 Analyses shall make suitable allowances for differences in dimensions, performance characteristics, working fluid, orientation, and other applicable parameters. The analytical method must be based on similarity between parent valve assembly and candidate valve assembly sufficient to justify the use of simple rules of proportionality for such allowances. For such qualification, a candidate valve assembly shall be limited in basic valve inside diameter (d_m in NB -3500)[1] between 50% and 200% of the parent valve assembly, and in pressure rating between 90% and 200% of the parent valve assembly.

J2.2 The requirements for similarity and evaluation of differences shall include, where applicable, but not be limited to the following:

(a) Valves are of identical type (gate, globe, ball, etc.). Valve body and bonnet assemblies are generally similar in appearance, with the principal difference being overall size and/or weight.

(b) Valve-actuators and accessories may be of different types and appearance, provided the performance parameters satisfy the requirements of this Annex.

(c) Dimensional ratios of the basic body shape of the candidate valve assembly differ from the corresponding ratios of the parent valve by an amount not exceeding 25% of the difference from unity of the corresponding ratios in the parent valve assembly, including:

(1) width of flow passage at crotch section to basic valve inside diameter (d_m);

(2) inside diameter of body neck (or greatest internal width of body neck if cavity is not circular) to d_m;

(3) greatest internal width of flow passage to d_m.

Example: If ratio (c)(1) above in the parent valve assembly is 1.2, the difference between the ratio and unity is 0.2; ±25% of 0.2 is ±0.05, therefore the acceptable range of ratio (c)(1) above for the candidate valve assembly is 1.15 to 1.25.

(d) Dimensional ratios of basic sections are evaluated. The smallest of these ratios shall be used to determine the limiting multiple of qualification pressure rating of the parent valve assembly which may be applied to the candidate valve assembly, including:

(1) in the body section midway from body neck to pipe end: minimum design wall thickness to inside diameter, or to inside width and to inside height if section is not circular;

[1] References identified by NB refer to Subsection NB of Section III of the ASME Boiler and Pressure Vessel Code.

(2) in the body section of crotch–See A-A Fig. NB-3545.2(a)-1[1]: minimum design wall thickness to width of flow passage;

(3) in Fig. NB-3545.1(a)-1[1]: A_m to A_f;

(4) in the body neck section at crotch: minimum design wall thickness, excluding fillet to run section, to inside diameter, or to inside width and to inside height if section is not circular.

Examples:

(a) If ratios for the candidate valve assembly are all equal to or greater than ratios for the parent valve assembly, except that (d)(3) above is 0.96 times the value for the parent valve assembly, the candidate valve assembly qualification pressure rating is limited to 96% of the qualification pressure rating of the parent valve assembly.

(b) If ratios for the candidate valve assembly are 1.53, 1.79, 1.50, and 1.90 times the values for the parent valve assembly, the candidate valve qualification pressure rating is limited to 150% of the qualification pressure rating of the parent valve assembly.

(e) In seat geometry, for example, taper angles are substantially equal.

(f) Stem packing is in similar geometric form in parent valve assembly and candidate valve assembly.

(g) The ratio of calculated stalled thrust and/or stalled torque of the actuator at maximum motive power to stem compressive and/or torsional yield strength (calculated load to produce yield in stem), or buckling load (whichever is limiting), is no greater in the candidate valve assembly than in the parent valve assembly.

(h) For the condition of minimum motive power, the ratio of the rated thrust and/or rated torque of the actuator of the candidate valve assembly to the calculated required stem thrust and/or torque for the working pressure conditions is no less than the equivalent ratio for the parent valve assembly.

(i) The average closure velocity of the parent valve is greater than or equal to the average closure velocity of the candidate valve, with velocity expressed in inches (millimeters) per second for linear motion and degrees per second for angular motion.

(j) Ratios indicative of ability of body-yoke-actuator mounting to preserve operational geometry while sustaining combined seismic, pressure, and dead weight loading are evaluated. The smallest of these ratios shall be used to determine the limiting multiple of the qualification seismic load for which a parent valve assembly has been qualified to be used as the qualification seismic load rating for the candidate valve assembly, including:

(1) the stem deflection angle (angle between the seismic load-deflected stem center line and the bonnet center line) in the parent valve assembly to the stem deflection angle in the candidate valve assembly;

(2) the relative yoke to stem stiffness:

$$\frac{\text{moment of inertia of yoke in its least rigid direction}}{\text{moment of inertia of valve stem section}}$$

in the candidate valve assembly to the yoke to stem stiffness of the parent valve assembly;

(3) the highest calculated yield strength utilization based on superimposed seismic, dead weight, and rated pressure loading of yoke (least rigid direction), yoke clamp (if applicable), or yoke bolting (if applicable) in the parent valve assembly to the corresponding highest yield strength utilization of any of these elements in the candidate valve assembly.

Examples:

(a) If the smallest of the ratios defined in (j)(1), (j)(2), and (j)(3) above is 0.91, the seismic load qualification value for the candidate valve assembly must be reduced by whatever amount is required to increase that ratio to 1.0.

(b) If all of the ratios defined in (j)(1), (j)(2), and (j)(3) above are equal to or greater than 1.25, the seismic qualification loading for the candidate valve assembly may be made greater than that for the parent valve assembly by an amount that will change the smallest ratio to 1.0. Note that the change in seismic loading is not the same as the limiting ratio, because pressure and dead weight loading remain constant.

(k) The method of mounting the actuator is similar to that in the parent valve assembly.

(l) Attached functional accessories are mounted on the candidate valve assembly in a manner similar to the way they are mounted on the parent valve assembly.

(m) Differences in materials of candidate valve assembly components compared to corresponding parent valve assembly components are acceptable, provided (not applicable to packing):

(1) Appropriate adjustments in qualification rating parameters are made based on the relative yield strengths of the materials.

(2) Due consideration is given to functional performance capabilities of materials and combinations of materials. Variations will be considered acceptable in this regard if any one of the following is satisifed:

(a) there is no functional rubbing contact or possible incidental rubbing contact between two components;

(b) all points of rubbing contact are protected as by hard facing;

(c) both candidate valve assembly and parent valve assembly have materials such as ferritic, austenitic, or martensitic steels in rubbing contact in a similar combination, and the differential hardness specified in candidate valve assembly is equal to or greater than that in parent valve assembly;

(d) a combination of materials in rubbing contact is changed but does not have unprotected austenitic stainless steel in place of another type, carbon steel in place of martensitic, or any unprotected material in place of hard surfacing.

J3 CANDIDATE VALVE TESTING

J3.1 If candidate valve testing is required, a test valve assembly shall be selected as representative of the production valves.

J3.2 If all the requirements of J2.1 and J2.2 are met, no testing of the candidate valve is required.

J3.3 If any of the requirements of J2.2 (b), (f), (h), and (i) are not satisfied by a candidate valve assembly, new tests in accordance with Annexes A, B, C, and G shall be made on either the parent valve assembly appropriately modified, or the candidate valve assembly.

J3.4 If J2.2 (g) is not satisfied, a new test in accordance with Annex B shall be made on either the parent valve assembly appropriately modified, or the candidate valve assembly.

J3.5 If J2.2 (j), (k), and/or (l) is/are not satisfied, new tests in accordance with Annexes E and F (and H if applicable), shall be made on either the parent valve assembly appropriately modified or the candidate valve assembly.

J3.6 If a fundamental frequency of 33 Hz or greater, as required in F2.1 for use in Seismic Loading Test procedure of Annex F, is not determined based on fundamental frequency calculations for the candidate valve assembly, the candidate valve assembly shall be seismically qualified by test in accordance with the applicable requirements of IEEE-382. For the purpose of this determination, fundamental frequency calculations shall be made for the parent valve assembly and for the candidate valve assembly, both by the same method. The calculation method may be wholly analytical, or may involve the use of actual measured load-deflection characteristics of the valve-actuator assembly as the basis for fundamental frequency calculation. In any case, the calculation, without adjustment of constants or arbitrary factors, is required to produce a predicted fundamental frequency within 20% of the observed value for the parent valve. A correction factor shall be determined for the parent valve assembly defined as the ratio between the observed resonance frequency found in E3 and the calculated fundamental frequency, and that correction factor shall be applied to the candidate valve calculated fundamental frequency value.

J3.7 New tests, if and as required by J3.3, J3.4, J3.5, and/or J3.6, will complete the qualification for the candidate valve assembly, which can then be identified as a "test qualified candidate valve assembly."

J3.8 Other candidate valve assemblies may be qualified by reliance upon the original parent valve assembly and upon the "test qualified candidate valve assembly" for satisfying those requirements of J2.2 which necessitated the testing for that valve assembly. The limitations of J2.1 shall be satisfied by other candidate valve assemblies with respect to both the parent valve assembly and the "test qualified candidate valve assembly" considered as a "parent valve assembly."

J3.9 If any of J2.2 (a), (c), (d), (e), or (m) are not satisfied, a complete new qualification shall be made.

J4 FLOW INTERRUPTION CAPABILITY TESTING

Qualification of a candidate valve assembly by analyses showing generic similarity with a parent valve assembly as indicated in J2 may be provided, subject to the provisions of 5.2, by reference to an alternative "parent," of at least 8 in. nominal size, which would otherwise be prohibited by the "200%" dimensional constraint specified in J2.1, for Flow Interruption Test (Annex G) only. For such qualification, the pressure rating range shall be limited to between 90% and 110% of the alternate parent assembly. Such qualification is subject to all other applicable requirements of Annex J.

ANNEX K
REFERENCES

This Annex is an integral part of American National Standard B16.41, and is placed following the main text for convenience.

The following is a list of standards and specifications referenced in this Standard showing the year of approval.

ASME Publications (Approved as American National Standards)

ANSI N278.1-1975	Self-Operated and Power-Operated Safety-Related Valves, Functional Specification Standard
ANSI/ASME BPV-III-1980	ASME Boiler and Pressure Vessel Code, Nuclear Power Plant Components
ANSI/ASME BPV-XI-1980	ASME Boiler and Pressure Vessel Code, Rules for Inservice Inspection of Nuclear Power Plant Components

Drafts (Not Approved or Published)

IEEE-382	Standard for Qualification of Safety Related Valve Actuators

Publications of the following organizations appear on the above list:

ASME	The American Society of Mechanical Engineers 345 East 47th Street, New York, New York 10017
IEEE	Institute of Electrical and Electronics Engineers 345 East 47th Street, New York, New York 10017

Publications appearing above which have been approved as American National Standards may also be obtained from:

ANSI	American National Standards Institute, Inc. 1430 Broadway, New York, New York 10018

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