and the environment for each of the following operational categories shall include

(a) installation testing
(b) system testing
(c) preoperational testing
(d) start-up testing
(e) normal and abnormal facility operations
(f) inservice testing
(g) vibration
(h) others, as applicable

QDR-I-5320 Environmental Conditions. The need for restraints to perform within normal and abnormal environmental conditions, with or without maintenance, shall be stated. Since the attaching hardware can influence the performance of the restraint, it shall also be considered. The operating environment for all service levels must be considered and shall include

(a) chemistry
(b) temperature
(c) pressure
(d) humidity
(e) radioactivity
(f) others, as applicable

QDR-I-5400 Functional Parameters

The functional parameters as listed in Section QDR shall be specified and include the following as a minimum:

(a) *Hydraulic Snubbers*

(1) activation level (when applicable) at loads, tolerances, and temperatures

(2) release rate at 5%, 10%, 25%, 50%, and 100% of rated load and at Service Level C load at tolerances and temperatures

(3) acceptable limits for the breakaway force at temperatures

(4) acceptable limits for drag force associated with moving at velocities and temperatures

(5) acceptable limits for the dead band at loads, restraint locations, and temperatures

(6) load ratings for all service levels

(7) acceptable range of spring rates at temperatures, frequencies, load ranges, and load classifications at which the spring rate is to be determined with restraint locations at ¼-, ½-, and ¾-stroke locations

(8) availability of full design stroke

(9) fluid level sufficient to maintain acceptable operation of the device

(b) *Mechanical Snubbers*

(1) activation level (when applicable) at loads, tolerances, and temperatures

(2) release rate (when applicable) at 5%, 10%, 25%, 50%, and 100% of rated load and at Service Level C load at tolerances and temperatures

(3) acceptable limits for the breakaway force at temperatures

(4) acceptable limits for drag force associated with moving under a specified velocity at temperatures

(5) acceptable limits for the dead band at loads, restraint locations, and temperatures

(6) load ratings for all service levels

(7) acceptable range of spring rates at temperatures, frequencies, load ranges, and load classifications at which the spring rate is to be determined with restraint locations at ¼-, ½-, and ¾-stroke locations

(8) availability of full design stroke

(9) lubrication degradation that can affect other parameters

(c) *Gap Devices*

(1) acceptable limits for the drag force

(2) inclusion of the range of available gap adjustment

(3) acceptable range of spring rates at load ranges, tolerances, and load classifications

(4) acceptable number of cycles for spring fatigue testing

(5) load ratings for all service levels

(d) *Viscoelastic Dampers*

(1) acceptable limits for the drag force

(2) load ratings for all service levels

(3) acceptable range of spring rates at positions, temperatures, frequencies, load ranges, and load classifications at which the spring rate is to be determined

(4) damping resistance characteristics

(5) allowable displacement range

QDR-I-5500 Special Material Requirements

Special material requirements of the restraint should be specified. Items to be considered shall include, but not be limited to, the following:

(a) hydraulic or viscous fluids
(b) seals
(c) springs
(d) special surface preparations or coatings
(e) lubricants
(f) bearings
(g) any material that can affect the intended function of the restraint

QDR-I-5600 Installation and Orientation Requirements

The following requirements for the installation of the restraint shall be specified:

(a) orientation of the hydraulic restraint and relative position of the hydraulic reservoir to the restraint if any limitations exist

(b) orientation of the mechanical restraints installation if any limitations exist

(c) orientation of the viscoelastic restraint installation if any limitations exist

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(d) the available space for installation and removal if any limitations exist

(e) travel location in the restraint as installed

(f) the range of transverse movement provided

(g) any special mounting provided or required

(h) consideration of the conservative worst-case installation, if such an installation exists, as identified in para. QDR-6221 shall be given

QDR-I-5700 Maintenance, Examination, and Testing Requirements

The following requirements for inservice maintenance, examination, and testing activities shall be specified:

(a) Provision for restraint maintenance, examinations, and testing shall be specified.

(b) Special provisions for in situ restraint maintenance, examinations, and testing shall be specified, if required.

(c) Requirements for demonstrating the feasibility of performing the required in situ inservice tests and/or activities shall be specified, as applicable.

(d) For hydraulic restraints, a requirement shall be specified for the determination of acceptable fluid level ranges, such that the snubber shall be operable in any combination of piston positions and temperature ranges as identified in the Design Specification.

(e) For viscoelastic restraints, a requirement shall be specified for the determination of acceptable fluid level ranges, such that the damper shall be operable in any combination of piston positions and temperature ranges as identified in the Design Specification.

QDR-I-5800 Special Performance Requirements

Other requirements for special performance or loading conditions, as applicable, shall be specified.

QDR-I-6000 FILING REQUIREMENTS

A copy of the Qualification Specification shall be filed at the location of the installation and shall be available to the enforcement authorities having jurisdiction over the facility installation.

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Nonmandatory Appendix QDR-A Restraint Similarity

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QDR-A-1000 SCOPE

This Appendix provides guidance in determining whether design similarity exists such that the qualification analysis procedure may be applied to candidate restraint sizes and ratings without further verification by testing. Examples are included that illustrate how design similarity may be established, in terms of specific similarity parameters defined in Subsubarticle QR-7340.

QDR-A-2000 EXAMPLES OF DESIGN SIMILARITY

Examples of design similarity in terms of specific parameters are listed below. These are limited, selected examples and are not intended to be all inclusive. It should be noted, however, that all similarity parameters defined in Subsubarticle QDR-6420 must be considered when determining the acceptability of applying a qualification analysis procedure without further verification by testing.

QDR-A-2100 Similarity of Design Configuration

With hydraulic snubbers, activation level and release rate may be defined in terms of flow rate and pressure. For hydraulic snubbers that use the same control valve or a similar configuration, the effect of temperature on these parameters should be determined by extrapolation or interpolation of data obtained by testing one snubber size.

QDR-A-2200 Similarity of Materials

Wear or aging data obtained by testing a selected restraint model or size should be applied to other models or sizes provided that the same or similar materials (i.e., mechanical, physical, and chemical properties) are used. Justification of differences should be provided.

QDR-A-2300 Similarity of Dimensions/Tolerances

Seal-aging data obtained by testing O-rings of a specific size should be applied to other O-ring sizes that have the same cross-section thickness. Tolerances for mating parts should be the same, or the differences should be justified.

QDR-A-2400 Similarity of Surface Finish

Wear or aging data obtained by testing restraints of a given model should be applied to other models provided that surface finishes between mating parts for which relative motion exists are representative of the restraints to which the data are to be applied.

QDR-A-2500 Similarity of Fabrication/Assembly Method

Life-cycle test data (e.g., data obtained from cyclic loading or vibration tests) obtained by testing a specific restraint model should be applied to other models, provided that both models were fabricated and assembled in the same or a similar manner. Application of data obtained using a model that is assembled by welding to a model that is assembled by bolting would normally not be acceptable.

QDR-A-2600 Similarity of Coatings/Plating

Corrosion resistance data obtained by testing a selected restraint model should be applied to other models or sizes provided that the same or similar plating or coatings are used.

QDR-A-2700 Similarity of Production Testing

Production tests for some snubber models may involve quasi-static testing in which activation parameters such as activation level, release rate, or acceleration threshold are measured. For other restraint models, dynamic testing methods may be used for production tests. Qualification testing, on the other hand, generally involves dynamic testing. Similarity of production test methods should be considered when applying qualification test data from one restraint model to another.

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Nonmandatory Appendix QDR-B
Typical Values of Restraint Functional Parameters

QDR-B-1000 SCOPE

This Appendix is provided to aid both the restraint designer and the specification writer. It can be used as an example of how to specify the functional parameters required by Mandatory Appendix QDR-I. The selection of applicable parameters and values, either the ones identified herein or others specified as required, is at the option of the Owner.

QDR-B-2000 FUNCTIONAL PARAMETERS

QDR-B-2100 Hydraulic Snubbers

Typical values for hydraulic snubber functional parameters are as follows:

(a) activation level 4 in./min (IPM) to 20 IPM

(b) release rate 0 IPM to 6 IPM

(c) breakaway for less than 1 kip rated load, 5% max.; for 1 kip and above, 3% max.

(d) drag for less than 1 kip rated load, 5% max.; for 1 kip and above, 3% max.

(e) dead band (lost motion) generally should not exceed 0.04 in. when measured across the snubber, excluding end fittings

(f) load rating, see subpara. QDR-4110(f)

(g) spring rate is the peak-to-peak displacement under load, excluding end attachments, and should not exceed 0.12 in. when the input frequency is in the 3 Hz to 33 Hz range

(h) the stroke should be able to accommodate the thermal and dynamic movements plus an additional 1 in. of travel on each end (inclusive of installation tolerances)

(i) fluid loss rate should not exceed that which would empty the reservoir during the expected service life of the component

QDR-B-2200 Mechanical Snubbers

Typical values for mechanical snubber functional parameters are as follows:

(a) Activation level: acceleration-limiting snubbers are generally designed to a maximum value of 0.02*g*.

(b) Release rate for a snubber that does not have an active/passive mode should be within 25% of the theoretical performance curves (unless specifically designed, neither acceleration- nor velocity-limiting snubbers should have a release rate of zero).

(c) Breakaway/drag is the force required to initiate and maintain axial movement of mechanical snubbers and is typically restricted to less than 2% or 3% of the rated load.

(d) Drag for less than 1 kip rated load, 5% max.; for 1 kip and above, 3% max.

(e) Dead band (lost motion) generally should not exceed 0.04 in. when measured across the snubber, excluding end fittings.

(f) For load rating, see subpara. QDR-4210(f).

(g) Spring rate is the peak-to-peak displacement under load, excluding end attachments, and should not exceed 0.12 in. when the input frequency is in the 3 Hz to 33 Hz range.

(h) The stroke should be able to accommodate the thermal and dynamic movements plus an additional 1 in. of travel on each end (inclusive of installation tolerances).

(i) Any lubrication degradation should not affect other parameters such as drag.

QDR-B-2300 Gap Restraints

(a) Gap (see para. QDR-6223).

(b) Spring rate tolerances should be kept to ±20% if no specific value is given from the analysis of the piping system.

(c) Fatigue life of springs should be greater than the service life of the component.

(d) Drag developed should be a maximum of 2% of rated load of the device.

(e) Load ratings are the minimum load that the device will restrain under the given loading condition. However, for a load-limiting device, the load rating is a maximum load, and the device should be within 10% of the rated load.

QDR-B-2400 Viscoelastic Dampers

(a) The spring rate of the damper for rated load application at representative impact or impulse loading rates.

(b) The resultant damper spring rate and damping at 68°F (20°C) and 122°F (50°C).

(c) Damper functional characteristics at accident temperature 350°F (177°C) should be in accordance with gap restraint qualification procedures.

(d) The spring rate of the damper for active degrees of freedom at a different velocity of the piston applied as a cyclic load at 0.1 Hz (effectively static load) and at

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incremental rates of loading in the range specified in the Qualification Specification.

(e) Restraint spring rate curves for different levels of rated load with a cyclic rate of loading through the Qualification Specification range for the load applied as a sine beat wave.

(f) From the damper spring rate curves, a representative stiffness should be developed to define damper elastic stiffness.

(g) Damping resistance characteristics for cyclic load, size, and temperature as required for stiffness evaluation.

(h) Limits for the drag force associated with moving the piston with rated load applied under a range of specific applied velocities at 122°F (50°C) and at start-up temperature of 68°F (20°C). At design-basis accident temperature, the viscoelastic damper will act as a gap restraint and should be qualified according to existing Section QDR requirements.

(i) Load ratings for applicable ASME Code Service Levels for active dampers' axes should be defined.

QDR-B-3000 AGING AND SERVICE CONDITION SIMULATION QUALIFICATION PROGRAM

The qualification program should specify a steam humidity simulation of 350°F (177°C) saturated steam for 72 hr if the restraint service area is inside the containment. It should specify submergence in 200°F (93°C) water for 72 hr if the restraint service is in a water environment.

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Section QP
Qualification of Active Pump Assemblies

QP-1000 SCOPE

Section QP contains the qualification requirements and guidelines for active pump assemblies that are required to perform a nuclear safety-related function in nuclear facilities (active pumps) or, alternatively, have been shown to be risk significant based on an approved risk significance categorization process. Pump assembly items may be qualified as part of a single pump assembly or may be qualified separately, provided their combination into a single unit is addressed. It is the responsibility of the Owner to specify those pump assemblies that require qualification to this Section.

Pump assemblies and pump assembly items qualified in accordance with this Section shall meet the requirements of Section QR. When the requirements of Section QP conflict with the requirements of Section QR, the requirements of Section QP take precedence.

Section QP is applicable to all pump types. Specifically, pumps that operate on velocity or displacement principles, regardless of the arrangement, are included. Shaft-sealing systems, drivers, power transmission devices, and auxiliary equipment are included. Section QP does not apply to electrical equipment, such as motors, instruments, and control devices. Qualification of the motor driver mechanical effects on the pump assembly is included in Section QP.

QP-2000 PURPOSE

It is the purpose of Section QP to provide requirements for the qualification of pumps. This includes the qualification of mechanical drives, such as turbines, as well as the interfacing effects of the motor driver.

QP-3000 REFERENCES

The following references are in addition to references contained in Article QR-3000:

ANSI/HI 1.1-1.5, Centrifugal Pumps
ANSI/HI 1.6, Centrifugal Pump Tests
ANSI/HI 9.1-9.5, Pumps—General Guidelines

Publisher: Hydraulic Institute (HI), 6 Campus Drive, Parsippany, NJ 07054-4406 (http://www.pumps.org)

API 610/ISO 13709, Centrifugal Pumps for Petroleum, Heavy Duty Chemicals, and Gas Industry Services, September 2010, 11th Edition
API 611, Steam Turbines for General Refinery Service, March 2008, 5th Edition
API 682, Shaft Sealing Systems for Centrifugal and Rotary Pumps, May 2014, 4th Edition

Publisher: American Petroleum Institute (API), 1220 L Street, NW, Washington, DC 20005 (http://www.api.org)

ASME B73.1, Specification for Horizontal End Suction Centrifugal Pumps for Chemical Process
ASME B73.2, Specification for Vertical In-Line Centrifugal Pumps for Chemical Process
ASME OM Code, Operations and Maintenance of Nuclear Power Plants
ASME PTC 8.2, Performance Test Codes—Centrifugal Pumps

Publisher: The American Society of Mechanical Engineers (ASME), Two Park Avenue, New York, NY 10016-5990 (http://www.asme.org)

IEEE Std 323, Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations
IEEE Std 344, Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations
IEEE Std 382, Standard for Qualification of Safety-Related Actuators for Nuclear Power Generating Stations

Publisher: Institute of Electrical and Electronics Engineers (IEEE), 445 Hoes Lane, Piscataway, NJ 08854 (http://www.ieee.org)

SM 23, Steam Turbines for Mechanical Drive Service

Publisher: National Electrical Manufacturers Association (NEMA), 1300 North 17th Street, Suite 900, Arlington, VA 22209 (http://www.nema.org)

STLE SP-1, Glossary of Seal Terms, March 1995
STLE SP-30, Guidelines for Meeting Emission Regulations for Rotating Machinery with Mechanical Seals, April 1994

Publisher: Society of Tribologists and Lubrication Engineers (STLE), 840 Busse Highway, Park Ridge, IL 60068-2302 (http://www.stle.org)

QP-4000 DEFINITIONS

The following definitions apply specifically to pump assemblies and supplement the definitions listed in

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Section QR. Other definitions pertinent to pumps are contained in Mandatory Appendix QP-I. When there are conflicting definitions between Sections QR and QP, the definitions in Section QP take precedence with regard to the application of Section QP.

auxiliary equipment: items necessary to support the operation of the pump, shaft-seal system, driver, or power transmission device, including any appurtenances as defined in ASME Boiler and Pressure Vessel Code (BPVC) Section III, NCA-1260.

best efficiency point: the hydraulic flow at which the pump assembly achieves its highest efficiency, i.e., the reference point for which the specific speed is calculated for similitude comparisons.

component coolant: a fluid used as a heat removal medium and separated from the process fluid by a barrier.

injection fluid: a fluid injected into the seal area at a pressure higher than the process fluid to lubricate and cool the seal and, in some instances, to prevent leakage of process fluid along the shaft.

motor driver: a class of machines that convert electrical energy into rotary motion.

operating point(s): any hydraulic point at which the pump is expected to operate, under the various operating conditions of the facility. Multiple operating points may be specified for a pump within the flow range from minimum flow to the maximum runout condition.

power transmission device: an item that transmits the rotary motion from the turbine or motor driver to the pump.

process fluid: the fluid pumped.

pump: the basic component of the pump assembly that transfers the process fluid.

pump assembly: the pump and grouping of items needed to ensure the operation of the pump.

shaft seal: a device designed to prevent or limit the leakage of fluid between two surfaces of relative motion. This includes mechanical end face seals and packing.

shaft-seal system: a system of shaft seals and directly associated appurtenances as required that limits the process fluid leakage to the atmosphere or low-pressure systems and collects and directs the leakage.

turbine driver: a class of machines that convert energy in a fluid stream to rotary motion.

QP-5000 QUALIFICATION PRINCIPLES AND PHILOSOPHY

The fundamental principles and philosophy pertaining to equipment qualification are provided in Article QR-5000 and apply to mechanical equipment in general. Qualification requirements and service conditions specific to the pump assembly or pump assembly items are contained in Articles QP-6000 through QP-8000. A specification for the pump(s) that are to be qualified is required per Mandatory Appendix QP-I.

QP-6000 QUALIFICATION SPECIFICATION

QP-6100 Responsibility

It is the responsibility of the Owner or the Owner's designee to identify the functional requirements for a pump assembly. These requirements shall be provided in a Qualification Specification prepared in accordance with Mandatory Appendix QP-I.

The manufacturer has the option to qualify the pump assembly for more stringent parameters than provided in the Qualification Specification, but shall ensure that the parameters to which the pump assembly is qualified envelop those in the Qualification Specification.

The Qualification Specification shall be certified by one or more Registered Professional Engineers in accordance with the requirements of Subsubarticle QR-8610.

QP-6200 Equipment Description and Boundary

The Qualification Specification shall identify those items that are part of the pump assembly. The Qualification Specification shall also define the interfaces between the pump assembly and external attachments and supports. When pump assembly items are qualified separately, the Qualification Specification shall also define interfaces between the pump and driver, shaft-seal system, power transmission device, and auxiliary equipment.

QP-6210 Pump Assembly/Pump. The pump assembly includes the pump and its shaft-seal system, driver, transmission device, and auxiliary equipment.

The pump pressure boundary is defined in ASME BPVC Section III. The pump includes items that

(a) contain the process fluid, such as the casing or barrel, including nozzles, thermal barrier, and closure members

(b) propel the process fluid, such as the impeller

(c) are an integral part of the pump, such as the diffuser or bowl, including the pump shaft, pump bearings, and bearing supports

(d) are auxiliary equipment

QP-6220 Shaft-Seal System. The shaft-seal system includes the seal assembly, seal system piping, seal water cooling, filtering devices, and auxiliary equipment.

QP-6230 Turbine Driver. The turbine driver includes the casing, shaft, blades, wheel, jets, governor, stop valves, shaft seals, bearings, and auxiliary equipment.

QP-6240 Power Transmission Device. Power transmission devices include shaft couplings, belt drives, fluid drives, gear drives, and auxiliary equipment.

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QP-6250 Auxiliary Equipment. Examples of auxiliary equipment are cooling water systems, lubricating systems, control valves, instrumentation, and external supports, which are supplied as part of the pump assembly.

QP-6260 Pump Stand. The pump stand is the support structure for the pump assembly, driver (electric or turbine), and power transmission device.

QP-6300 Margins

The required margin for acceptance criteria listed in Mandatory Appendix QP-I shall be specified.

QP-6400 Aging

The effects of the identified aging mechanisms shall be assessed and shown to be acceptable during the qualification process. Nonmandatory Appendix QR-B provides supplementary details associated with the qualification of nonmetallic parts.

QP-6500 Acceptance Criteria

The required acceptance criteria shall be specified in accordance with the requirements of subpara. QR-6000(h) and Mandatory Appendix QP-I.

QP-7000 QUALIFICATION PROGRAM

QP-7100 General Requirements

A Qualification Plan shall be prepared to translate the Qualification Specification into a step-by-step qualification program. The Qualification Plan shall also clearly describe how to demonstrate that the pump assembly will perform its safety function under all operating conditions identified in the Qualification Specification over the full range of operating conditions from normal operation up to and including design-basis accident conditions with specified fluid conditions. The range of operating conditions shall be clearly described in the specification.

NOTE: If the full range of operating conditions [such as temperature, pressure, flow rate, and net positive suction head (NPSH)] cannot be achieved in the test facility, then the Qualification Plan shall provide justification that the test conditions demonstrate qualification of the pump assembly to perform its intended function over the full range of operating conditions.

Individual items that form the pump assembly, as delineated in Subarticle QP-6200, may be excluded from the qualification process if it can be shown that their malfunctions have no effect on the pump assembly's specified function. For example, when the pumping function is not a requirement but the pressure retention function is, motive power to the pump need not be qualified, but the shaft-sealing system shall be qualified.

An Application Report, as described in Subsubarticle QP-8320, shall provide documentation and additional requirements as necessary to ensure that each of the production pump assemblies is qualified for the application specified in the Qualification Specification required by Article QP-6000.

The qualification program, as described in the Qualification Plan, shall account for dimensional variations of critical clearances of essential-to-function parts.

Any analytical techniques applied in the qualification of pump assemblies require verification to ensure that the analysis techniques are valid for the variations of the design being qualified. This qualification program shall demonstrate that the performance of pump assemblies, predicted by these analytical techniques, is applicable to all allowable variations of the pump clearances being qualified for the flow conditions specified by the pump Qualification Specification. The qualification program shall demonstrate that the design-limiting allowable variation in the critical clearances between essential-to-function parts during the manufacturing phase shall not render a pump assembly incapable of consistent performance for those conditions for which the pump assembly is to be qualified.

Section QP provides for qualification of a pump assembly by a combination of testing and analysis (see Subsubarticles QR-7310 and QR-7320). The functional qualification of a qualified pump assembly may be extended to another pump assembly through limited testing and demonstration of design similarity (see Subsubarticle QR-7340). This extension of qualification is based on the condition that both pump assemblies use the same design concept and that critical dimensional clearances are maintained. Diagnostic testing (such as vibration measurements for displacement, velocity, or acceleration) shall be performed during the qualification testing covered by this Standard.

QP-7200 Identification of Potential Malfunctions

Potential malfunctions shall be identified in accordance with the requirements of Subarticle QR-7200. Examples of potential malfunctions in pump assemblies that shall be reviewed include loss of rated flow/head, rotating element seizure, rotating element clearance/drag/leakage, and clogging, wear, seal failure, or adverse performance from worst-case postulated debris in the process fluid flow for which the pump is to be qualified. The effects of wear of critical components shall be part of this review.

QP-7300 Functional Qualification

Methods for qualification of pump assemblies and pump assembly items shall be in accordance with the requirements of Subarticle QR-7300. Analysis may be used as part of a qualification method, provided that sufficient test verification exists to justify the analysis used over the qualification conditions involved. Nonmandatory Appendix QP-D may be used for the analysis of similarity between pump assemblies.

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QP-7310 Pump. Pump qualification shall consider significant hydraulic and mechanical design factors that can degrade and impact the ability of the pump to perform its specified function. In addition to aging effects, qualification techniques shall address and incorporate, as necessary, the impact of periodic testing, maintenance, overhaul, and replacement of essential parts of the pump assembly. The qualification method shall identify the service conditions for which the pump is being qualified as described in subpara. (b) below.

(a) The pump qualification program shall include the following:

(1) testing over the full range of normal and design-basis event (DBE) operating points for hydraulic performance, leak tightness, and structural integrity, including anticipated system fluid conditions, low-suction head, recirculation cavitation at low flow or recirculation mode, and elevated water temperature.

(2) the test assembly with the pump, its auxiliary equipment, and the baseplate (if one is provided).

(3) visual and dimensional inspections at appropriate intervals to identify excessive wear or degradation of pump assembly parts.

(b) Service aspects that shall be considered in formulating a qualification program are

(1) pump functional conditions {such as flow capacities, developed head requirements, suction head provided [NPSH available (NPSHA) and its uncertainties], system fluid conditions including transients, operating time, and operating frequency anticipated over the life of the facility}. Functional conditions shall include periodic inservice testing (IST) and anticipated inoperative periods.

(2) system fluid conditions with the full range of potential debris as described in Subsubarticle QP-7370.

(3) environmental conditions.

(4) starting requirements.

(5) normal operating loads.

(6) externally applied loads (such as seismic, nozzle, and end loads).

(7) bearings and couplings.

(8) aging of nonmetallic materials (Nonmandatory Appendix QR-B may be used to identify supplementary details associated with the qualification of nonmetallic parts).

(9) maintaining design life (such as maintenance, overhaul, and replacement).

QP-7320 Shaft-Seal System. For qualification of the shaft-seal system, a plan shall be prepared with appropriate inspection and test records to define test objectives, test fluids, conditions of the test, permissible maintenance or adjustments, and acceptance criteria. A shaft-seal system test facility shall be used that provides rotation, appropriate means for pressurization, fluid thermal control, and seal leakage measurement. Prior to the start of a test sequence, all system conditions shall be recorded as applicable to the test shaft-seal assembly and test installation according to the plan. Test data shall include face surface finish and flatness, face loads at installation length, shaft-seal system leakage, temperature, pressure, and seal face power requirements. The test fluid shall include the range of potential debris as noted in Subsubarticle QP-7370. Testing sequences shall include all service conditions. A shaft-seal system may not be functionally qualified by analysis alone. However, analysis may be used to extend previous testing to the specified design service conditions, provided the analytical techniques have been validated through comparison with measured performance of a comparable shaft-seal system. Types of permitted analysis include heat generation and removal, mechanical stress, thermal stress, wear rate, interface velocity, axial movement, radial movement, angular movement, torsional deflection, and natural frequency.

Environmental and aging effects on the materials of construction shall encompass the process and environmental effects on the material properties. The environmental qualification program shall include nonmetallic components, such as O-rings and the rotating and stationary seals of the mechanical seal that may contain nonmetallic materials.

Nonmandatory Appendix QP-E provides guidelines for shaft-seal system material and design consideration when qualifying the shaft-seal system.

The manufacturer shall demonstrate the adequacy of the shaft-seal system in either or both of the following ways:

(a) by supplying documentation as specified in Subarticle QP-8200 that the proposed system was qualified through a comprehensive testing program. The testing program shall have included full-scale tests over the full range of operating conditions from normal operation up to and including design-basis accident conditions. The documentation shall include a detailed description of the tests, analysis, test equipment, and actual test results.

(b) by providing documentation justifying the extrapolation of qualification to similar shaft-seal systems and their applications through testing or a combination of testing and analysis.

The test information used to justify extrapolation of the shaft-seal system qualification shall include full-scale tests over the full range of operating conditions from normal operation up to and including design-basis accident conditions. The documentation as specified in Subarticle QP-8200 shall include a detailed description of tests, analysis, test equipment, and actual test results.

QP-7330 Turbine Driver. Turbine driver qualification shall address significant hydraulic and mechanical design factors that can degrade and impact the ability of the turbine driver to perform its specified function. In addition to aging effects, qualification techniques shall

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address and incorporate, as necessary, the impact of periodic testing, maintenance, overhaul, and replacement of essential parts of the turbine driver. The qualification method shall identify the service conditions for which the turbine driver is being qualified as described in subpara. (b) below.

(a) The turbine driver qualification program shall include the following:

(1) testing over the full range of operating conditions from normal operation up to and including design-basis accident conditions for steam performance, leak tightness, and structural integrity.

(2) the test assembly with the turbine and its auxiliary equipment.

(3) visual and dimensional inspections at appropriate intervals to identify excessive wear or degradation of turbine parts.

(4) loading and vibration of bearings and couplings.

(b) Service aspects addressed in formulating a test qualification program shall include

(1) turbine functional conditions (such as turbine horsepower/speed including transients, operating time, and operating frequency anticipated over the life of the facility).

NOTE: Functional conditions shall include periodic inservice testing and anticipated inoperative periods.

(2) environmental conditions.

(3) starting requirements.

(4) normal operating loads.

(5) externally applied loads (such as seismic and nozzle loads).

(6) bearing performance, including acceptable displacement during normal operation and design-basis events with normal and upset piping loads, acceptable time period for bearing performance with abnormal displacement, and acceptable nonmetallics used in bearings.

(7) coupling performance, including acceptable displacement during normal operation and design-basis events with normal and upset piping loads, acceptable time period for coupling performance with abnormal displacement, and acceptable nonmetallics used in couplings.

(8) aging of nonmetallic materials (Nonmandatory Appendix QR-B provides supplementary details associated with the qualification of nonmetallic parts).

(9) maintaining design life (such as maintenance, overhaul, and replacement).

(c) Any electrical controls associated with the turbine shall be qualified in accordance with the requirements of IEEE Std 323 and IEEE Std 344. Qualification of any motor-operated control or block valve actuators in the steam supply systems shall be in accordance with the requirements of Section QV and IEEE Std 382, as applicable.

(d) In cases where the pump is to be qualified separately from the driver, the qualification shall address the required mounting rigidity such that the required maximum misalignment at the coupling is specified at the rotational speeds for which the assembly is to be qualified. This misalignment may be verified by calculation or test. The maximum misalignment versus rotational speed shall be documented such that the maximum allowable pump-to-driver alignment will not be exceeded for the range of load and environmental conditions for which the pump assembly is being qualified.

QP-7340 Power Transmission Device

(a) Power transmission device qualification shall address significant hydraulic and mechanical design factors that can degrade and impact the ability of the device to perform its specified function. Qualification shall address the full range of speed and horsepower requirements. In addition to aging effects, qualification techniques shall address and incorporate, as necessary, the impact of periodic testing, maintenance, overhaul, and replacement of essential parts of the power transmission device.

The qualification program shall include the following:

(1) The power transmission device shall be tested at the design conditions of speed and horsepower (torque) over the full range of operating conditions from normal operation up to and including design-basis accident conditions for both mechanical performance and structural integrity.

(2) Visual and dimensional inspections shall be performed at appropriate intervals to identify excessive wear or degradation.

(3) Maximum allowed static misalignment shall be determined for installation and maintenance guidelines.

(b) Service aspects addressed in formulating a test qualification program shall include

(1) power transmission device functional conditions (speed, horsepower, operating time, and operating frequency anticipated over the life of the facility). Functional conditions include periodic inservice testing and anticipated inoperative periods.

(2) environmental conditions.

(3) starting requirements.

(4) normal operating loads.

(5) externally applied loads (such as seismic and end loads).

(6) aging of nonmetallic materials (Nonmandatory Appendix QR-B provides supplementary details associated with the qualification of nonmetallic parts).

(7) maintaining design life (such as maintenance, overhaul, and replacement).

(c) Any electrical controls associated with speed-changing devices shall be qualified in accordance with the requirements of IEEE Std 323 and IEEE Std 344.

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QP-7350 Auxiliary Equipment. When auxiliary equipment is qualified separately from the pump assembly, pump, shaft-seal system, driver, and transmission device, its qualification shall address significant hydraulic and mechanical design factors that can degrade and impact performance of the specified function. The approach to qualification shall identify the service conditions and interfaces with pump assembly items.

QP-7360 Pump Stand. The pump stand deflections due to thermal expansion, dynamic and/or seismic effects, and pipe end loading shall be considered in the qualification of the power transmission device (see Subsubarticle QP-7340). Care shall be taken to avoid a natural frequency of the pump stand near the driver rotational speed in revolutions per minute (rpm).

QP-7370 Qualification for Ingestion of Air and/or Debris. The pump assembly, including the sealing system as applicable, shall be qualified to accommodate postulated debris ingestion as specified by the Owner in the procurement/Qualification Specifications. The qualification shall consider the full range of potential debris including post-LOCA debris constituents (such as material, quantity, size, density, abrasiveness, and concentration in fluid); pump capability over the full mission time; verification that debris distribution size during testing is consistent with debris size in the procurement/Qualification Specifications; basis and justification for use of any surrogate debris used as a substitute for material in the specification; and capability of filters in the pump assembly or associated components to perform their intended function without clogging or otherwise causing adverse pump performance.

The Owner shall specify qualification requirements for air/gas ingestion in the procurement/Qualification Specifications.

The following are qualification methods for addressing the effect of debris on the pump and its sealing system:

(a) When the system is designed for specific debris loading, the Owner shall specify the designed debris load in the procurement/Qualification Specifications.

NOTE: In this case, the pump and/or shaft-seal system shall be qualified by test or a combination of test and analysis for the designed debris load such that the pump and/or shaft-seal system will perform its safety function.

(b) The maximum debris load that can be accommodated by the pump and/or shaft-seal system shall be qualified by test or a combination of test and analysis such that the pump and shaft-seal system will perform its safety function. This information shall be supplied to the Owner, who designs the system such that the characteristics of the maximum debris size and constitutents cannot be exceeded. Documentation supplied to the Owner shall specify debris constitutents used for qualification (such as material, quantity, size, density, abrasiveness, and concentration in fluid) and any limiting conditions of operation as a result of the debris load.

For both qualification methods described in subparas. (a) and (b) above, credit taken for debris separation or filtration from seal or bearing flushing flow shall be corroborated by testing.

QP-7400 Environmental and Aging Considerations

Pump assemblies and pump assembly items shall be qualified in accordance with para. QR-7311 or para. QR-7321. Environmental qualification of pump assemblies and pump assembly items shall be performed in accordance with IEEE Std 323. Nonmandatory Appendix QR-B provides supplementary details associated with the qualification of nonmetallic parts.

QP-7500 Dynamic/Seismic Loading

(a) Pump assemblies and pump assembly items shall be qualified in accordance with para. QR-7312 or para. QR-7322. Nonmandatory Appendix QR-A provides supplementary details associated with the dynamic qualification of mechanical equipment. The qualification shall consider if the pump is operating during the dynamic event, if so specified.

(b) Qualification for seismic and/or dynamic loads shall demonstrate the ability of a pump assembly to withstand a loading that is representative of the specified seismic load qualification level.

(c) Seismic qualification of pump assemblies shall be in accordance with IEEE Std 344 or Nonmandatory Appendix QR-A.

(d) All essential-to-function accessories shall be attached to the pump assembly. The essential-to-function accessories that have not been previously qualified in accordance with IEEE Std 344 as part of the pump assembly shall be seismically qualified in accordance with IEEE Std 344 or Nonmandatory Appendix QR-A.

(e) The determination of the allowable static misalignment of the power transmission device shall consider the impact of the seismic and/or dynamic loading.

QP-7600 Nozzle Loading

The pump assembly shall be qualified to accommodate postulated end loading. End-loading qualification may be justified by analysis, if the intended application for the pump does not impose significant end-load reactions. There are several methods for addressing end loading on the pump or on its driver (in the case of a turbine driver).

(a) The maximum load (forces and moments) that can be placed on the pump/turbine case such that operation is not adversely affected may be qualified analytically. In turn, this load shall be supplied to the piping system designer, who shall design the system such that the load cannot be exceeded.

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