demonstrate that the pump assembly will perform its safety function. The qualification plan must also clearly describe how it is demonstrated 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 must be clearly described in the specification.

**Note:** If the full range of operating conditions (such as temperature, pressure, flowrate, and net positive suction head [NPSH]) cannot be achieved in the test facility, then the qualification plan must 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 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 section 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 (QR-7310, 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 section QR-7340). This extension of qualification is based upon the condition that both pump assemblies utilize 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 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 QR-7300. Analysis is permissible 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 provides guidance may be used for the analysis of similarity between pump assemblies.

QP-7310 Pump

Delete (a). 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 section QP-7310(b).

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 shall include 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 addressed 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 are to include periodic in-service testing and anticipated inoperative periods.
2. System fluid conditions with the full range of potential debris as described in QP-7370.
3. Environmental conditions.
4. Starting requirements.
5. Normal operating loads.
6. Externally applied loads (such as seismic, nozzle, and end load).
7. Bearings and couplings.
8. Aging of nonmetallic materials (Nonmandatory Appendix QR-B provides 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 the 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 section 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 non-metallic components, such as O-rings and the rotating and stationary seals of the mechanical seal that may contain non-metallic 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 QP-8200 that the proposed system had been 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 section QP-8200 shall include a detailed description of tests, analysis, test equipment, and actual test results.

**QP-7330 Turbine Driver**

(a) 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 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 section QP-7330(b).

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 shall include 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 nonmetalics 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 nonmetalics 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 load).
(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.

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 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 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 (i) post-LOCA debris constituents (such as material, quantity, size, density, abrasiveness, and concentration in fluid); (ii) pump capability over the full mission time; (iii) verification that debris distribution size during testing is consistent with debris size in the procurement/qualification specification; (iv) basis and justification for use of any surrogate debris used as a substitute for material in the specification; and (v) 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 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) Qualify by test or a combination of test and analysis. 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 constituents cannot be exceeded. Documentation supplied to the Owner shall specify debris constituents 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 paragraphs (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

Pump assemblies and pump assembly items shall be qualified in accordance with section QR-7311 or 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 section QR-7312 or QR-7322. Nonmandatory Appendix QR-A provides supplementary details associated with the dynamic qualification of mechanical equipment. The qualification must 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) Qualify analytically. 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 must design the system such that the load cannot be exceeded.

(b) Qualify by test. The maximum load that can be placed on the pump/turbine such that operation is not adversely affected may be qualified by test. In turn, this load shall be supplied to the piping system designer who must design the system such that the load cannot be exceeded.

(c) Require that. The maximum stress intensity in the attached piping at the pipe to pump/turbine junction resulting from the combination of the primary or local membrane stress ($P_M$ or $P_L$) plus the bending stress ($P_b$) plus the expansion stress ($P_e$) shall be limited to a value of $(G_b/F_b) \times S_y$ with $G_b$ and $S_b$ as defined below. That is,

$$ (P_M \text{ or } P_L) + P_b + P_e \leq (G_b/F_b) \times S_y $$  \hspace{1cm} (eq QP-1)

If $G_b$ is unknown, then $(G_b/F_b)$ may be taken as 1.
where

\[ F_b = \text{bending modulus of the connecting pipe} \]
\[ G_b = \text{pump assembly body section modulus at the crotch region} \]
\[ P_b = \text{bending stress} \]
\[ P_e = \text{expansion stress} \]
\[ P_L = \text{local primary membrane stress} \]
\[ P_M = \text{primary membrane stress}. \]

The determination of the maximum stress intensity shall be based on the highest combination of concurrent loads considering all concurrent loads defined in the qualification specification. The value of \( S_y \) shall be taken at the highest metal temperature of the attached piping for the concurrent load combination under consideration.

**QP-7700 Extrapolation of Qualification of Pump Functional Capability**

The extrapolation of the qualification of the functional capability of a qualified pump assembly to another pump assembly shall be justified using a combination of analytical comparison of physical attributes and diagnostic test data. Nonmandatory Appendix QP-D provides guidance [may be used](#) for considerations of the similarity of pumps when extrapolating the qualification of a pump assembly to another pump assembly.

**QP-7800 Demonstration of Functional Capability of Production Pump Assemblies**

The functional capability of the production pump assembly shall be demonstrated by verification of the physical attributes, application, and diagnostic test data of the production pump assembly to its qualified pump assembly.

**QP-7900 Post-Installation Verification and IST Baseline**

After the pump has been installed in the facility, the pump shall be operated under representative fluid flow conditions as necessary to collect diagnostic data for use in future performance monitoring and to verify that the pump is performing as it was specified. Specifically, the pump needs to be testable as required by the ASME OM Code. The requirements of QP-7900 are the responsibility of the owner.

**QP-8000 DOCUMENTATION**

**QP-8100 Documentation Scope**

\((a)\) Qualification documentation is intended to verify that each pump assembly in a nuclear facility application is qualified to perform its designated function when used for its intended service. Qualification is substantiated by showing and explaining the relationship between the service requirements and the testing and analysis that are conducted as part of the qualification program.
(b) A Qualification Plan, as described in QP-8200, is required to translate the Qualification Specification into a step-by-step qualification program and the testing and analysis that is conducted as part of the qualification program.

(c) A Functional Qualification Report, as described in QP-8310, is required to document compliance of the qualified pump assembly and its production pump assemblies with Section QP.

(d) An Application Report, as described in QP-8320, is required to document the suitability of any qualified pump assembly and its production pump assemblies for a specific nuclear facility application.

QP-8200 Qualification Plan

A Qualification Plan, which may be part of the Functional Qualification Report, shall be prepared with appropriate inspection and test records to define test objectives, test fluids, extrapolation parameters, test instrumentation, conditions of the test, orientation, permissible maintenance or adjustments, and acceptance criteria. The plan shall also specify the activities to ensure that production pump assemblies will perform consistent with their applicable qualified pump assembly.

QP-8300 Reports

QP-8310 Functional Qualification Report

(a) A Functional Qualification Report shall be prepared for each qualified pump assembly qualified in accordance with this Section of the standard directly or by extrapolation. This Functional Qualification Report shall provide complete identification of the pump by type, size, and other data as appropriate, including the Qualification Plan, test results, extrapolation parameters and justification, and inspection data. The Functional Qualification Report shall also contain a summary of the parameters established by the functional qualification testing and analysis for both the qualified pump assembly and its production pump assemblies. Any specific limitations that restrict qualification shall be stated.

(b) Where prequalified components of the pump assembly are utilized as part of the pump assembly qualification, the Functional Qualification Report shall reference the report(s) upon which such prequalification is based. In addition, it must be shown that the mounting and integration of this prequalified component on the pump assembly does not degrade or otherwise interfere with the prequalification of the component.

(c) Each Functional Qualification Report shall be certified by one or more registered professional engineers in accordance with the requirements of QR-8630).

QP-8320 Application Report

(a) An Application Report is required to demonstrate the suitability of any qualified pump assembly and its associated production pump assemblies to meet the requirements of a specific application. An Application Report is required for each serial-numbered pump assembly, except that pump assemblies whose construction and service conditions are identical, differing only in serial numbers and tag numbers, may be combined into one Application Report.

(b) The Application Report shall reference the appropriate Functional Qualification Report and shall further show how each of the specific application requirements of the Qualification Specification are appropriately addressed by the Functional Qualification Report or other tests and analysis as outlined in this Section. Where prequalified parts of the pump assembly are utilized as part of the pump assembly qualification, the Application Report shall reference the report(s) upon which such
prequalification is based. In addition, it must be shown that the mounting and integration of this prequalified part on the pump assembly does not degrade or otherwise interfere with the prequalification of the part.

(d) The Application Report shall contain the following, as applicable:

(1) Serial number, tag number, or other unique identification of the pump assembly.
(2) Complete description of the pump assembly construction configuration, including an assembly drawing. This description shall include a complete identification of the pump by type and size.
(3) A summary of the functional parameters and how they are met by the pump assembly.
(4) Reference to the Functional Qualification Report(s) upon which qualification is based.
(5) All test results and analyses used to show that the pump assembly satisfies the requirements of this Section for the specific application.
(6) Reference to the qualification reports for all prequalified components used per above.
(7) Any specific limitations that restrict application shall be stated.
(8) Additional information as may be necessary to support the demonstration of functional capability for the qualified pump assembly and its production pump assemblies.
(9) Special installation requirements and maintenance required to maintain qualification.
(10) Dimension of mechanical fits and clearances for the pump assembly.
(11) Shaft-seal assembly drawing with appropriate bill of materials, service conditions, and precautions noted that would preclude malfunction.
(12) Dimension of mechanical fits and clearances of the turbine driver.

Note: The documentation for the turbine driver shall also be as specified in IEEE Std 323 and IEEE Std 344 where these standards are invoked.

(13) Dimensions of mechanical fits and clearances of the power transmission device. The documentation for the power transmission device shall also be as specified in IEEE Std 323 and IEEE Std 344 where these standards are invoked. The allowable static misalignment of the power transmission device shall be documented.
(14) Dimension of mechanical fits and clearances for auxiliary equipment.
Mandatory Appendix QP-I
Qualification Specification for Active Pump Assemblies

QP-I1000 SCOPE

This Mandatory Appendix establishes requirements for a Qualification Specification for active pump assemblies as required by ASME QME-1, Articles QR-6000 and QP-6000.

QP-I2000 PURPOSE

(a) This Mandatory Appendix provides details of functional requirements that supplement piping and pump codes and standards applicable to active pump assemblies.

(b) The information requested in this Mandatory Appendix must be provided as part of the Design Specification or as a separate document.

(c) Compliance with the requirements of this Mandatory Appendix is intended to ensure that the operating conditions and safety functions of the pump assembly have been adequately addressed and defined by the Owner as necessary for which the pump assembly must be qualified to Section QP.

(d) The Functional Specification is required to ensure that the Owner has provided the qualification parameters for the active pump assembly to the manufacturer or qualification facility.

(e) It is the responsibility of the Owner to identify any qualification parameters (such as operating conditions, safety functions, testing requirements, or acceptance criteria) in the qualification specification that are not listed in this appendix.

QP-I3000 REFERENCES

References are as listed in Articles QP-3000 and QR-3000.

QP-I4000 DEFINITIONS

Definitions are as listed in Article QP-4000.

QP-I5000 FUNCTIONAL SPECIFICATION CONTENTS

The Functional Specification shall identify the following as applicable:

QP-I5100 Pump Assemblies

(a) The qualification specification shall identify those items that are part of the pump assembly.

(b) The qualification specification shall also define the interfaces between the pump assembly and external attachments and supports.
(c) 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-15110 Service Conditions

(a) Service conditions defining the application of the pump assembly shall be specified.

(b) Service conditions consist of all operating conditions, including the seismic and environmental conditions to which the pump assembly will be subjected, and the full range of fluid flow, differential pressure, electrical conditions, and temperature conditions with debris-laden fluids for which the pump assembly must have functional capability to operate up to and including design basis accident conditions.

QP-I5120 Environmental Conditions

(a) Environmental conditions in which the pump is to be operated, as well as conditions where the pump must remain leak tight but need not operate, are to be specified.

(b) In cases where pump leakage is permitted, specify the maximum leak rate shall be specified.

(c) The qualification specification shall require that significant aging mechanisms along with components and/or materials subject to aging be identified.

QP-I5130 Design and Construction Characteristics

The following characteristics shall be identified where applicable:

(a) pump type
(b) design life
(c) functional, operating, environmental, and service conditions under which the pump must operate
(d) operational modes, including time limit for recirculating flow testing
(e) fluid pumped, specific gravity at given temperatures
(f) design pressure
(g) design temperature
(h) rated flow, maximum required flow (runout flow)
(i) head at rated flow, maximum required flow, and shutoff conditions
(j) suction temperature: minimum, normal, and maximum
(k) suction pressure: maximum and normal
(l) net positive suction head available (NPSHA) under the full range of service conditions (including fluid flow, temperature, and air and debris content)
(m) ambient temperature, humidity, and radiation
(n) water chemical content (pump and/or seal cooling water)
(o) minimum operating flow limitations
(p) use of mechanical seals and type of seal cooler, if applicable
(q) flow restrictor from seal cavity, if applicable
(r) vent and drain from pump casing and types of connections
(s) type of pump nozzle connections and details
(t) connection requirements to other ancillary piping
(u) support and anchorage requirements and configuration
(v) cooling water piping code requirements
(w) maximum input driver horsepower for diesel generator loading
(x) cooling water; temperature, minimum and maximum; pressure; and maximum pressure drop
(y) entrained material for which the pump is designed; such as dirt, debris, insulation, molten fuel, diesel oil, and fish, under normal and abnormal service conditions
(z) separation of running frequency from shaft natural frequency and pump assembly torsional natural frequency
(aa) start-up and operating time
(bb) coupling: flexibility, alignment, service life, bearing load, balance
(cc) specific location at nuclear facility site (inside or outside containment)
(dd) recirculation flowrate shutoff head
(ee) NPSH required (NPSHR) for pump assembly under the full range of service conditions
(ff) uncertainties in the qualification process
(gg) filter size and performance requirements
(hh) service and environmental conditions for qualification of non-metallic parts.

QP-I5140 Description of Interface Attachments and Loads

Location, nature, and magnitude of externally applied loads and structural characteristics for interface attachments shall be specified.

QP-I5150 Structural, Seismic and Dynamic, and Environmental Qualification Requirements

The following requirements shall be specified:

(a) requirements for dynamic analysis or testing
(b) designation of loads, load combinations, and related code service conditions
(c) demonstration of operability by analysis or test under all applicable loading conditions
(d) seismic loading (operating basis earthquake [OBE] and safe shutdown earthquake [SSE])
(e) stress limits
(f) seismic and/or dynamic design criteria
(g) minimum acceptable force and moment carrying capability of the pump nozzles, casing, and support attachments
(h) seismic acceleration, both horizontal (two orthogonal directions) and vertical
(i) delineation of whether the pump needs to operate during the dynamic loading
(j) nozzle loading
(k) environmental qualification requirements and acceptance criteria.

QP-I5160 Material and Manufacturing Requirements

The following requirements shall be specified:

(a) specific material requirements.
(b) specific manufacturing requirements
REC #15-2846
QP-I5170 Acceptance Criteria

(a) The qualification specification shall indicate the performance required from the pump assembly/pump during specified service conditions.

(b) Acceptance criteria shall be specified for
   (a1) capacity (flow)
   (2b) total developed head (or pressure)
   (3c) NPSHR including its range of uncertainties as discussed below in this section
   (4e) start-up and operating time based upon facility conditions
   (5e) transients such as thermal or pressure
   (6f) priming time
   (7g) process fluid conditions
   (8h) environmental parameters and aging
   (9l) minimum flow rates and associated time limitations
   (10j) vibration limits
   (11k) fluid filter performance
   (12l) air ingestion capability
   (13m) debris and solids ingestion capability
   (14n) seismic and dynamic loading application
   (15o) end loading application
   (16p) interface acceptability for pump assembly items qualified separately
   (17q) operation time and flow rates when pump is in recirculation mode
   (18r) degraded motor voltage conditions.

(c) Instrument accuracy for pressure, flow rate, speed, vibration, differential pressure, and vibration acceptance criteria shall not be less than that prescribed in ASME OM Code.

(d) The uncertainties of NPSHR must be addressed in the qualification specification. These uncertainties include, for example:
   (a1) NPSHR variation with changes in pump speed caused by motor slip
   (b2) NPSHR decrease with increasing water temperature
   (c3) NPSHR effects resulting from differences between qualified test suction piping and as-installed suction piping
   (d4) NPSHR variation resulting from differences in air content of water between qualification test and field conditions
   (e5) NPSHR effects from wear ring leakage.

QP-I5180 Testing Requirements

The following requirements shall be specified:

(a) shop performance test and measurements to be taken, including capacity, total head, power input, efficiency, NPSHR and their applicable ranges, recirculation flow rate at shutoff head, and vibration at the bearing or on the shaft

(b) prequalification transient test requirements and acceptance criteria.

QP-I5190 Documentation, Instructions, and Limitations
The following requirements shall be specified:

(a) documentation requirements
(b) requirement for manufacturer’s provision of values of maximum allowable forces and moments
(c) operational limits for pump recirculation or operation without cooling water
(d) requirement for manufacturer’s provision of values for minimum flow capability and time limitations
(e) requirements for manufacturer’s provision of bolting material requirements, torque values, and washer configuration
(f) quantified acceptable limits for wear of bearings to establish minimum service life.

QP-I5200 Pump Shaft-Seal System

QP-I5210 Design and Construction Requirements

The following requirements shall be specified:

(a) type of seal or seal system to be provided
(b) design life
   (1) static
   (2) dynamic
(c) post-design basis event design life
   (1) number of cycles
   (2) duration of cycles
(d) conditions at seal cavity
   (1) fluid pumped, specific gravity at given temperature
   (2) design pressures
   (3) design temperature
   (4) thermal and pressure transient (rate, range, direction)
   (5) thermal and pressure transient duration (minutes)
   (6) allowable leakage
   (7) radiation
   (8) shaft speed
   (9) maximum entrained material size under normal and abnormal service conditions
(e) component coolant conditions
   (1) pressure
   (2) temperature
   (3) flow rate
   (4) chemistry
   (5) pressure drop
(f) availability of seal injection, including the quantity, temperature, chemistry, and solids particle size
(g) possible inaccessibility of pump during operation that restricts opportunities for visual inspection and preventive maintenance to the seal system
(h) the need for assembly and maintenance features to limit personnel exposure time in radiation fields
(i) shaft direction or rotation as viewed from the drive end
(j) specific location at facility site (inside or outside containment)
(k) effect of wear, abrasion, and blockage due to entrained material (includes debris and chemical precipitants)
(l) service and environmental conditions for the qualification of non-metallic parts.

**QP-I5220 Structural, Seismic and Dynamic, And Environmental Qualification Requirements**

The following requirements shall be specified:

(a) structural qualification requirements and acceptance criteria
(b) seismic and dynamic qualification requirements and acceptance criteria
(c) environmental qualification requirements and acceptance criteria.

**QP-I5230 Materials and Manufacturing Requirements**

The following requirements shall be specified:

(a) specific material requirements.
(b) specific manufacturing requirements.

**QP- I5240 Acceptance Criteria**

(a) The qualification specification shall specify the performance required from the shaft-seal system during specified service conditions.

(b) Acceptance criteria shall be specified for:
   (a1) flow rate of coolant through cooling jacket or seal cavity
   (b2) start-up and running torque requirements
   (c3) seal leakage rates under static and dynamic operating conditions
   (d4) maximum leakage rates under complete seal failure
   (e5) operation with entrained material (including any chemical precipitates).

**QP-I5250 Testing Requirements**

(a) Specify the requirement that the pump shaft-seal system demonstrates that it will provide acceptable sealing and seal injection, as applicable, over the full range of service.

**QP-I5260 Documentation, Instructions, and Limitations**

The following documentation shall be specified:

(a) documentation requirements
(b) requirements for manufacturer's provision of bolting material, torque values, and washer configuration.

**QP-I5300 Pump Turbine Driver**

**QP-I5310 Design and Construction Requirements**
(a) required design life of major components (nonconsumables)
(b) functional, operating, environmental, and design conditions under which the turbine must operate
   (1) design pressures and temperatures (maximum, normal, and minimum) for inlet and exhaust
   (2) operating pressures and temperatures (maximum, normal, and minimum) for inlet and exhaust
   (3) operating conditions (such as brake horsepower and revolutions per minute) at corresponding design/operating conditions
   (4) ambient temperature, pressure, humidity, and radiation
   (5) maximum horsepower
   (6) cooling water: minimum, normal, and maximum temperature and pressure
   (7) process fluid analysis (such as chlorides)
(c) operational modes, including operating and design process fluid conditions, and duration and frequency of operation
(d) interface requirements (such as control system, utilities available, and flanged connections)
   (e) shaft vibration limits
   (f) specific location at facility site (inside or outside containment).

QP-I5320 Structural, Seismic and Dynamic, and Environmental Qualification Requirements

   (a) seismic and dynamic qualification requirements (specification must shall include definition of seismic environment) and acceptance criteria
   (b) environmental qualification requirements and acceptance criteria
   (c) additional applicable design qualification requirements (i.e., pressure vessel analysis).

QP-I5330 Material and Manufacturing Requirements

   (a) specific material requirements (if differing from the manufacturer’s standards).

QP-I5340 Acceptance Criteria

   (a) The qualification specification shall specify the performance required from the turbine driver during specified service conditions.

   (b) Acceptance criteria shall be specified for:
       (a1) speed/output torque at operating steam conditions (pressure, temperature, flow, and quality)
       (b2) required start-up and operating time based upon facility conditions
       (c3) capability of the governor system to regulate steam flow within specified limits
       (d4) vibration limits
       (e5) bearing displacement.

QP-I5350 Testing Requirements

   (a) Specify the requirement for demonstration that the unit will operate through all modes of operation for duration specified).
QP-I5360 Documentation, Instructions, and Limitations

The following requirements shall be specified:

(a) document requirements
(b) requirements for manufacturer’s provisions of bolting material requirements, torque values, and washer configuration.

QP-I5400 POWER TRANSMISSION

QP-I5410 Design and Construction Requirements

The following requirements shall be specified:

(a) required design life of major components (nonconsumables)
(b) functional, operating, environmental, and design conditions
(c) operational modes, including operating and design process fluid conditions, and duration and frequency of operation
(d) interface requirements
(e) shaft vibration limits
(f) specific location at facility site (inside or outside containment).

QP-I5420 Structural, Seismic and Dynamic, and Environmental Qualification

The following requirements shall be specified:

(a) structural qualification requirements and acceptance criteria
(b) seismic and dynamic qualification requirements and acceptance criteria
(c) environmental qualification requirements and acceptance criteria.

QP-I5430 Materials and Manufacturing Requirements

The following requirements shall be specified:

(a) specific material requirements (if differing from the manufacturer’s standards).
(b) specific manufacturing requirements.

QP-I5440 Acceptance Criteria

(a) The qualification specification shall specify the performance required from the power transmission device during specified service conditions.

(b) Acceptance criteria shall be specified for:

(a1) torque and horsepower capacities
(b2) input/output speeds
(c3) vibration limits
(d4) total indicated runout
(e5) cooling requirements
(6) coupling displacement.
QP-I5450  Testing Requirements

(a) Specify the requirement for demonstration that the unit will operate through all modes of operation for duration specified.

QP-I5460  Documentation, Instructions, and Limitations

The following requirements shall be specified:

(a) document requirements
(b) requirements for manufacturer’s provisions of bolting material requirements, torque values, and washer configuration.

QP-I5500  AUXILIARY EQUIPMENT

QP-I5510  Design and Construction Requirements

The following requirements shall be specified:

(a) required design life of major components (nonconsumables)
(b) functional, operating, environmental, and design conditions
(c) operational modes, including operating and design process fluid conditions, and duration and frequency of operation
(d) interface requirements
(e) specific location at facility site (inside or outside containment).

QP-I5520  Structural, Seismic and Dynamic, and Environmental Qualification

The following requirements shall be specified:

(a) structural qualification requirements and acceptance criteria
(b) seismic and dynamic qualification requirements and acceptance criteria
(c) environmental qualification requirements and acceptance criteria.

QP-I5530  Materials and Manufacturing Requirements

The following requirements shall be specified:

(a) specific material requirements (if differing from the manufacturer’s standards).
(b) specific manufacturing requirements.

QP- I5540 Acceptance Criteria

The qualification specification shall specify the performance required from any uniquely identified auxiliary equipment during specified service conditions.
QP-I5550 Testing Requirements

(a) Specify the requirement for demonstration that the unit will operate through all modes of operation for duration specified.

QP-I5560 Documentation, Instructions, and Limitations

The following requirements shall be specified:

(a) document requirements
(b) requirements for manufacturer’s provisions of bolting material requirements, torque values, and washer configuration.

Nonmandatory Appendices QP-A through C were deleted but have been reserved reserved for future use in post-2012 editions.
Nonmandatory Appendix QP-D
Pump Similarity Checklist

QP-D1000 SCOPE

(a) This Nonmandatory Appendix is provided to aid both the pump designer and specification writer.

(b) It lists items that may be considered when establishing rules of similarity between either pump designs or process conditions.

(c) The selection of applicable similarity items, either the ones identified herein or others specified as required, is may be selected at the option of the Owner.

QP-D2000 PUMP DESIGN

The following parameters should be considered:

(a) hydraulic capability
   (1) rating of pump, discharge size, NPS (DN)
   (2) best efficiency point as percentage of condition
   (3) rise-to-shutoff from condition
   (4) NPSHR and its range of uncertainties
   (5) specific speed
   (6) suction specific speed
   (7) speed(s) of rotation
   (8) tip speed

(b) number of vanes

(b) mechanical capability
   (1) size of suction and discharge nozzles, NPS (DN)
   (2) impeller diameter, in. (mm)
   (3) vane treatment, finish and filing (over and under)
   (4) stationary to rotating fit clearances
   (5) rotation
   (6) method of support (frame, foot, and centerline)
   (7) speed control (constant/variable)
   (8) type and size of bearing system
   (9) type and size of drive coupling
   (10) stiffness of pump and driver support on base
   (11) arrangement (vertical or horizontal)
   (12) open or closed impeller
   (13) single or multistage
   (14) metallurgy of wetted parts
   (15) shaft-seal system

(c) filters
   (1) type
   (2) design
   (3) application
QP-D3000 PROCESS DESIGN

(a) The following conditions for the pumped fluid should be considered:

(a) pumped fluid
   (1) start-up conditions
   (2) normal and abnormal conditions
   (3) transient conditions of flow, temperature, fluid chemistry, and pressure
   (4) test conditions
   (5) process fluid conditions

(b) The following external conditions should be considered:

   (1) start-up conditions
   (2) normal and abnormal conditions
   (3) transient conditions of flow, temperature, fluid chemistry, and pressure
   (4) amplitude and duration of seismic excitation
   (5) transient piping interaction
   (6) cooling water for seal or bearing cooling

(c) Similarity can may be undertaken only within pumps of the same class and type.

(d) The collection of the above parameters provides a means of narrowing the differences between pumps.

(e) To establish similarity, it must shall be shown that when exposed to like internal and external loads, expressed as casing stress and assembly strain in response to normal and abnormal loads, similar pumps will exhibit congruent performance — hydraulic and mechanical.

(f) Similar pumps must equally be expected to withstand like aging effects and retain their ability to perform their specified design function.

(g) Exceptions will may be considered if documentation demonstrates similarity of performance, notwithstanding the above criteria.
Nonmandatory Appendix QP-E
Guidelines for Shaft-Seal System Material and Design Consideration

QP-E1000 SCOPE

This Nonmandatory Appendix contains guidelines for the special material and design considerations for shaft-seal systems that are intended to be qualified in accordance with the requirements of Section QP.

QP-E2000 PURPOSE

This Nonmandatory Appendix provides material and design guidance to the qualification specification writer.

QP-E3000 DEFINITIONS

The following definition establishes the meaning of a term in the context of its use in this Nonmandatory Appendix and supplements those found in Sections QR and QP:

stress index: the ratio of the design stress to the minimum ultimate strength of the material ($S/S_u$).

QP-E4000 MATERIAL CONSIDERATIONS

QP-E4100 Pressure-Retaining Material

Gland plates and associated bolting are defined as pressure-retaining material by the ASME Boiler & Pressure Vessel Code (BPV Code), Section III. Requirements to be included in the qualification specification for material used in pressure-retaining applications are to be in accordance with the appropriate ASME BPV Code, Section III classification and its associated material requirements.

QP-E4200 Nonpressure-Retaining Material

(a) Considerations to be included in the qualification specification for material used for seal-mating faces applications are

(1) no detrimental physical property changes occurring when subjected to the seal cavity fluids for the times listed in Table QP-E4200-1

(2) no detrimental physical property changes occurring when subjected to the maximum seal cavity temperature listed in Table QP-E4200-1

(3) no detrimental wear rate, abrasion, or blockage when subjected to the conditions listed in Table QP-E4200-1

(b) Material with a stress index less than 0.1, used for retainers, bolts, pins, bushings, and other parts, may be manufactured from any material suitable for the intended service.

(c) Material with a stress index greater than 0.1, used for springs, bolts, pins, and other metallic or brittle parts, should meet an ASME, ASTM, or AMS specification that controls the quality of the material.

(d) Proprietary material with a stress index greater than 0.1, used for springs, bolts, pins, and other metallic or brittle parts that do not have a suitable national specification available, should be qualified by testing in accordance with Section QP. Such proprietary materials are
designated by a specific identification number by the material manufacturer and certified to meet all the quality assurance requirements of the originally qualified material.

QP-E5000 DESIGN CONSIDERATIONS

QP-E5100 General

For normal operating conditions, the shaft-seal system is designed to operate without maintenance for the design life listed in Table QP-E4200-1.

For service conditions other than normal, the shaft seal system is designed to operate without maintenance for a specified duration and specified number of cycles. If only one cycle of a specific operating condition is specified, then it is understood that replacement or maintenance may occur before resuming normal operation, unless other design considerations are specified in the qualification specification.

Special shaft-seal systems, such as double seals, tandem seals, bellows, and/or cartridge seals, are to be specified in the qualification specification.

QP-E5200 Design Input

(a) The pump manufacturer will supply the seal manufacturer with the following general design criteria:
   (1) applicable edition and addenda of Section III of the ASME BPV Code
   (2) service conditions and associated duty cycles as listed in Table QP-E4200-1

(b) The pump manufacturer will supply the seal manufacturer with the following arrangement and interface conditions:
   (1) type of seal to be provided (i.e., packing, mechanical, bellows, double tandems, and cartridge)
   (2) shaft or sleeve diameter at seal
   (3) shaft or sleeve material
   (4) shaft orientation (i.e., vertical or horizontal)
   (5) direction of rotation
   (6) seal cavity maximum diameter at seal
   (7) seal cavity length
   (8) shaft-to-seal cavity misalignment conditions (i.e., static eccentricity, static angularity, and range of axial travel)
   (9) shaft motions (i.e., radial, axial, and angular) relative to the seal cavity during seismic and design basis conditions as listed in Table QP-E4200-1

(c) The pump manufacturer will supply the seal manufacturer with the following shaft-seal system external conditions:
   (1) seal system piping arrangements and seal flushing systems shall conform to ASME B73.1M, ASME B73.2M, API 610, API 682, and STLE SP-30
   (2) availability of component coolant, including the quantity, maximum temperature, pressure, available pressure drop, and chemistry
   (3) availability of seal injection, including the quantity, temperature, chemistry, and solids particle type and size

(d) The pump manufacturer will supply the seal manufacturer with the following special provisions:
   (1) maintenance provisions
   (2) inaccessibility of the pump during operation that would restrict visual inspection and preventive maintenance
(3) necessary assembly and maintenance features that limit personnel exposure time in radiation fields

QP-E5300 Mechanical Face Seals

(a) Mechanical face seals should be of the hydraulically balanced type, except as provided for in Table QP-E5300-1.
(b) Either a sliding gasket (i.e., O-ring, V-ring, or U-ring) or a metal or rubber bellows should be used between the axially moving seal face and shaft sleeve or housing.
(c) For applications involving seal face velocities over 5,000 fpm (1,524 m/min), it is preferred that the axially movable seal face be mounted on the stationary housing rather than on the shaft.

QP-E5400 Packings

(a) Stuffing boxes on all pumps should be packed with a sufficient amount of packing as recommended by the packing manufacturer. The minimum packing size is 1/4 in² (160 mm²); however, a packing size of 3/8 in² (240 mm²) or greater is preferred.
(b) Pump-stuffing boxes are to be provided with a lantern ring for fluid injection directly into the packing. Inlet and outlet connections must be provided for the lantern ring.
(c) Sufficient space is to be provided for the packing to be replaced without removing or dismantling any part other than the gland and lantern ring if split.
(d) If the stuffing box of a vertical pump is subjected to discharge pressure and a bleed-off to suction is used, the bleed-off should be by means of internal rather than external piping.
(e) Adequate seal draining is to be provided so that no liquid can collect in the driver support piece.

QP-E5500 Shaft Sleeves

(a) Shaft sleeves, when used, are to be sealed to prevent leakage between the sleeve and shaft and machined for concentric rotation.
(b) Ends of shaft sleeve assemblies or nuts, when used on pumps arranged for packing, are to extend beyond the outer face of the packing gland.
(c) Shaft sleeves are to extend beyond the external seal gland plate on pumps employing an auxiliary seal other than a throttle bushing.
<table>
<thead>
<tr>
<th>Conditions at Seal Cavity</th>
<th>Normal [Note (1)]</th>
<th>Design Basis Condition</th>
<th>Design Basis Event</th>
<th>In-Service Tests</th>
<th>Hydrostatic [Note (2)]</th>
<th>Other [Note (3)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluid pressure, psia</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Temperature, °F (°C)</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>Thermal transient rate</td>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Thermal transient duration, min</td>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Allowable leakage [Note (5)]</td>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Radiation, rads</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Speed, rpm</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>Abnormal Condition Info (Design Life)</td>
<td>N/A</td>
<td>Number of cycles</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Duration of cycles, hr</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>Component Coolant Conditions</td>
<td>N/A</td>
<td>Pressure, psia (MPa)</td>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td></td>
<td></td>
<td>Temperature, °F (°C)</td>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Flow rate, gpm (mm³/s)</td>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Design Life</td>
<td></td>
<td>Static, hr</td>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dynamic, hr</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

GENERAL NOTE: NA indicates not applicable.

NOTES:
(1) Normal conditions refer to seal conditions in pump that are required to function during normal facility operation.

(2) Include this information if seal is to be used during hydrostatic tests.
(3) Other refers to conditions that may affect the seal cavity environment, such as external loads and loss of component coolant or injection, and to conditions that are not covered in the other categories.
(4) If fluid is water, specify quantity of chemicals present as additives or impurities and solids particle type and size.
(5) Allowable leakage refers to that leakage which can be collected as liquid at the seal-operating conditions.
# Table QP-E4200-1 Shaft-Seal System Specification

<table>
<thead>
<tr>
<th>Shaft-Seal System Parameters</th>
<th>Normal [Note (1)]</th>
<th>Design Basis Events</th>
<th>Inservice Tests</th>
<th>Hydrostatic [Note (2)]</th>
<th>Other [Note (3)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shaft Seal System</td>
<td>Design Basis Condition</td>
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<tr>
<td>Conditions at Seal Cavity</td>
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<tr>
<td>Fluid [Note (4)]</td>
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<td>Pressure, psia (MPa)</td>
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<td>Temperature, °F (°C)</td>
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<td>Thermal transient rate, range, and direction, °F/min (°C/s)</td>
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<tr>
<td>Thermal transient duration, min</td>
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<td></td>
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<tr>
<td>Allowable leakage [Note (5)]</td>
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<tr>
<td>Radiation, rad/s</td>
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<td>NA</td>
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<tr>
<td>Speed, rpm</td>
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<td>Abnormal Condition Information (Design Life)</td>
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<td>Duration of cycles, hr</td>
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<tr>
<td>Component Coolant Conditions</td>
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<td>Pressure, psia (MPa)</td>
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<tr>
<td>Flow rate, gpm (mm³/s)</td>
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<td>Dynamic, hr</td>
<td>NA</td>
<td>NA</td>
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</tr>
</tbody>
</table>
General Note: NA indicates not applicable.

NOTES:

(1) Normal conditions refer to seal conditions in pumps that are required to function during normal facility operation.

(2) Include this information if seal is to be used during hydrostatic tests.

(3) Other refers to conditions that may affect the seal cavity environment, such as external loads and loss of component coolant or injection, and to conditions that are not covered in the other categories.

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