UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

January 30, 1985

Docket Nos. 50-424
and 50-425

Mr. Donald O. Foster
Vice President and General Manager
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Dear Mr. Foster:

Subject: Transmittal of Draft Standards ANSI/ASME QNPE-1 through QNPE-4

The Vogtle DSER transmitted to you by letter dated November 6, 1984 requested you to comment on your usage of draft standards ANSI/ASME QNPE-1 through QNPE-4. Because you have been unable to locate copies of these standards, we are transmitting them to you as enclosures to this letter.

If there are any questions, contact the project manager, Melanie Miller, at (301) 492-4259.

Sincerely,

Elinor G. Adensam

Elinor G. Adensam, Chief
Licensing Branch No. 4
Division of Licensing

Enclosures:
As stated

cc: See next page

DESIGNATED ORIGINAL
Certified By Angela Hatton

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Draft

QP-1

STANDARD FOR QUALIFICATION OF PUMP ASSEMBLIES FOR SAFETY SYSTEMS SERVICE IN NUCLEAR POWER PLANTS GENERAL REQUIREMENTS

Draft ~~4~~ 5 ~~Oct.~~ Nov. 1984

CAUTION

This Standard is being prepared or revised and has not been approved by ANSI/ASME. It is subject to revision or withdrawal before issue.

TABLE OF CONTENTS

1.0 SCOPE

This Standard addresses the general qualification requirements for pump assemblies consisting of the pump, its appurtenances, the pump sealing system, and the pump driver. The designation of pump assemblies as safety related is the responsibility of the owner. that are covered by this Standard

2.0 PURPOSE

The purpose of this standard is to define the general requirements for qualification of pump assemblies intended to be installed in various safety systems of a nuclear power plant.

3.0 DEFINITIONS

These definitions establish the meanings of words in the context of their use in the pump qualification (QP) series of standards.

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

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

Auditable Data - Information which is documented and organized in a readily understandable and traceable manner that permits independent auditing of the inferences or conclusions ~~base~~ based on the information.

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

Code Classes - Levels of structural integrity and quality commensurate with the relative importance of the individual mechanical components of the nuclear power generating station.

NOTE: For the recognized code classes, refer to the following documents:

1. Nuclear Safety Criteria for the Design of Stationary Pressurized Water Reactor Plants, ~~ANSI N51.1~~ → ANSI/ANS 51.1

2 1977 ASME Boiler and Pressure Vessel Code, Section III

3 Nuclear Safety Criteria for the Design of Stationary BWR Plants - ANSI/ANS N52.1

Components - Items from which equipment is assembled (for example: attachments, bearings, bolts, capacitors, connectors, governors, inspection access ports, instrument sensors, locking devices, position indicators, resistors, seals, sight glasses, springs, switches, transistors, tubes, wires, etc.)

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

Demonstration. The provision of evidence to support the conclusion derived from assumed premises.

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

Documentation - A systematic assembly of evidence including quality assurance procedures, as applicable.

Equipment. An assembly of components designed and manufactured to perform specific functions.

Generic Environment - A set of environmental conditions intended to envelop~~e~~ the range of expected environments.

Generic Equipment - A family of pump assemblies having similar design characteristics in respect to manufacturing processes, limiting stresses, and operating principle which may be represented for qualification purposes by a selected individual unit.

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

Interface - A junction between components of a pump assembly is an internal interface. Similarly a junction at the pump assembly boundary with outside elements of the system or the building structure is an external interface.

Margin. The difference between service conditions and the conditions used during equipment qualification.

Operating Experience - An accumulation of verifiable service data for conditions considered to be equivalent to or exceeding those defined for the equipment to be qualified.

Pump. The basic component of the pump assembly that affects the transfer of fluids.

Pump Assembly. The grouping of items needed to insure the operation of the pump that includes, but is not limited to the pump, its appurtenances, seals, bearings, cooling system, filters and strainers.

Qualification. The generation, documentation, and maintenance of evidence adequate to demonstrate that the pump assembly can perform within the equipment specification requirements during all specified service conditions.

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

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

4.0 GENERAL QUALIFICATION REQUIREMENTS

A pump assembly installed in a nuclear plant power system required to perform a safety function may be subject to postulated operating conditions defined by the station safety analysis as design basis events (DBE). During the occurence of, or immediately following a DBE, the pump assembly may be required to function while subject to harsh environmental conditions and while subject to external loads imposed by interfaces with the system or the building structure. This standard addresses the criteria needed to provide assurance of qualification under these conditions.

The qualification requirements shall be defined in the pump assembly specification. (Refer to Section 5.0). The qualification program to satisfy these requirements is outlined in section 6.0. The final requirement is the orderly documentation of specified requirements, the scope and the results of the qualification program, and the definition of quality assurance procedures to verify the qualification package.

5.0 PUMP ASSEMBLY SPECIFICATION

5.1 GENERAL

To be qualified by the QP series of standards a pump assembly requires specifications which exceed those normally considered for a nonsafety related pump assembly installed in a nuclear power plant. nonsafety system in a The requirements related to the safety systems' function(s) specified, the service conditions postulated during the time frame of the safety function, and the interface conditions, both internal and external, which must be accounted for in the qualification process. The complete specification shall define these requirements in addition to the conventional specification data. Appendix A provides a check list of items for guidance in specification preparation.

For a pump assembly designated for a specific application which is to be qualified to this standard, it is the responsibility of the owner or his designee to prepare the qualification specification and approve the qualification program which demonstrates that the acceptance criteria have been satisfied.

qualified to a generic environment

For a generic pump assembly qualification, the manufacturer develops both the specification and the qualification program for the product. The qualification conditions should be selected to include service conditions postulated for the potential applications for the generic type pump assembly.

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5.2 SPECIFICATION REQUIREMENTS

As a minimum, the following shall be included:

5.2.1 Acceptance Criteria for Pump Assembly Qualification.

The acceptance criteria shall include the parameters for acceptable performance of the pump assembly during specified service conditions. Examples of operational parameters include, but are not limited to: flow, discharge pressure, net positive suction head required (NPSHR), required operation or startup time, recirculation rate, or flow regulation capability, as applicable. In addition, environmental parameters pertaining to functional operation during normal, abnormal, design basis event and post design basis event service conditions shall be defined for each operating event where the function of the pump assembly is vital for safety system operation. The criteria must also define external loads acting on the equipment via interfaces with the system external to the equipment boundary. Some examples are postulated seismic loads, external loads imposed through piping connections, and vibration transmitted by the interface.

startup and operating

For clarity, the acceptance criteria for each service condition essential to qualification should be grouped and related to each particular operational serice requirement. In addition, consideration should be given to mechanisms such as wear, aging, errosion and corrosion that affect the pump assembly or its components. shall

5.2.2 Definition of the pump assembly equipment boundary.

The pump assembly, in general, includes the pump, its appurtenances, its sealing system the pump driver, a coupling if applicable, and mounting provisions. Auxiliary equipment such as cooling water systems, lubrication systems, control valves, and instrumentation may be included in the assembly or may be external equipment. The equipment boundary shall indicate which components are part of the pump assembly and where interfaces exist with the external system. The limits of the pump pressure boundary are defined in ASME Boiler and Pressure Vessel Code , Section III, NC-1130 and ND-1130. The boundary of the pump assembly will encompass additional components, appurtenances and other items.

5.2.3 Description of Interface Attachments, Loads, Power Sources and Control Signals.

Location of loads and structural characteristics for interface attachments shall be specified by the ASME Boiler and Pressure Vessel Code, Section III, Subsection NCA, when they provide constraint to the code component. Other interface attachments, including the driver motor electrical raceway interface, shall be specified. The specified limits of the supplied power shall be sufficient to operate the pump assembly at its required performance.

5.2.4 Design Codes and Standards.

For the pump assembly, the following Codes and Standards apply:

a. ASME Boiler and Pressure Vessel Code, Section III and Section XI.
b. ASME/ANSI QP (applicable sections of the QP standards)
c. IEEE Standards, IEEE 334-1974, IEEE 323-1974, IEEE 344-1975, IEEE 627-1980 (as applicable)
d. ANSI/ASME NQA-1-1983 Quality Assurance Program Requirements for Nuclear ~~Power Plants~~ Facilities (as applicable)
e. Hydraulic Institute Standards.

The applicable sections of the above Codes and Standards pertinent to qualification of the pump assembly shall be specified.

5.2.5 Specification of Conditions,

Specification of service conditions including conditions resulting from design basis events (e.g., seismic, loss of coolant accident, high energy line break accident, reactivity insertion, loss of reactor coolant pumps, etc.) for the pump assembly and the nature of the safety function(s) to be performed is required. The time the pump assembly must remain operable subsequent to each postulated event shall also be specified. The service conditions for these events shall be expressed as an estimated time history for each parameter that may effect the pump assembly function during the event.

Some parameters to be considered are:
(a) Pressure.
(b) Temperature.
(c) Relative humidity.
(d) Radiation - hourly rate and/or integrated dose. (Specify gamma, beta, and/or neutron, as applicable.)
(e) Chemical effects (air, water quality etc.)
(f) Seismic and dynamic excitation.

Some operational parameters to be considered are:
(a) Duty cycle during the postulated event.
(b) Power supply (deviation from normal conditions.)
(c) Vibration.

5.2.6 Margin.

Margin shall be considered in the qualification program to account for reasonable uncertainties in demonstrating satisfactory performance, errors in experimental measurements and to address normal variations in commercial production, thereby providing greater assurance that the equipment can perform under the most severe conditions for which it is qualified.

Because of the variety of equipment that must be qualified and the different demands made on equipment, it is not practical to specify generally applicable margins. Specific equipment qualification standards should provide specific guidelines on margins. In identifying margin, it is permissible to take into consideration known margins already applied. shall

5.2.7 Special Materials.

Materials having superior wear characteristics or corrosion resistance may be specified for certain component parts of the pump assembly. Conversely, other materials may be excluded. Non-metallic materials such as gaskets, seals, or lubricants that may be susceptible to aging in a radiation, temperature or chemical environment may be pre-qualified individually and a conservative qualified life assigned to provide assurance of functional capability. These materials should be specified, as required, for the intended service conditions.

5.2.8 Maintenance Requirements.

A procedure for programmed replacement of subcomponents of the pump assembly shall be provided when environmental or service conditions or both predicted for the specific application indicate that the aging of parts may impair the functional capability of the pump. The specification shall state who will specify the replacement procedure. Also, a listing of allowable tolerances or clearances or both for interfacing parts shall be provided by the manufacturer when maintenance of these limits is necessary to assure operability of the pump assembly.

5.2.9 Quality Assurance Requirements.

Quality assurance requirements for components not constructed to the rules of Section III as defined in the ANSI/ASME NQA-1 shall be specified whole or in part, as required.

5.2.10 Documentation Requirements.

Reports and supporting data that are necessary to substantiate the qualification of the pump assembly shall be listed. The qualification report shall be certified to verify that all acceptance criteria have been met.

6.0 ~~Certification~~ Qualification Program

A program to verify the pump assembly capability to meet the specified qualification requirements shall be developed. The scope of the program will depend on the complexity of the requirements specified for the pump assembly application and on the generic pump assembly qualification data established by the pump assembly manufacturer. If the available generic data envelop the specified requirements and meet the acceptance criteria, the qualification program may be oriented to an analysis demonstrating similarity of the pump assembly being qualified to ~~a prototype of the generic~~ pump assembly previously qualified. If one or more of the acceptance criteria have not been verified by generic qualification, an extension of the generic program via analysis or supplementary testing or both will be required as a part of the qualification program.

The development of the qualification program shall be based on the appropriate QP standards relative to the components which include the type of pump, the pump sealing system, type coupling, and the specified pump driver. Each of these standards provides further detail on the requirements for qualification.

The qualification program for the pump assembly shall be documented and arranged in an orderly manner to demonstrate that each of the acceptance criteria have been verified.

6.1 Qualification Alternatives

Due to the traditional design of pump assemblies, the majority of safty related pumps are qualified in configurations such that the qualification of assembly interfaces and components is encompassed in the pump qualification program. Normally, it is necessary to include the shaft seal assembly and a driver and interface structure in the qualification activities of the pump. Major components of a pump assembly may be qualified separately and the following alternative approaches to pump assembly qualification are acceptable.

that are covered by the QP series of standards.

6.1.1 (a) Qualification of a shaft seal assembly in accordance with QP-3 and
(b) Qualification of a driver in accordance with QP-4 or 5 and
(c) Qualification of pump assembled with the qualified shaft seal and the qualified driver in accordance with QP-2 or

6.1.2 (a) Qualification of a shaft seal assembly in accordance with QP-3 and
(b) Qualification of a driver in accordance with QP-4 or 5 and
(c) Qualification of pump assembled with the qualified shaft seal and an alternative driver in accordance with QP-2 or

6.1.3 (a) Qualification of a driver in accordance with QP-4 or 5 and
(b) Qualification of pump and shaft seal assembled with qualified driver in accordance with QP-2 and 3 or

6.1.4 (a) Qualification of a driver in accordance with QP-4 or 5 and
b. Qualification of pump and shaft seal assembled with alternative driver per QP-2 and 3 .

6.2 Qualification By Analysis

6.2.1 Component Parts and Interface Items

After completing one of the above programs an analytical evaluation of the pump assembly shall be performed to justify that:

(a) all component parts have been qualified.

(b) all interface items have been considered.

6.2.2 Items That Have Not Been Qualified to QP-1

Components or interfaces ~~that have~~ not ~~been~~ incorporated ~~considered~~ in the qualification test program shall be subject to qualification in accordance with QP-2 . This requires that, as a minimum, analysis be performed to justify the capability of the interface or component to perform its function.

6.2.3 Generic Pump Assemblies

If a generic pump assembly has been previously qualified by the QP series of standards, the qualification program will be designated to provide analysis, supplementary tests, or evidence of operating experience to establish the similarity of the specific pump assembly being qualified to that previously qualified. If no previous qualification data is available to verify capability, the qualification program must be formulated to comply with the QP series of standards.

7.0 DOCUMENTATION

7.1 General

The qualification documentation shall verify that the safety system equipment is qualified for its application and meets its specification criteria. The basis for claiming qualification shall be explained in a clear logical fashion. Evidence shall be presented to show that:

(a) the fundamental qualification requirement is satisfied, and

(b) the qualified life is justified.

Data used to demonstrate the qualification of the equipment shall be pertinent to the application and organized in an auditable form. In addition, any aging processes not treated during the design qualification, but reserved for in-service surveillance monitoring shall be specifically identified.

7.2 Documentation Files

The end user shall maintain a qualification file(s), not necessarily at the nuclear power generating station site. The file~~(s)~~ shall contain the equipment specification ~~criteria~~ and ~~shall include~~:

(a) evidence of compliance with specified design codes and standards and

(b) evidence of compliance with functional qualification standards and

(c) description and records of periodic inspection, maintenance and component replacement requirements during the life time duty cycle and

(d) determination of qualification and

(e) summary and conclusions and

(f) approval signature and date.

APPENDIX A - SPECIFICATION ITEM CHECKLIST

This non-mandatory appendix is provided to aid the specification writer. It lists items which may require consideration when developing specification for a specific pump assembly application. The selection of items to be specified is the option of the owner in order to satisfy his special requirements, and those of Section 5 of this standards, as applicable.

I. ITEMS TO BE SPECIFIED FOR PUMP DESIGN AND QUALIFICATION

A. Specification Content

1. Construction Code Class, applicable edition date.
2. Definition of in-service inspection requirements including references to specific ISI Codes, as applicable.
3. Functional, operating, environmental and design conditions under which the pump must operate. See data sheet items.
4. Operational modes including time limit for recirculating flow testing.
5. Pump type.
6. Mimimum operating flow limitations.
7. Design life.
8. Requirements for dynamic analysis or testing .
9. Designation of loads, load combinations and related ASME Code service conditions.
10. Demonstration of operability by analysis or test under all applicable loading conditions.

11. Seismic loading OBE and SEE — SSE
12. Stress limits.
13. Seismic design criteria.
14. Quantified acceptable limits for wear of bearings to establish minimum service life.
15. Use of mechanical seals and type of seal cooler, as applicable.
16. Flow restrictor from seal cavity, if applicable.
17. Vent and drain from pump casing and types of connections.
18. Operational limits for pump recirculation or operation without cooling water.
19. Type of pump nozzle connections and details.
20. Connection requirements to other ancillary piping.
21. Support and anchorage requirements, and configuration.
22. Cooling water piping code requirements.
23. Separation of running frequency from shaft natural frequency.
24. Minimum acceptable force and moment carrying capability of the pump nozzles, the pump casing, and the pump support attachments.
25. Requrement for manufacturer's provision of values of maximum allowable forces and moments.
26. Water chemical content. (Pump and/or seal cooling water).
27. Materials of construction when restrictions exist, such as delta ferrite content.
28. Material testing details required to be specified by the Code.
29. Quality assurance requirements for code and non-code parts.

30. Shop performance test and measurements to be taken including: capacity, total head, power input, efficiency, NPSH, and vibration at the bearing or on the shaft.
31. Prequalification transient test requirements and acceptance criteria.
32. Inspection requirements and acceptance criteria.
33. Cleaning requirements.
34. Painting requirements.
35. Preparation for shipping.
36. Identification.
37. Documentation and identification of documents.
38. Document approval responsibility.

B. <u>Data Sheet Items</u>

1. Fluid pumped, specific gravity at given temperatures.
2. Design pressure.
3. Design temperature.
4. Requirement for manufacturer's provision of values for minimum flow capability.
5. Rated flow, maximum required flow (runout flow).
6. Head at rated flow, maximum required flow, and shutoff conditions.
7. Suction temperature; minimum, normal, maximum.
8. Suction pressure; maximum and normal.
9. NPSH available at rated and maximum required flows.
10. Ambient temperature, humbidity and radiation.
11. Seismic acceleration; both horizontal (two orthogonal directions) and vertical.
12. Maximum horsepower for diesel generator loading.

13. Cooling water; temperature, minimum and maximum; pressure, and maximum pressure drop.
14. Entrained material for which the pump is designed; dirt, debris, insullation, molten fuel, diesel oil, fish, etc. under normal and abnormal service conditions.

II. <u>ITEMS TO BE SPECIFICED FOR PUMP SEALING SYSTEM</u>

A. <u>Specification Contents</u>

1. Pump construction Code Class and date of applicable ASME Code Edition.
2. Type of seal or seal system to be provided.
3. Shaft direction or rotation as viewed from the drive end.
4. Availability of component coolant, including the quantity, temperature, pressure, available pressure drop, and chemistry.
5. Availability of seal injection, including the quantity, temperature, chemistry, and solids particle size.
6. Possible inaccessability of pump during operation that restricts opportunities for visual inspection and preventive maintenance to the seal system.
7. The need for assembly and maintenance features to limit personnel exposure time in radiation fields.

B. Data Sheet Items

The following data is required for the design basis conditions in the operating modes of normal, safety related functions, in service test, hydrostatic tests, and others. (See Table I, of QP-3). system

1. Conditions At Seal Cavity:
   1.1. Fluid pumped, specific gravity at given temperature.
   1.2. Design pressures
   1.3. Design Temperature
   1.4. Thermal transient (°F/Min)
   1.5. Thermal transiet duration (min)
   1.6 Allowable leakage
   1.7. Radiation (rads)
   1.9 Maximum entrained material size under normal and abnormal service conditions.
   1.8. Shaft speed (rpm)

2. Design Life:
   2.1. Static (hrs.)
   2.2. Dynamic (hrs.)

3. Component Coolant Conditions:

   3.1. Pressure (PSIA)
   3.2. Temperature (°F)
   3.3. Flow Rate (GPM)

4. Design Basis Event Condition Information (Design Life):

4.1. Number of cycles
4.2. Duration of cycles (hrs.)

III. ITEMS TO BE SPECIFIED FOR PUMP MOTOR DRIVERS

The following information, as a minimum, shall be included in specifications by the organization responsible for the design of the plant.

MOTOR DRIVERS

A. MOTOR APPLICATION

1. Driven equipment function.
2. Specific location at Plat Site. n
3. Inside or outside to containment. of
4. Duty Cycle - continuous or intermittent. (If intermittent, specify in detail.)
5. Type drive (direct, belt, gear or hydraulic coupling).
6. Applicable motor design standard - NEMA, etc.
7. Functional, operating, environmental and design conditions under which the motor must operate:
   a) Design pressures and temperatures (maximum, normal, minimum).
   b) Operating pressures and temperatures (maximum, normal, minimum).
   c) Operating conditions (BHP, RPM) at corresponding design/operating conditions.
   d) Ambient temperature, pressure, humidity, radiation and any limits on air circulation to motors, if applicable.
   e) Maximum horsepower.
   f) Seismic environment.
   g) Cooling water - minimum, normal, maximum temperature, pressure and chemistry.

8. Required design life of major components (nonconsumables).
9. Seismic qualification requirements (specification must include definition of seismic environment).
10. Environmental qualification requirements.
11. Requirement that the unit demonstrate operability through all modes of operation for duration specified (i.e., shop or field test, analysis, and/or experience).
12. Interface requirements (control system, utilities available, flanged connections, etc.).
13. Shaft vibration limits.
14. Special materials requirements if different from manufacturers standards.
15. Design Qualification requirements (i.e., pressure vessel analysis, low cycle fatigue analysis, etc.).
16. Support or anchorage requirements and configuration.
17. Qualification acceptance criteria.
18. Documentation requirements.
19. Insullation class.

B. MOTER PREFORMANCE SPECIFICATIONS
1. Normal voltage (include tolerance)
2. Minimum starting voltage
3. Phase
4. Frequency (including tolerance)
5. Starting torque
6. Maximum time to accelerate load
7. Temperature rise and method of measurement

IV. ITEMS TO BE SPECIFIED FOR TURBINE DESIGN AND QUALIFICATION

A. SPECIFICATION CONTENT

1. Driven equipment function.
2. Specific location at Plant Site.
3. Location relative to containment.
4. Applicable turbine design standard - NEMA, API, etc.
5. Functional, operating, environmental and design conditions under which the turbine must operate -
   a) Design pressures and temperatures (maximum, normal, minimum) for inlet and exhaust.
   b) Operating pressures and temperatures (maximum, normal, minimum) for inlet and exhaust.
   c) Operating conditions (BHP, RPM) at corresponding design/operating conditions.
   d) Ambient temperature, pressure, humidity and radiation.
   e) Maximum horsepower.
   f) Cooling water - minimum, normal, maximum temperature and pressure.
   g) Process fluid analysis (chlorides, etc.)
6. Operational modes including operating and design process fluid conditions, and duration and frequency of operation.
7. Required design life of major components (nonconsumables).
8. Seismic qualification requirements (specification must include definition of seismic environment).
9. Environmental qualification requirements.
10. Requirement for demonstration that the unit will operate through all modes of operation for duration specified. (i.e., shop or field test, analysis, and/or experience).
11. Interface requirements (control system, utilities available, flanged connections, etc.)

12. Shaft vibration limits.
13. Special materials requirements (if differing from the manufacture's standards).
14. Design qualification requirements (i.e., pressure vessel analysis, low cycle fatigue analysis, etc.)
15. Qualification acceptance criteria.
16. Documentation requirements.

APPENDIX B - MOTOR SPECIFICATION

This appendix is not part of this standard, but is included for information only. The following information, as a minimum, should be reviewed in the preparation of specifications generated by the organization responsible for the plant design.

I. MOTOR APPLICATION AND SAFETY FUNCTION

1. Driven equipment function.
2. Specific location ~~location~~ in the plant.
3. Mounting (vertical or horizontal).
4. Environmental conditions for each service condition; normal, abnormal, design basis event and post design basis event, as applicable.
5. Control system auxiliary equipment.

II. INTERFACES (motor supplier, user or others)

1. Shaft (material, extension, and other special features).
2. Couplings (one-half coupling mounted by motor supplier, self-release coupling, solid, nonreverse type).
3. Motor lead termination (lugs, insullation, and qualification).
4. Seismic qualification of motor and driven equipment.
5. Water for bearings and air to water heat exchanger, if required.
6. Motor/driven equipment mounting.

III PERFORMANCE AND MOTOR DESIGN REQUIREMENTS PROVIDED BY SPECIFICATION TO MOTOR MANUFACTURER

1. Horsepower at each operating condition.
2. Synchronus speed (number of windings if multispeed).
3. Normal voltage including tolerance.
4. Minimum voltage for starting and running.
5. Phase and direction of rotation.
6. Frequency including tolerance.
7. Load inertia (WK^2).
8. Driven equipment speed-torque curve (minimum and normal voltage).
9. Minimum time permitted to accelerate load.
10. Temperature rise and method of measurement.
11. Service fator. c
12. Insullation life and other insullation requirements such as temperature class.
13. Thrust requirements (static and running, upward and downward, side thrust, etc.).
14. Locked rotor current limit (amps or percent of rated current).
15. Type of motor.
16. Type of enclosure (see NEMA MG-1-1.26)
17. Description and size of terminal and auxiliary enclosures.
18. Paint finish requirements including internal finish if motor is to be exposed to high pressure steam or similar event.
19. Bearings
    a. Type.
    b. Detectors.
    c. Vent and drain plug.
    d. Lubricant requirements.
20. Maximum reverse speed or fan reverse speed torque curve.

21. Complete test (see IEEE 112)
    a. Temperature rise.
    b. Speed torque curve
    c. Flow pressure drop curve (if pipe ventilated).
22. Surge protection required.
23. Current transformers.
24. Space heaters.
25. Winding temperature detectors.
26. Type of ventilation (air, air to water, heat exchangers).
27. Duty cycle.

ENVIRONMENTAL CONDITION

1. Normal.
    a. In or out of containment.
    b. Temperature range. — time profile
    c. Pressure range.
    d. Relative humidity range
    e. Radiation.
    f. Chemical spray.
    g. Steam.
    h. Operating Basis Earthquake (OBE).
    i. Vibration.
2. Abnormal conditions if other than those listed.
3. Design Basis Event (DBE) including rate of change and duration where appropriate.
    a. Temperature range.
    b. Pressure range.
    c. Relative humidity range.
    d. Radiation range.
    e. Chemical spray.
    f. Safe Shutdown Earthquake (SSE).
    g. Vibration.
4. Post Design Basis Event including rate of change and duration where appropriate.
    a. Time.
    b. Temperature range.
    c. Pressure range.
    d. Relative humidity range.
    e. Radiation.
    f. Chemical spray.
    g. Vibration.
5. Containment test conditions.

V MOTOR DESIGN DATA

Data furnished or confirmed by motor designer if required by user.

1. Frame number.
2. Horsepower(s) under all specified service conditions and speed or windings.
3. Speed torque curve(s).
4. Amperes.
    a. Full, three quarters, and one half load current(s).
    b. Locked rotor current(s).
5. Service factor(s).
6. Torques, speed torque curves at minimum and normal voltages, or at least:
    a. Minimum starting torque(s).
    b. Pull up torque(s).
7. Efficiencies at full, three quarters, and one half loads.
8. Power factor(s).
    a. At full, three quarters, and one half load.
    b. At minimum and normal voltage.
    c. At locked rotor.
9. Space heater wattage, number and description.
10. Bearing system description in detail.
    a. Locked bearing or maximum end play if not locked.
    b. shielding or labyrinth.
    c. Type, manufacturer, life under specified loads, speeds, and environmental conditions.
    d. Insulated bearing.
    e. Normal bearing operating temperature or rise.
11. Insulation system description.
    a. Rise(s) by resistance and installed detectors.
    b. Sealed winding.
    c. Estimated life at design temperature.

12. Permissable successive starts.
   a. At ambient and maximum temperature.
   b. Time to recover from maximum starts, standing and running.
   c. Plugging limitations.
   d. Time motor can withstand locked rotor.
   e. Safe time vs. current characteristic for locked rotor, acceleration and running without loss of life.

13. Shaft mounted fan CFM vs. pressure drop curve if required.

14. WK^2 of motor.

VI NAME PLATE MARKING PER NEMA MG1-10.39

VII OUTLINE DRAWING

VIII LIST OF SOURCE AND DESCRIPTION OF PURCHASED ITEMS

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CAUTION NOTICE - This standard is being prepared and reviewed and has not been approved by ANSI. It is subject to revision or withdrawal before issue.

American National Standard
for
Nuclear Power Plant Equipment

Standard for Qualification of ASME Code Class 2 & 3 Pumps
for Safety System Service

ANSI/ASME
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FOREWORD

(This Foreword is not a part of the prepared Standard for functional Qualification of ASME Code Class 2 & 3 Pumps for Safety System Pump Assemblies for Nuclear Power Plant Applications ANSI/ASME N551.2)

This Standard is one of a series of standards written to define the design, installation and functional qualification requirements of ASME Class 2 and 3 pump assemblies installed as components of safety systems in nuclear power plants. Qualification of pump assemblies for this service requires demonstration of the adequacy of the equipment to perform its safety function in the expected range of normal, design basis event, and post design basis event service conditions. The designation of pump assemblies as "safety-related" is outside the scope of this Standard; this is to be resolved by the station owner as part of the station licensing procedure. Also, the ASME Boiler and Pressure Vessel Code establishes the rules for the pressure boundary integrity of the pump, and this standard addresses the requirements for qualification of the pump assembly for functional adequacy. It is the intent of this Standard that the requirements shown shall be mandatory, unless otherwise specified in the text.

The initial development of this Standard was assigned to the ANSI N-45 Committee with the project designation of N-551. Subsequentially, the ANSI N-45 Committee was dissolved and IEEE has assumed the primary responsibility for nuclear equipment qualification standards. Development of the standard is being continued by the N-551 Steering Committee with ASME sponsorship. The present intent is to develop a series of N-551 standards as follows:

N-551.1 Standard for Qualification of ASME Code Class 2 & 3 Pump Assemblies for Safety Systems Service - General Requirements

N-551.2 Standard for Qualification of ASME Code Class 2 & 3 Pumps for Safety System Service

N-551.3 Standard for Qualification of Shaft Seal Assemblies for ASME Code Class 2 & 3 Pumps for Safety System Service

N-551.4 Standard for Qualification of Motor Drivers for ASME Code Class 2 & 3 Pumps for Safety Systems Service

N-551.5 Standard for Qualification of Turbine Drivers for ASME Code Class 2 & 3 Pumps for Safety System Service

These standards are to be balloted independently and submitted for ANSI approval via the ANSI N-41 Committee with IEEE as the Secretariat.

STANDARD FOR QUALIFICATION OF ASME CODE CLASS 2 & 3 PUMPS FOR SAFETY SYSTEM SERVICE

1.0 PURPOSE AND SCOPE

1.1 Introduction

Safety-related nuclear pumps may be required to operate under normal plant design conditions, and may be required to operate during or after abnormal conditions arising from a postulated accident or event. For pumps designated for this service, complete specifications, special design considerations, and procedures for functional qualification of the pump are required by this Standard to provide assurance that the pump will function when required. Design requirements pertinent to the integrity of the pressure retaining boundary and its supports are delineated by the ASME Code Section III. This Standard supplements these requirements to provide assurance of operability for the service requirements.

1.2 Scope

1.2.1 This standard establishes the requirements for design and material considerations, and the procedures for functional qualification of nuclear power plant pumps for safety-related applications. The standard covers all phases of the pump development from initial design through production testing. It is the responsibility of the owner or his authorized agent to designate those pumps which are safety-related active pumps that require qualification under this Standard.

1.2.2 Functional qualification consists of tests and/or analyses specified herein to demonstrate that a pump will perform its required safety related function. Requirements allow qualification of a production pump by analyses which demonstrate design similarity to a pump qualified by testing.

1.2.3 Qualification to this Standard is limited to requirements for the safety-related pumps and their directly associated appurtenances. Requirements for drivers and seals are provided in ANSI Standards N551.3, N551.4, N551.5. General requirements for pump assemblies are provided in N551.1.

1.2.4 A Functional Qualification Report is required to document compliance with this Standard. The qualification of a pump for a specific order for a nuclear power plant is documented by an Application Report.

2.0 REFERENCES

The following references supplement those in ANSI N551.1 and form a part of this Standard.

2.1 American National Standards Institute

2.1.1 N45.2.1 Cleaning of Fluid Systems and Associated Components during Construction Phase of Nuclear Power Plants

2.1.2 N45.2.2 Packaging, Shipping, Receiving, Storage and Handling of Items for Nuclear Power Plants

2.1.3 B 2.1 Pipe Threads

2.1.4 B 16.5 Steel Pipe Flanges, and Flanged Fittings.

2.2 Nuclear Regulatory Commission

2.2.1 Regulatory Guides

2.2.1.1 RG 1.92 Combining Modal Responses and Spatial Components in Seismic Response Analysis

2.3 ASME Papers

2.3.1 ASME 1972 — Flexible Rotor-Bearing System Dynamics-1, Critical Speeds and Responses of Flexible Rotor Systems

2.4 ASME Boiler and Pressure Vessel Code

D2 2.4.1 ASME Section III, Division 1, Subsection NCA, NC& ND

2.5 Other Standards

2.5.1 Hydraulic Institute Standards for Centrifugal, Rotary & Reciprocating Pumps.

2.5.2 Annular Bearing Engineers Committee.

3.0 DEFINITIONS

The following definitions supplement those in ANSI N551.1:

A Prototype pump is a first of a kind, first of a type or series of pumps to be qualified to this standard.

Production pumps are those which are equivalent to pumps previously qualified.

Axis Orientation is illustrated in Appendix C.

4.0 FUNCTIONAL SPECIFICATION

The functional requirements for a safety-related pump shall be provided in a specification. This specification shall be prepared by either the manufacturer, the owner or his authorized agent in accordance with ANSI Standard N551.1.

The qualification criteria shall be identified for each specified service condition. The specification shall define the equipment boundary, interfaces and external loads transmitted via the interfaces, and environmental conditions that effect functional operation. In addition, requirements for margin in design parameters, special materials, maintenance and quality assurance shall be specified, as applicable.

5.0 MATERIAL REQUIREMENTS

5.1 Material Designation

5.1.1 For items not covered by ASME Code Section III or Code Case N-119, materials shall conform to ASTM Standards. Other material standards such as AISI, SAE, or military or federal specifications may be used if suitable ASTM standards are not available.

5.1.2 If none of the above material standards apply, the material manufacturer's designation may be used accompanied by sufficient data to demonstrate adequacy for the intended service. The material manufacturer shall certify that successive shipments have the same properties as those in the manufacturer's specification and agreed upon with the pump manufacturer.

5.2 Material Selection and Evaluation

The material selection shall be evaluated as a part of the verification required by Section 7.0.

The following specific concerns shall be included in the material evaluation:

a. Corrosion resistance with respect to specific flow conditions and pumped liquid in applicable areas of the pump. All types of corrosion attack shall be considered, such as crevice effects, fouling, galvanic effects, stress corrosion, etc.

b. Thermal expansion compared to adjacent parts both for stress and operability.

c. Stress level, deflection and fatigue life.

d. Resistance to galling and tearing in relation to adjacent materials where relative motion is present.

e. Stability when subjected to all design conditions, including radiation, thermal cycles, mechanical and pressure load cycles, and environmental conditions.

f. Suitability for use with the manufacturing processes intended.

g. Suitability for weld repair during manufacture while retaining the required corrosion resistant properties.

h. Stability during manufacturing for parts required to maintain close tolerances on straightness and concentricity for operability.

5.3 Material Examination and Repair

5.3.1 All wrought materials and finish machined castings shall be examined visually for defects. The acceptance criteria for this examination is as follows:

Linear defects shall not be acceptable if the length exceeds the values defined in NC/ND 2500 of the ASME B&PV Code Section III, Division 1.

5.3.2 For materials not covered by the ASME B&PV Code Section III, Division 1, or Code Case N-119 nonlinear defects shall be acceptable provided the following requirements are met:

a. The limit of the defect can be seen or found by excavation.

b. Interchangeability with other parts is not affected.

c. The basic integrity of the part is not affected.

d. The section has the minimum required thickness after excavation.

e. The defect does not adversely affect a running clearance or a close fit with a mating part.

5.3.3 When required, materials shall be repaired in accordance with the procedures in the material specification, ASME Code Section III, or Code Case N-119 as applicable.

5.4 Documentation

The manufacturer shall establish procedures to provide documentary evidence of the material properties in accordance with Section 11.0, Quality Assurance and Reporting.

6.0 DESIGN AND FABRICATION REQUIREMENTS

The operability of a pump is influenced by a number of design features that must be considered or included in order to obtain the desired quality and dependability. The design and fabrication requirements are presented below. Nonmandatory guidance is presented in Appendix A.

6.1 Responsibility

The pump manufacturer shall assure that:

a. all requirements of this Standard and the design specification are followed in the design of this equipment.

b. the pump deformation limits are not exceeded under all applicable loading combinations.

c. the allowable stress values and material properties for the non-code materials to be used in the design analysis are provided.

6.2 Pump Structural Parts

6.2.1 Casing

a. The pump case shall be designed to withstand the combined forces and moments imposed by the system piping, as well as all other loads specified by the owner, without distortion that could cause malfunction of the pump.

b. Unless essential for pump operation or maintenance, no tapped (threaded) openings shall be located in the suction or discharge nozzles or other areas directly exposed to high fluid velocity. Pressure-gage connections, if required, shall be described in the Design Specification.

c. Pumps shall be provided with drain and vent connections unless the pump is self-venting by the arrangement of the nozzles.

6.2.2 Nozzles

Suction and discharge nozzles of all pumps covered by this Standard may be designed with either flanged or welded ends. Threaded nozzle ends are prohibited.

6.2.3 Flanges

Pipe flanges shall conform to ANSI Standard B16.5.

6.2.4 Fasteners

a. Threaded fasteners shall conform to Unified Screw Thread Standards, ANSI Standard B1.1.

b. Threaded fasteners wetted by process fluid shall be locked in such a manner that if the fastener is sheared or broken, all parts will be retained in place.

6.3 Rotating Parts

6.3.1 Bearings

a. Radial bearings may be any standard design including antifriction, sleeve, hydrodynamic or hydrostatic.

b. Antifriction bearings shall be selected to give three years (25,000 hours) minimum L-10 rating life (ABEC-1) with continuous operation at rated pump conditions, but not less than 16,000 hours at maximum axial and radial loads and rated speed.

c. Where water cooling of bearing oil is required, neither gasketed nor threaded connection joints shall be permitted between water passages and lubricating oil.

d. Hydrodynamic radial bearings and/or thrust bearings shall be required under the following conditions:

(1) Where DN factors are 300,000 or greater. [DN is Antifriction Bearing Manufacturer's Association terminology, where D represents journal diameter and N represents shaft revolutions per minute.]

(2) When antifriction bearings are not available to meet the minimum L-10 rating life.

e. Thrust bearings may be any standard type such as antifriction, hydrodynamic, or pivoted shoe, and may be combined with the radial bearings. Thrust bearings shall be designed to carry the full load if the normal direction of rotation is reversed. Thrust loads shall include the axial loads imposed by coupling engagement at rated horsepower. The minimum coefficient of sliding friction used in the coupling design thrust shall be 0.15.

f. Antifriction bearings shall be retained on the shaft and fitted into housings in accordance with the recommended practices of the Annular Bearing Engineers Committee (ABEC-1). However, locking of antifriction thrust bearings to the shaft shall be restricted to the tongue-type lock washer and locknut.

g. The bearing housing for oil lubricated bearings on horizontal shaft pumps shall be arranged so that the bearings can be replaced without disturbing pump drivers or the mounting of the pumps in the piping system.

h. Bearing housings shall be equipped with labyrinth-type end seals or lip-type seals, and/or deflectors where the shaft passes through the housing. The seal deflector design shall effectively retain oil in the housing and prevent entry of foreign material into the housing.

i. Provision shall be made to drain oil completely from each bearing housing when in the normal operating position.

j. Nonpressure oil-lubricated bearings shall be equipped with constant-level oilers. The recommended oil levels shall be accurately located and clearly marked on the outside of the bearing housings by permanent metal tags, marks inscribed in the castings, or other durable means.

k. Design of the lubricating system shall include features to limit bearing inlet or sump oil temperature. The oil temperature shall not exceed the lower of the following for the specified normal conditions:

(1) Antifriction bearings: 160°F, or 60°F above ambient;

(2) Hydrodynamic bearings: 140°F, or 60°F above ambient.

6.3.2 <u>Wearing Rings</u>

6.3.2.1 Wearing ring material combinations shall meet one or more of following criteria:

a. The hardness of both surfaces is 400 Brinell hardness number (BHN) or over;

b. The hardness difference between running surfaces is a minimum of 50 BHN.

c. The materials have nongalling tendency;

d. At least one of the surfaces shall be grooved if materials with a tendency to gall are used.

e. Wearing rings shall be held in place by a positive locking method, such as threaded against rotation, flanged and threaded, or press fit and locked with pins, set screws, or welded at three or more points.

f. Only stationary wear rings shall be used on pumps over 3600 rpm.

<u>6.3.2.2 Running Clearances for Wear Rings</u>. Running clearances between stationary wearing rings and other moving parts are influenced by manufacturing or tolerance build-up, pumping temperatures, suction conditions, character of fluid handled, thermal transients, deformation of the casing and components due to all internal and external loadings, and the expansion and galling characteristics of the ring material. Clearances shall be liberal to obtain dependability of operation and freedom from excessive rubbing or seizure during operating conditions, even at some sacrifice in hydraulic efficiency.

Required clearances are as follows:

a. For bronze, 11 to 13 percent chromium stainless steel (type 410), and materials of similar galling characteristics, the following running clearances shall be used for wear rings.

Diameter of Rotating Member (inches)	Minimum Diametral Clearance (inches)
Less than 3	0.015
3 to 4.999	0.016
5 to 6.999	0.018
7 to 8.999	0.020
9 to 10.999	0.022
11 to 12.999	0.024
13 to 14.999	0.026
15 to [illegible]	0.028

b. For materials which have greater galling tendencies, such as the 300 series stainless steels, 0.005 inch minimum shall be added to the diametral clearances shown above.

c. For materials which have less galling tendencies, such as steel with a minimum hardness of 45 Rockwell "C" (430 Brinell), 0.004 inch may be subtracted from the diametral clearances shown above.

6.3.3 Shaft

a. The shaft shall be sized to transmit the maximum torque at any given location.

b. The shaft shall be designed to limit reduction of fatigue strength due to stress concentration at corners in keyway slots, abrupt changes in shaft diameter or notches.

6.3.4 Shaft Sleeves

Shaft sleeves shall be used at the stuffing box where the shaft is subject to wear.

a. The sleeves shall be locked to the shaft in a positive manner, and shall be designed to be removable and replaceable in the field.

b. The shaft sleeves for packing shall be of a wear, corrosion, and erosion resistant material.

c. The outside surface finish or the wear surface of the shaft packing sleeve shall not exceed 63 R.M.S when packing is used.

6.3.5 Impeller Retention

If a nut is used on the pump shaft to retain [illegible] impeller, this [illegible] be prevented from loosening by a posit[illegible] locking [illegible]ice.

6.4 Piping Joints - Auxiliary Systems

6.4.1 Threads for valves, fittings and auxiliary connections shall be taper pipe threads in conformance with the specifications of ANSI B2.1.

6.4.2 Tapped openings and bosses for pipe threads shall conform to ANSI B16.5.

6.4.3 Only ground-joint type unions may be used.

6.4.4 Unions shall not be used as follows:

a. In any piping that cannot be isolated from the process fluid;

b. Where it is practicable to provide the required disassembly capability by use of flanges.

6.5 Fabrication

6.5.1 Welding - Nonpressure Boundary Parts

Pump internals essential for pump reliability and/or functionability shall meet the following requirements:

a. The welding procedures and the welders shall be qualified in accordance with ASME Code, Section IX.

b. Welds that are visually inspected shall be designed with an allowable joint efficiency of 70 percent of the allowable stress.

c. Non-destructive examination shall be applied as specified.

6.5.2 Balancing

Major rotating parts such as impellers, couplings and balancing drums shall be dynamically balanced if the pump is to be operated at any of the following conditions:

a. At speeds over 1,700 rpm, if rated capacity exceeds 250 gpm and rotating part diameter is more than 6 inches;

b. At speeds over 1,700 rpm for two or more stages;

c. At speeds over 3,500 rpm.

6.5.3 Vibration

The pump shall be designed, fabricated, and tested to prevent excessive vibration. Vibration measurements shall be taken on the bearing housing. Measurements shall be taken at rated speed and within plus or minus ten percent of rated capacity. Measurements shall not exceed the following limits:

Speed (rpm)	Double Amplitude Vibration, Max. (mils)
1200 and below	4.0
1201 to 1800	3.0
1801 to 4500	2.5
4501 to 6000	2.0
Over 6000	1.5

6.6 Driver Sizing

The driver efficiency and horsepower shall be such that nameplate rating (without service factor) is not exceeded anywhere on the pump performance curve from minimum to runout flow.

6.7 Documentation

The manufacturer shall establish procedures to provide the data packag[illegible] in accordance with Section 11.0, Quality Assurance and Reporting.

7.0 VERIFICATION OF [illegible]TOTYPE PUMP DESIGN

Verification of prototype pump shall [illegible] performed by analysis, qualif[illegible]tion/test or operating experience. For verification it is necess[illegible] to d[illegible] prototype pumps and previously qualified pumps to which changes have been made that make functional requalification necessary. The requirements for verification are presented below. For clarity the seismic qualification requirements are explained separately from the functional pump requirements.

7.1 General

The verification process is to assure functional qualification of the pump prototype and is performed by one or more acceptable methods as outlined below. Each verification method used, and the results of the verification, shall be documented in a form that is readily retrievable. The results of the verification shall be auditable against the verification requirements. The term "verification" as used throughout this Standard implies not only that an analysis, qualification test and experience is valid and correct, but also that the analysis, test and field experience is applicable to the prototype pump under consideration.

Where changes are made to a previously qualified pump, verification methods shall be applied to the changes in the same manner as for the original prototype, including evaluation of the effects of the changes on the overall pump.

Verification of the prototype pump may be performed by verification of all its component parts. Justification of this approach shall be provided by evaluating the effects of interaction of the parts. Where this approach is used the evaluation of interaction shall be included in the documentation.

7.1.2 Procedures

The methods of prototype pump verification are:

a. analyses;

b. qualification test;

c. experience;

d. a combination of any of the above.

The method to be used is dependent on many variables such as size, safety-related function, mechanical complexity, configuration and loading requirements. It is expected that most safety-related prototype pumps will require a combination of methods including analyses and tests to satisfy verification of the prototype.

7.1.3 Verification by Analyses

Verification by analyses may be used where accurate analytical techniques are available. Analysis may be used when:

a. The response of the system is linear or is approximately linear;

b. The dynamic forcing function of concern does not increase the response of the rotating portion of the pump or tend to produce instability;

c. The configuration and size of the pump make testing impractical;

d. The effect of attached components is too complex for accurate duplication;

e. The load conditions are too complex to be simulated by testing.

7.1.4 Verification by Test

Verification by test is recommended where it can be accommodated. The most adverse conditions shall be applied, not only to verify the pump but also to show that a satisfactory margin is provided. Previous valid and documented tests may be used as a part of the verification procedure where applicable.

7.1.5 Verification by Experience

Where sufficient experience exists to qualify a pump, the method as given in Section 7.4 may be used.

7.2 Analyses

The pump manufacturer shall determine the deformation limits, which shall not be exceeded to maintain the operability of the pump.

The pump manufacturer shall provide the necessary allowable stress values and material properties for the noncode materials used and analyzed for parts which affect operability.

In addition, the pump manufacturer shall assure the operability of the pump during normal and abnormal conditions by complying with the requirements stated below.

7.2.1 Loadings and Loading Combinations

The design specification shall identify all steady-state and cyclic loadings, mechanical, thermal or hydraulic transients that may occur during the life of the plant and the number of the anticipated transients in each case, the external loads which may act on the pump and the combinations of these loads which may occur simultaneously. The pump manufacturer shall consider in the analysis all specified conditions under which the pump is expected to operate.

7.2.2 Rotor Dynamics and Natural Frecuencies

Satisfactory performance of the assembled pump/driver unit shall be the responsibility of the pump manufacturer. Any additional data required for this purpose shall be furnished by the driver and/or gearbox manufacturer.

Vibration limits of the pump shaft, or bearing housing if the shaft is not accessible, are specified in paragraph 6.5.3. Vibration of [illegible] of the unit shall be limited to prevent internal damage, piping fatigue and failure.

7.2.2.1 Rotating Element Lateral Critical Speeds

a. Pump rotors shall be analyzed for lateral critical speeds. Any well recognized analytical method may be used.

b. For single speed pumps, no lateral natural frequency shall be within 20 percent of the normal operating speed;

c. For pumps which operate at varying speeds, the first critical speed should preferably be above the highest operating speed or turbine trip speed and with the 20 percent margin specified in b. above. If this is not possible with the offered design, then the pump manufacturer and owner or his agent shall agree that operation will be possible with adequate margin (a minimum of plus or minus 10 percent) maintained on either side of the calculated critical speeds. Satisfactory operation shall be proved by test;

d. On single speed, multistage horizontal or vertical pumps with closely fitted internal parts, which may provide significant damping or bearing effects, the use of Matrix Iteration, Prohl-Myklestad Method, Modal Analysis using finite element methods, Direct Integration or other equal analytical techniques are acceptable to calculate critical speeds. Such methods shall be considered when a simplified analysis shows an operating speed to be unacceptably close to a critical speed or operation at a speed above the first critical. Due to the reduced inherent margin of conservatism in these methods, an increased safety margin of ± 25 percent shall be applied. The paper "Flexible Rotor-Bearing System Dynamics-I, Critical Speeds and Response of Flexible Rotor Systems, ASME, 1972," discusses these techniques.

7.2.2.2 Stability of Rotor Bearing System. Lightly loaded high speed fluid film bearings may become unstable and be subject to vibration problems as a result of "half-speed whirl." This phenomenon shall be considered in the design of all fluid film bearings.

7.2.3 Natural Frequencies of Assembled Pumping Unit or Parts

For vertical pumps similar to those shown in Figures 3 and 4, Appendix A, the design shall be such that the primary natural frequency of the pump/driver/support unit above the baseplate of an assembled and mounted pump is at least 15 percent above or below any continuous operating speed. For other configurations, pump parts, assemblies or appurtenances a similar margin shall be maintained. Satisfactory operation shall be proved by test.

7.2.4 Shaft

The analysis of the shaft shall show that the shaft deflection due to any of the postulated loading combinations does not:

a. exceed the design clearances and cause excessive rubbing;

b. exceed the operability deflection limits, and

c. provide undesirable misalignments which may reduce the transmitted power below the minimum required.

d. exceed the stress limit that may produce high or low cycle fatigue failure.

7.2.5 Bearings

Environmental conditions and configuration of the pump affect the bearing performance. These conditions shall be described in detail and used in a bearing stability evaluation. An estimation of the loads acting on the bearing shall be made for steady-state and transient conditions and a detailed evaluation depending on the type of bearing shall be performed. The bearing evaluation shall consider at least the following:

a. Static and Cyclic Loading;

b. Rotor dynamic imbalance at running frequency;

c. Possible magnetic imbalance at twice the running frequency;

d. Shaft deflection;

e. Hydraulic loading in both radial and axial directions;

f. Rotor weight;

g. Bearing fits and clearances;

h. Angular misalignment.

7.2.6 Other Parts

Any other part of the pump whose deformation could affect the reliability of the pump shall be analyzed to demonstrate that the deformation would not prevent the pump from performing its safety function.

7.3 Tests

7.3.1 Special Requirements

Where the installation subjects the pump to unique conditions which cannot be evaluated adequately by either analysis or experience, the purchaser shall require special tests in addition to the required tests of this section and Section 9.4. The requirements for Special Tests shall be defined in the Specification. These tests shall take into account specific instrumentation requirements and mandatory in-service test and inspection requirements of ASME Code Section XI.

Unless otherwise stated in the Design Specification or this Standard, the test liquid shall be clean, cold water (see Reference 2.5.1).

7.3.2 Qualification by Testing

The pump as prepared for qualification testing shall consist of all items either being supplied in accordance with the Design Specification or equivalent items to those being supplied and shall include but are not limited to the pump, seal, auxiliary equipment and instrumentation. Only a single set of tests is required by this standard. When testing has been performed previously on equivalent items no further testing is required.

7.3.3 Required Tests

The following basic tests are required for qualification of the pump and are defined in Section 9.4.4.

a. Hydrostatic Test

b. Hydraulic Performance Test

c. Mechanical Running Test

d. Natural frequency of pump assembly for vertical turbine type pumps.

e. Net Positive Suction Head Required Test

f. Endurance Test

7.3.3.1 Net Positive Suction Head Required Test.

a. The NPSH Test shall be conducted in accordance with Hydraulic Institute Standards.

b. A drop in head of 3 percent (3 percent of first stage head in multistage pumps) at a given flow shall be used to establish NPSH required.

c. A minimum of three NPSH breakdowns shall be performed to establish suction requirements throughout the specified pump operating range.

d. The resulting test curve shall be included with the certified performance curve.

7.3.3.2 <u>Endurance Test</u>

A. An extended operational test shall be run to verify compliance with system operational requirements.

B. The Design Specification shall define the duration of the test, in any event not less than 4 hours.

C. The Design Specification shall define the number frequency of start-stop cycles.

D. The Design Specification shall define acceptance criteria to be demonstrated by disassembly and inspection at the completion of testing.

E. The Design Specification shall list required data to be obtained during the test.

F. The Design Specification shall identify if the pump will not be accessible in a post-accident situation, and those pumps shall have extended testing.

<u>7.3.3.3 Design Transient Test</u>

D2 a. A <u>design</u> transient test <u>(i.e. temperature, pressure, etc.)</u> is required for each prototype where the pump must be capable of withstanding such transients. Where suitable transient conditions cannot be established by testing, qualifications by analysis may be acceptable.

b. The Design Specification shall describe the rate and magnitude of design transient change in the pumped fluid. When the lower temperature of the D2 change cannot be conveniently duplicated by the test fluid, the upper test temperature shall be established by adding the total temperature change to the lower test temperature.

c. The test shall be run in accordance with a written procedure defining minimum temperature change and maximum time within which transient must occur, as well as the beginning and ending conditions of operation. The test shall be considered successful if the pump continues to operate for a minimum of 1 hour at the new temperature or until all temperatures have stabilized, followed by a stop and restart. Acceptance criteria should be established and agreed to in the procedure by the owner and supplier.

d. All pumps so tested shall be completely dismantled and D2 examined. All dimensions critical to operability of the pump assembly shall be checked and the results compared to the design requirements.

e. Dimensional change acceptance criteria shall be identified in the procedure. Parts whose dimensions have changed as a D2 result of the test shall have their design reviewed. An explanation shall be provided as to the cause and a recommendation for the need of a retest on design change shall be made. If design change is to be made retesting shall be required.

7.3.3.4 Flow Distribution Test.

7.3.4 Purchased Item Qualification

The manufacturers of purchased items shall demonstrate the adequacy of the item in either or both of the following ways.

a. By providing the purchaser with documentation showing that the proposed item as designed has been used successfully for a stated length of time in a similar installation. This method shall not be used if the proposed item or the environment in which it is to be used differs significantly from the one to which it is being compared.

b. By supplying the purchaser with evidence that the proposed item has successfully passed through a comprehensive testing program. The testing program shall have included full-scale testing which meets or exceeds the specified design basis conditions. A detailed description of the tests, test equipment, and actual test results shall be submitted.

7.3.5 Failure During Pump Qualification Test

D2 Specific criteria defining failure shall be identified in the test procedure. If any part of the pump fails during a qualification test program, the pump supplier shall prepare a report of the details of the failure and submit it to the purchaser as part of the Data Pacjage. The report shall describe the cause of the failure, circumstances of operation at the time of failure, corrective measures employed, and qualification by redesign and retest.

7.3.6 Qualification Report

Description of the test program, test conditions and test results shall be included in the qualification report required by Section 11.

7.4 Experience

7.4.1 Prototype

A prototype is the first of a type to qualify under this standard. It may be that it has been developed from a model or previous prototype which is similar in many ways, or actually identical to some features of the new machine. Where these are identical the previous field experience may be used as verification of the functional integrity of the prototype.

7.4.2 Prototype Characteristics

A prototype may qualify under this standard by experience related to the following characteristics. The experience must reflect an equal or more conservative set of qualifying values than will be required by the current specification.

a. Case Stiffness.

b. Shaft Stress, Material and Critical Speed.

c. Bearing Material, Mounting and Clearances.

7.4.3 Verification

7.4.3.1 Acceptance Criteria.

a. At least one pump identical to the prototype operating through conditions equivalent to specified criteria, or:

b. At least three identical pumps operating which do not vary by more than one item from Table 9.1.2 or:

c. At least five identical pumps operating which do not vary by more than three items from Table 9.1.2 and:

d. If pumps are vertically suspended, the undamped length below floor is at least as great as qualifying prototype and any differences in support surface rigidity is shown to have no significant effect on vibration characteristics.

7.4.3.2 Geometric similarity (scaling) is a prerequisite for utilization of other sized pumps. In addition to meeting the requirements of 7.4.3.1, the prototype pump being qualified shall not be physically more than 15 percent larger or smaller than the previously qualified pump being used for comparison; the diameters of the pump's volutes or impellers shall be compared. Flow at peak efficiency of the prototype shall be within plus or minus 20 percent of that for the previously qualified pump.

7.4.3.3 If the above experience requirements cannot be met as outlined, a test and/or analysis of the prototype shall be conducted.

7.6 Quality Assurance and Reporting

The quality assurance and reporting requirements applicable to prototype pump verification are given in Section 11.0.

8.0 DYNAMIC QUALIFICATION REQUIREMENTS

8.1 Qualification Approach

Dynamic qualification procedures may utilize testing, analysis or combinations of testing and analysis. The procedure selected shall demonstrate the operability of the pump, when subjected to the specified applicable loads, regardless of its size, configuration and mechanical complexity.

Ideally, the pump should be qualified under conditions identical to those expected during a design basis condition. Deviations from these conditions shall be justified.

8.2 Testing

Tests may be either supporting tests (only a part of the qualification program) or qualification tests. Supporting tests are these tests conducted to determine dynamic properties and characteristics of the pump to provide data needed for the final qualification either by testing or analysis. Qualification tests are performed to serve as evidence that the operability of the pump is maintained under the loading combinations associated with design basis conditions. Different supporting test methods and typical data to be obtained from them are given in Appendix B.

8.2.1 Qualification Tests

The pump shall be tested while operating. The following requirements are conditions for a properly conducted qualification test and shall be fulfilled:

a. Seismic Input

(1) Magnitude of Excitation

The magnitude of the floor motion in three orthogonal axes shall be provided in the specification. The method of simulating this motion shall be documented in a test procedure.

(2) Single and Multiaxis Excitation

Input motion shall be applied in a manner that simulates the response of the pump to the triaxial motion of the magnitude mentioned in 8.2.1.a.(1). The time phasing of the inputs shall be such that a purely rectilinear resultant input is avoided. Conditions for accepting single and biaxial or any other seismic input are stated in Appendix B.

(3) Single and Multiple Frequency

Random vibration input having a broad frequency content shall be used as seismic input. This input shall excite all modes to the required magnitude, such that the test response spectrum shall envelop the corresponding design response spectrum in the region of all pump natural frequencies. Single frequency input may be accepted if the dynamic characteristics of the pump show that its anticipated response is adequately represented by one mode, or, the floor response at the pump location is reasonably filtered to a single frequency type motion.

b. Mounting

The pump shall be mounted to simulate the recommended service mounting when practical. Where this is not practical, the effect of the actual supporting structure shall be considered in determining the input motion. As a minimum, the mounting fixture design shall have the same stiffness characteristics as the actual mounting and shall cause no extraneous dynamic coupling to the test item.

c. Nozzle Loads

The nozzle loads, as provided in the design specifications simulating the pipe effects on the pump for the corresponding loading combination, shall be applied during the test. Appendix B provides guidelines for nozzle load considerations. If supporting tests show that nozzle loads are not significant for pump operability, they may be disregarded during the qualification test.

The most severe loading combination that is feasible shall be used for the qualification test.

8.3 Analysis

For dynamic qualification by analysis the following shall be determined:

a. Applicable loads to be used in the analysis.

b. Dynamic characteristics (frequency, mode shape and damping) of the pump (and accordingly the methods of analysis). The damping values should be consistent with those in Regulatory Guide 1.61.

c. The allowable stresses and deflections (design limits) when subjected to all applicable loads.

8.3.1 Applicable Loads

The applicable loads include but are not limited to:

a. Seismic input excitation as specified in the design specification

b. Nozzle loads

c. Dead weight

d. Pressure and thermal loads as provided in the design specification

e. Vibratory loads due to pump operation

The most severe loading combination that is feasible shall be used in the analysis for qualification purposes. The resultant stresses and deflections at critical locations shall be lower than the stress and deformation allowables.

8.3.2 Methods of Analysis

The analysis may be either static, detailed dynamic, or simplified dynamic analysis. Appendix B provides the basis for the analysis method selection.

8.3.3 Stresses and Deflections Criteria

The pump shall be analyzed for three directional seismic forces. The stress components resulting from each force shall be combined by the square root of the sum of the squares method to obtain a single stress for the seismic loading. Seismic deflections (deflections due to seismic loads) shall be calculated in the same way. Other methods of combining the stresses and deflections resulting from the three components of earthquake may be used if it can be shown that the square root of the sum of squares method does not apply to a particular case. These seismic stresses and deflections shall be combined with the resulting stresses and deflections due to all other applicable loads and used to obtain the final resultant stresses and deflections. These values will be compared with the design limits established by the design specification and the pump manufacturer. The locations where the stresses and deflections shall be calculated include, but are not limited to, the following:

a. Pressure retaining/containing parts

b. Coupling

c. Pump hold down fasteners and bolts

d. Shaft and rotor assembly

e. Keys, pins, fasteners, welds and bearings

f. Pump support pads

g. Pump foundation anchor bolts.

8.4 Combination of Test and Analysis

In some cases the successful operation of the pump when subjected to the most severe combination of applicable loads cannot be demonstrated by either testing alone or analysis alone. In these cases a qualification program which consists of testing in part and analysis in part shall be developed to suit the particular pump. This qualification program shall demonstrate that the pump is capable of operating when subjected to all applicable loads.

8.5 Documentation

The quality assurance and reporting requirements applicable to dynamic qualification of pumps are given in Section 11.0.

9.0 VERIFICATION OF PRODUCTION PUMPS

Production pumps shall be verified for equivalence to a prototype pump that has already been qualified. Demonstration of equivalency includes comparison to a qualified prototype pump by analysis, testing, and operating experience or a combination of these methods.

9.1 Verification Method

a. demonstration of equivalency to a qualified prototype;

b. evaluation and qualification by analyses, test, experience or a combination of methods of the differences between the prototype and production pumps.

c. testing and other quality control measures to demonstrate that the required safety-related performance features were not downgraded during construction of the production pumps.

9.2 Procedures - Equivalency With Prototype

9.2.1 The manufacturer shall certify that the production pumps are identical with the qualified prototype pump where this is the case. In this event only the production tests outlined in Section 9.1, Step c and as required by Section 9.4, are necessary.

9.2.2 Where the prototype and production pumps are not identical the manufacturer shall compare the characteristics as given in Table 9.1.2. Where the production pump can be shown to meet the prototype pump features, the pumps are functionally equivalent. In this event only production tests as outlined in Section 9.1, Step c above, and as required by Section 9.4, are necessary.

9.2.3 Where the production pump equivalency to the prototype is not demonstrated, the manufacturer shall perform additional analyses or tests, provide additional experience or by a combination of these to demonstrate the adequacy of the production pump.

9.2.4 Analyses

Additional analyses required to qualify a production pump shall be performed in accordance with the applicable paragraphs of Section 8.2. (Appendix B)

9.2.5 Tests

Additional tests required to qualify a production pump shall be performed in accordance with the applicable paragraphs of Section 8.3 (Appendix B).

9.2.6 Experience

Additional experience provided to qualify a production pump shall meet the requirements of the applicable paragraphs of Section 7.4.

9.2.7 Dynamic Qualification

Additional dynamic qualification needed for production pumps shall meet the applicable requirements of Section B.2. (Appendix B).

9.3 Documentation

The documentation package for the pumps shall include, as applicable, the manufacturer's Certificate of Equivalency in accordance with paragraph 9.2.1 or the comparison of prototype and production pump features or the additional tests, analyses and experience that demonstrate the qualification of the production pumps. Each Functional Qualification Report shall be certified to be correct and complete and be in compliance with this Standard, by a responsible individual.

9.4 Production Pump Tests

9.4.1 General

The testing requirements of this section presume that the prototype testing has already been accomplished and a Certificate of Compliance furnished to the owner that the qualification test is applicable to the pump design being production tested. Pump production tests are those tests designed to verify that the production pumps conform to the prototype for which the certificate of compliance was issued.

9.4.2 Special Requirements

9.4.2.1 When the installation subjects the pump to unique conditions, special prototype tests may be necessary. Refer to paragraph B.3.2 (Appendix B).

TABLE 9.1.2

Equivalency with Prototype

Item

1. Chemical and Physical Prop. of materials.

2. FLUID SYSTEM REQUIREMENTS

   A. Head-Flow Characteristic Curve
   B. Power
   C. Net Positive Suction Head Required
   D. Thermal and Pressure Transients
   E. Specific Speed
   F. Impeller Diameter

3. MECHANICAL REQUIREMENTS

   A. Case Stress Levels
   B. Shaft
   C. Coupling
   D. Bearing Mounting & Type.
   E. Running Clearances
   F. Support System Stiffness
   G. Baseplate Stiffness
   H. Speed - Pump
   I. Stages
   J. Critical Speed

9.4.2.2 It may be necessary to test some vertical pumps with portions omitted because of factory height limitations. In this case, discharge head as measured will be different from rated head. Corrections for this head discrepancy shall be made by the manufacturer during the test and the correction noted in the test report.

9.4.3 Test Fluid

Unless otherwise stated in the Design Specifications, the test liquid shall be clean, cold water (see Hydraulic Institute Standard).

9.4.4 Required Pump Tests

9.4.4.1 - The following tests are required or optional. Optional tests shall be performed when required by the Design Specification.

		Required	Optional
A.	Hydrostatic Test	X	
B.	Hydraulic Performance Test	X	
C.	Mechanical Running Test	X	
D.	Net Positive Suction Head Test*		X
E.	Natural frequency test for vertical turbine type pumps only	X	
F.	Natural frequency test for horizontal pumps		x

D2

9.4.4.2 Hydrostatic Test - All pressure boundary parts which are under the jurisdication of the ASME Code, Section III, shall be hydrostatically tested in accordance with the applicable Code requirements, unless the Design Specification imposes more stringent requirements.

9.4.4.2.1 Special Hydrostatic Test for Vertical Pumps - For vertical pumps, when hydrostatic tests are specified for component parts which are not part of the pressure boundary, the test pressure shall be 1.5 times the maximum differential pressure to which the parts are subjected. Test may

*(Refer to Section 7.3.3.1 for description of test.)

be done as an assembly or in segments. Suction bowls or inlet elements that are not subjected to differential pressure need not be tested.

9.4.4.2.2 Hydrostatic Test of Auxiliary Systems - Cooling passages and jackets for bearings, stuffing boxes, pedestals, and oil coolers shall be hydrostatically tested to 1.5 times the cooling system design pressure or to 115 psig, whichever is greater.

9.4.4.3 Performance Test

9.4.4.3.1 The performance test shall be run in accordance with applicable Hydraulic Institute Standards for centrifugal pumps, except as modified below.

9.4.4.3.2 The manufacturer shall operate the pump in the shop for a sufficient period to enable him to obtain complete test data, including speed, head, capacity and power from shut-off to a flow beyond rated capacity or given runout. The minimum number of test points shall be specified in the Design Specification.

9.4.4.3.3 The manufacturer shall maintain a complete detailed log of all such final tests and shall prepare the required number of copies, including test curves and data certified as to correctness.

9.4.4.3.4 Unless otherwise mutually agreed upon, the speed to be used in connection with tests of motor-driven pumps shall be the rated speed shown on the certified outline drawings, applying to the specific driver being furnished.

9.4.4.3.5 Test tolerances on head and capacity at design point shall be in accordance with Hydraulic Institute Standards. If tolerances are required at flows other than design flow, they shall be defined in the Design Specification.

9.4.4.3.6 Auxiliary Systems. When auxiliary systems such as heat exchangers, oil coolers, etc. are furnished integrally with the pump, [illegible] shall be recorded for cooling water flow rate, pressure drop and temperature rise if data is meaningful with respect to the system design and/or operating conditions.

9.4.4.4 Mechanical Running Test. The mechanical running test may be conducted independently or simultaneously with the performance test. The following parameters shall be measured or observed after equilibrium conditions have been achieved and shall meet the tolerances or limits as follows.

9.4.4.4.1 Bearing oil temperature shall have stabilized and shall not exceed the limits given in Section 6.3.1.k; the equilibrium temperature shall be recorded.

9.4.4.4.2 Vibration measurements shall be taken on the shaft to bearing housing. Measurements for vertical pumps shall be taken at the top of the motor bearing housing. The pump shall be at rated speed and at a capacity of +10 percent from rated capacity and the measurements shall be recorded. Vibration amplitudes shall not exceed the limits given in Section 6.5.3.

The vibration measuring instrument shall have a frequency measuring capability from one-half rotational speed to three times rotational speed.

9.4.5 Failure of Pump on Test

If any part of the pump fails during production testing, a report shall be prepared describing the details of the failure and shall be submitted to the purchaser as a part of the data package. The report shall describe the corrective action taken to assure the acceptability of the part for use in the pump as shipped. Failure of critical pump components shall require retesting. Purchaser approval must be given to ship without retest when parts are replaced as a result of test failure.

9.4.6 Post-Test Procedures

Following the completion of all testing, the pump may be shipped as tested without disassembly, providing performance is satisfactory ... Or

Specification does not state otherwise. If desired by the manufacturer, seal faces may be relapped and other sealing parts such as O-rings and gaskets may be replaced. All basic components shall be shipped as tested unless specific authority is granted by the purchaser to substitute another part.

9.5 Quality Assurance and Reporting

The quality assurance and reporting requirements applicable to verification of production pumps are given in Section 11.0.

10.0 CLEANING, PACKAGING, SHIPPING, RECEIVING, STORAGE AND HANDLING

10.1 Cleanliness

Pumps within the jurisdiction of this Standard shall be manufactured and assembled under conditions which allow them to be installed in fluid systems having the appropriate cleanliness classification as defined in ANSI N45.2.1. Unless the Design Specification specifies a higher cleanliness classification, the following shall apply.

Item	Cleanliness Classification
Wetted surface of pump	Class C
Pump bearings, unless lubricated by pumped fluid	Class B
Lubrication systems other than the pumped fluid	Class B

10.2 Packaging, Shipping, Receiving, Storage and Handling

The manufacturer shall follow, and shall invoke for his suppliers to follow, the requirements of ANSI N45.2.2 for packaging, shipping, receiving, storage and handling of the finished pump and the finished pump parts. Level C of N45.2.2 shall apply unless Level A or B is required by the Design Specification.

11.0 QUALITY ASSURANCE AND REPORTING

11.1 Responsibility

It shall be the responsibility of the pump manufacturer, as prime contractor, to implement the quality assurance requirements of this Standard as well as those of the design specification.

11.2 Applicable Standards

The quality assurance program requirements and quality control requirements are established by the design specification. This Standard supplements those requirements. The requirements of the ANSI N45.2 series of quality assurance standards are to be followed as applicable to the activities covered by this standard.

11.3 Data Package

a. The Data Package is the total group of documents and records required by the design specification and this Standard.

b. That portion of the Data Package related to this Standard shall include the Functional Qualification Report (7.3.6), Production Pump Verification documentation (9.5) and Production Pump Test results (9.4), and Certificate of Compliance (9.4.1).

c. The Data Package shall be forwarded to the Owner or his agent prior to or accompanying shipment of the pump assembly.

d. The Data Package shall be reviewed by the Owner or his agent for completeness. Owner's acceptance of the Data Package does not relieve the manufacturer of his responsibility to comply with all the requirements of this Standard or the design specification.

APPENDIX A

RECOMMENDATIONS FOR THE DESIGN OF SAFETY RELATED PUMPS

A.1 PIPING, VALVES AND FITTINGS

All removable auxiliary piping, including supply and takeoff connections for the gland, seal leakoffs, vents, drains and oil system may terminate with a flange or pipe thread. The minimum size for connections to the pump should be 3/4-inch Schedule 80 nominal pipe size, except for seal connections. Smaller sizes are subject to approval by the owner or his agent.

A.2 PUMP ASSEMBLY TYPES

Typical pump assemblies covered by this Standard are shown in Figures 1 through 10. These figures are for classification only and are not intended to dictate details of construction or cover every acceptable design or arrangement.

Vertical Coupled Pump. Figure 2.

a. Thrust Bearing.

The pump axial thrust load is taken by the driver thrust bearing. Bearing loads imposed on the driver by the pump shall be specified by the pump manufacturer.

b. Pump Radial Bearing.

The bearing shall be lubricated by the fluid being pumped.

c. Journal for Sleeve-Type Bearing.

The shaft may have a sleeve, if desired. The journal and bearing shall form a non-galling combination.

d. Coupling.

The coupling shall be of the rigid type. A spacer-type coupling shall be provided for pumps when mechanical seals are specified and used. The spacer shall be of sufficient length to permit replacement of the seal assembly without removing the driver. The pump half coupling shall be of such design that it can be removed from the pump shaft without the use of heat.

Vertical Turbine-Type Pump. Figure 3

a. Thrust Bearing.

The pump axial thrust load is taken by the driver thrust bearing. Bearing loads imposed on the driver by the pump shall be specified by the pump manufacturer.

b. Pump Radial Bearings.

1. Sleeve or guide bearings in the pump may be lubricated by the fluid being pumped.

2. Bearing material shall be suitable for pumpage and service temperature.

3. Bearings shall be of sufficient length to withstand maximum loads.

4. Bearings shall be retained against rotation by an interference fit or a suitable mechanical method.

5. Bearings shall be retained against axial movement by snap rings, shoulders in the bearing housing, or other suitable method.

c. Couplings.

1. The pump to driver shaft coupling shall be rigid adjustable type. A spacer type coupling shall be provided for pumps when mechanical seals are specified and used. The spacer shall be of sufficient length to permit replacement of the seal assembly without removing the driver. The pump half coupling shall be of such design that it can be removed from the pump shaft without the use of heat.

2. Line shaft couplings shall be used when pump length prohibits the use of a single shaft.

   Line shaft couplings shall not depend on threads to do the driving and shall not loosen with reverse rotation. The use of keyways and keys or some similar method shall be used. Threads, split rings, retaining rings, or pins may be used to carry the axial thrust loads.

d. Mounting Plate.

The mounting plate is integral with the discharge head.

Vertical Turbine-Type Pump with Suction Barrel. Figure 4 (This pump is the same as Figure 3, but with suction barrel.)

a. Mounting Plate.

The pump shall have a steel mounting plate attached directly to the suction barrel. The foundation bolts shall not be used to secure the flanged joint under pressure.

Horizontal Frame Mounted Pumps. Figure 6

a. Coupling:

The shaft coupling between the pump and driver shall be a flexible-spacer-type. The spacer length shall permit removal of the coupling, bearings, seal and rotor as applicable.

b. Baseplate:

The baseplate and pump supports shall be constructed so as to minimize misalignment caused by external loads from connecting piping.

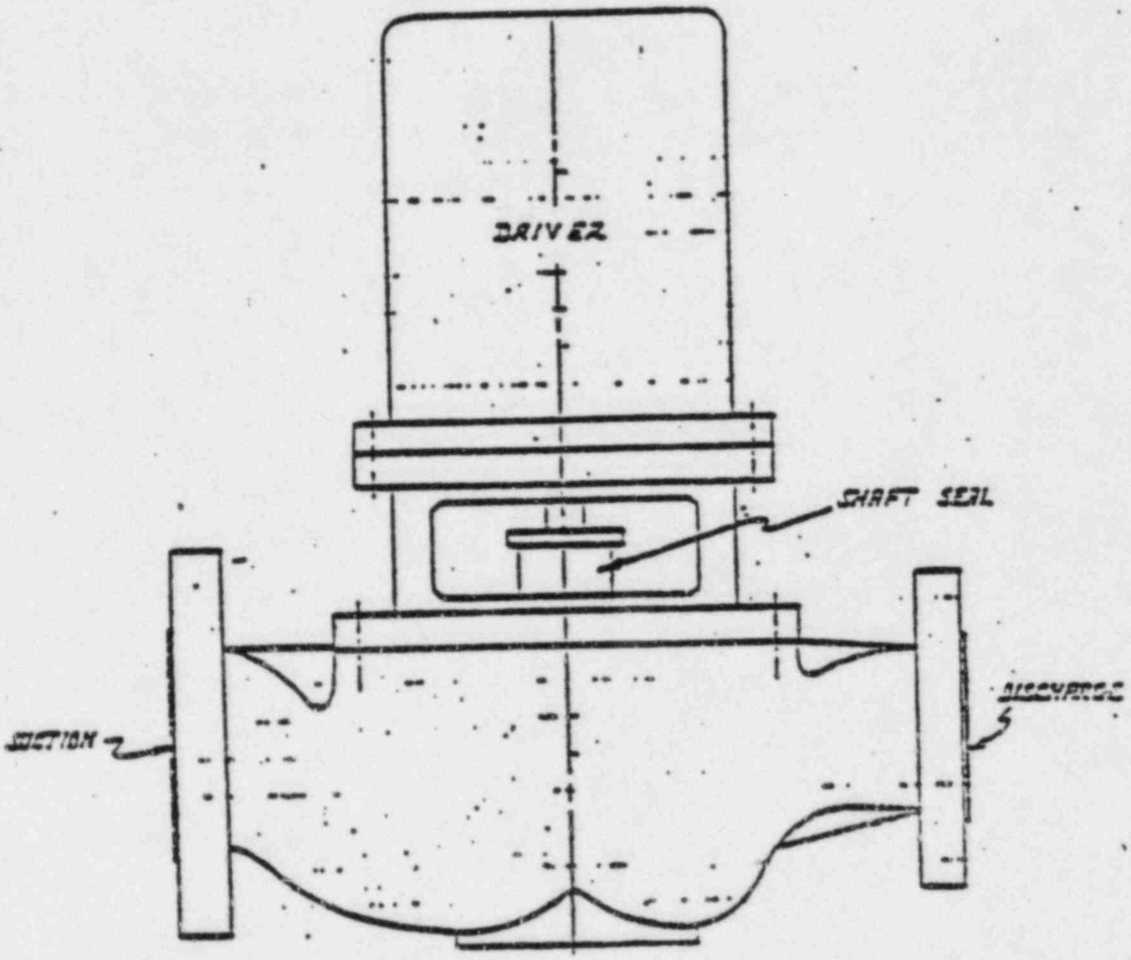
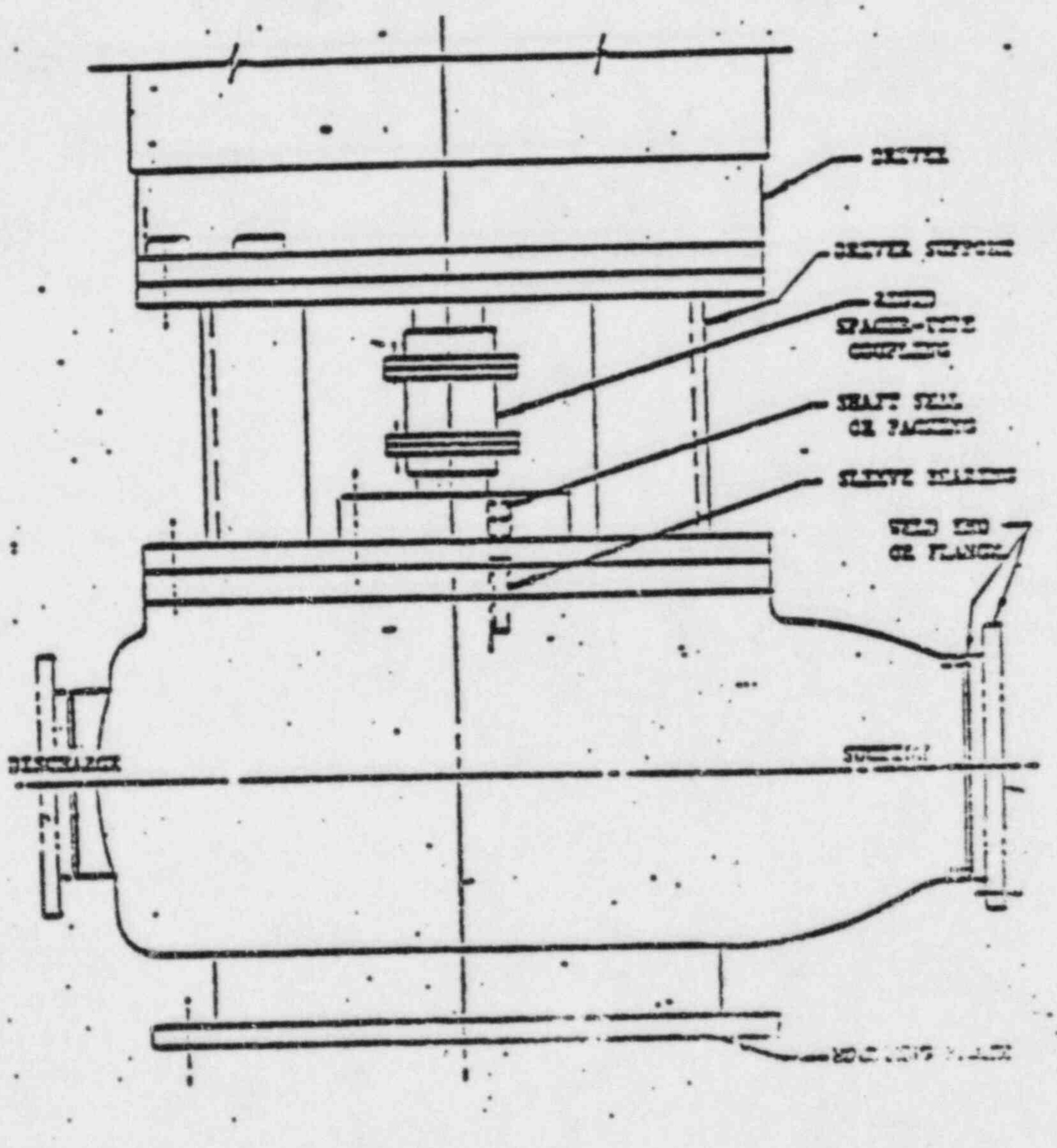
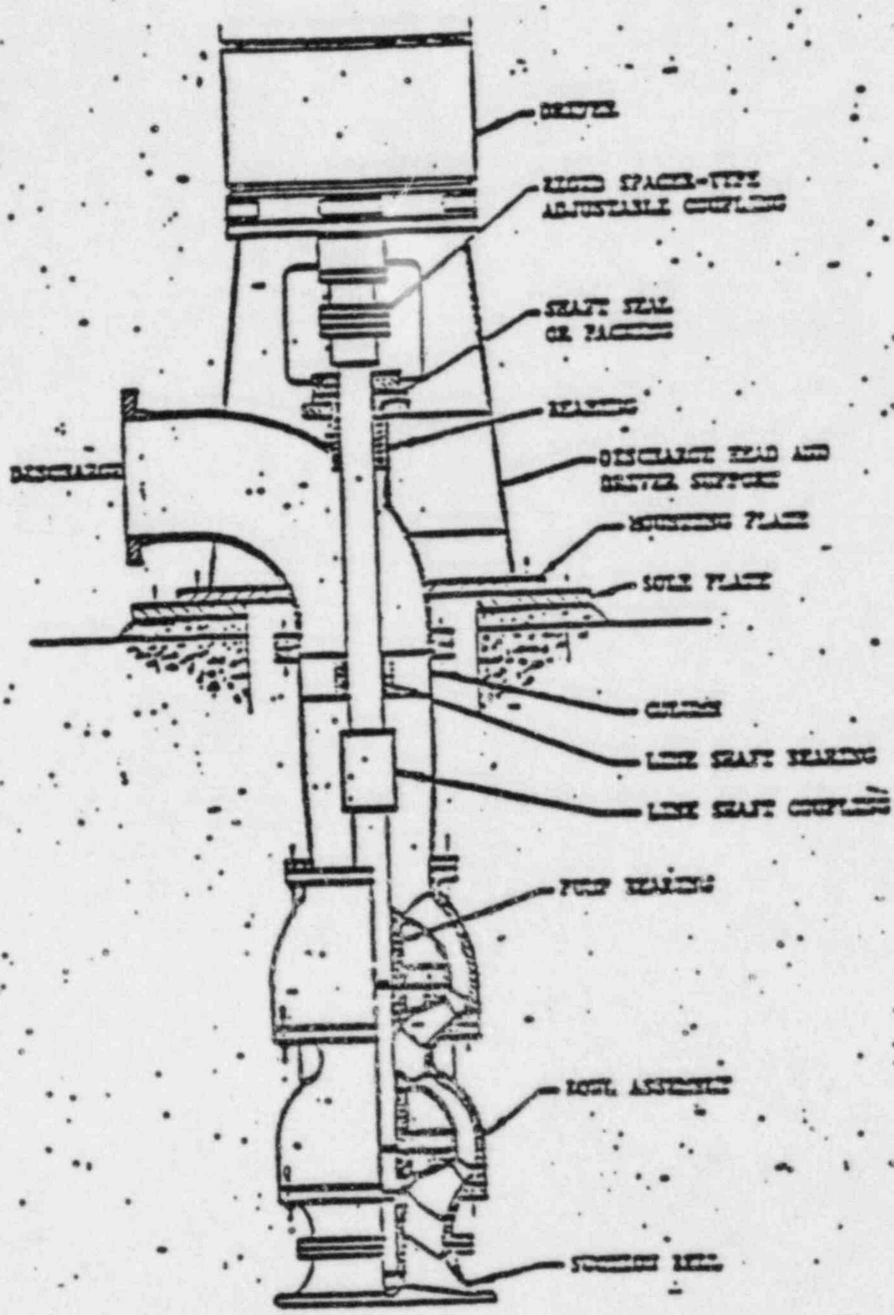


Figure 1: Vertical Close-Coupled Pump

The motor and pump have a common shaft. Bearings, radial and thrust, are in the driver. There is no radial bearing in the fluid being pumped.

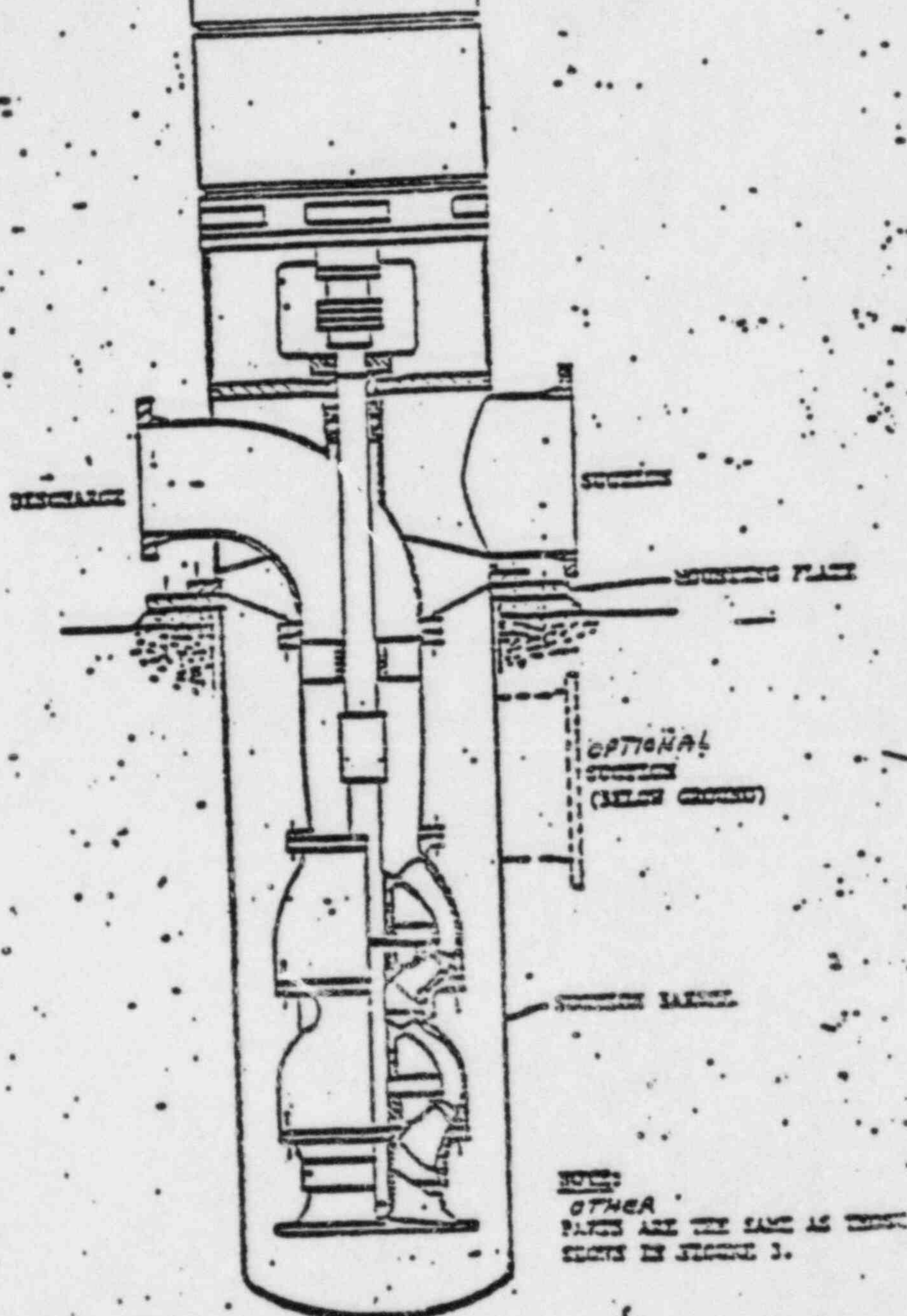


VERTICAL [illegible]



VERTICAL TURBINE PUMP

FIGURE 3.



VERTICAL TURBINE PUMP
WITH SUCTION BARREL

FIGURE 4

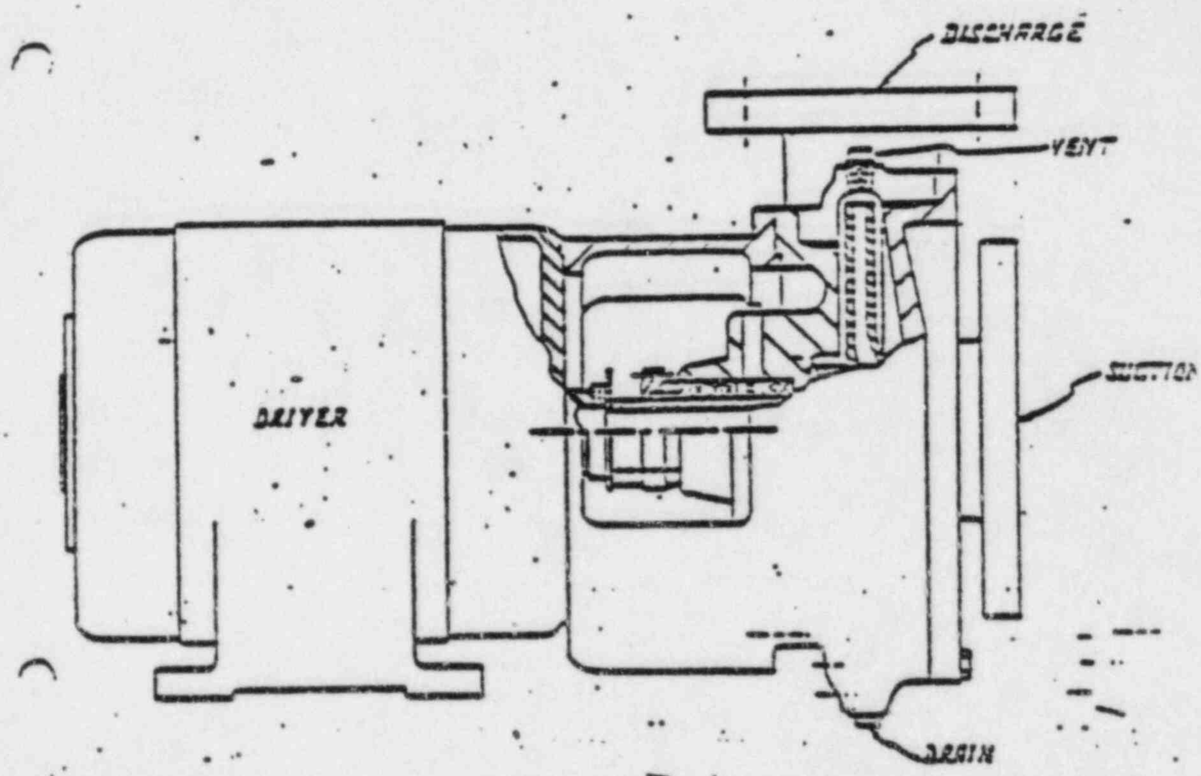


Figure 5: Horizontal Close Coupled Pumps

The motor and pump have a common shaft. Bearings, radial and thrust, are in the driver. (There is no bearing in the fluid being pumped.)

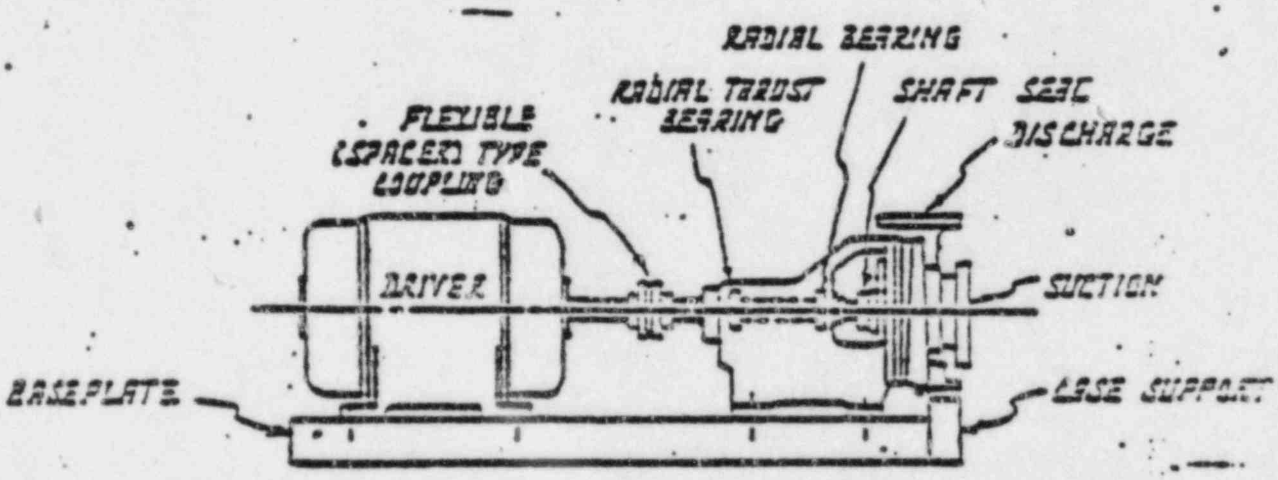


Figure 6: Horizontal Frame Mounted Pumps

Bearings, radial and thrust, in pump bearing housing. No bearing in fluid being pumped (overhung shaft). Self-aligning coupling. Driver and pump mounted on a common baseplate.

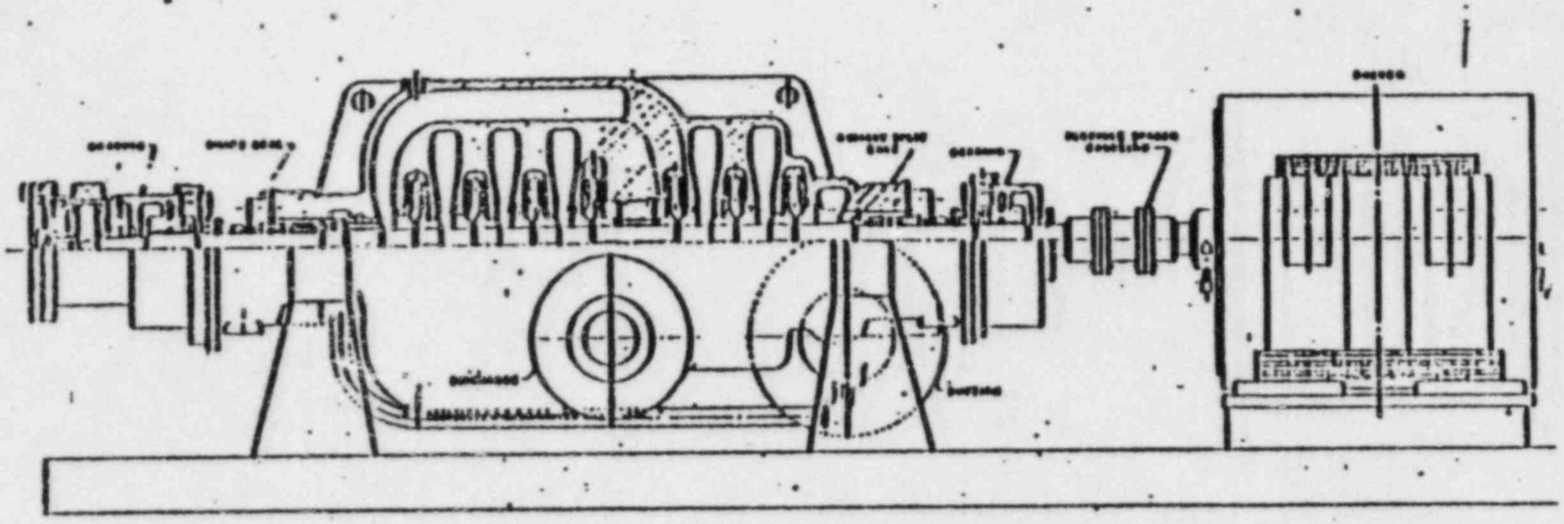


Figure 7: HORIZONTAL AXIALLY SPLIT MULTISTAGE PUMP

Axially split applies to pressure casing joints located parallel to the centerline of the pump shaft. Horizontal shaft through pump case. Bearings in pump bearing housings. Thrust and radial bearings on one end; radial bearing on other end. Bearings are oil lubricated. [illegible] seals--one on each end. Two or more stages. Single or double suction first stage. Flexible spacer coupling. Pump and driver mounted on a common baseplate. Axially split case pumps shall not be furnished if the pumping temperature is 400°F or higher. Centerline-supported pump casings shall be used for horizontal pumps with pumping fluid temperatures of 350°F or higher.

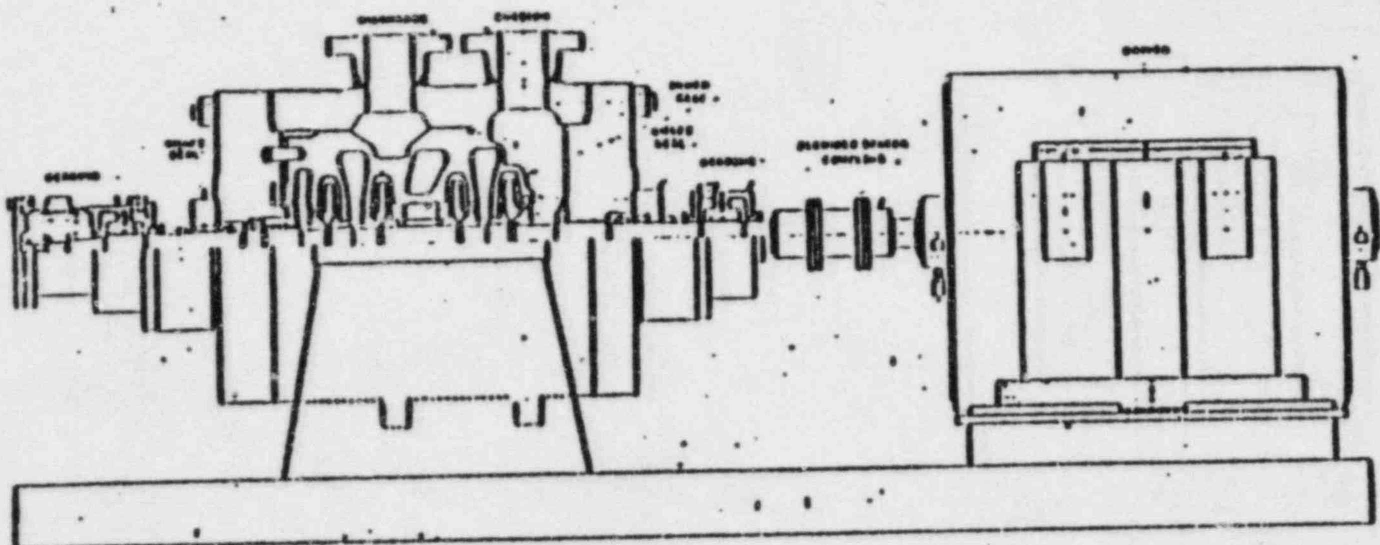


Figure 8: HORIZONTAL RADIALLY SPLIT DOUBLE CASE MULTISTAGE PUMP

Double case refers to the type of construction wherein the pressure casing is separate and distinct from the pumping element contained therein. Radially split applies to pressure casing joints located at right angles to the centerline of the pump shaft. Pump bearings and seals same description as Figure 7. Two or more stages. Single or double suction first stage. Flexible spacer coupling. Pump and driver on common baseplate. Design shall permit removal of the impellers, shaft, bearings, etc., without disassembling the suction or discharge piping. Centerline supported pump casings shall be used for horizontal pumps with fluid pumping temperatures of 350°F or higher.

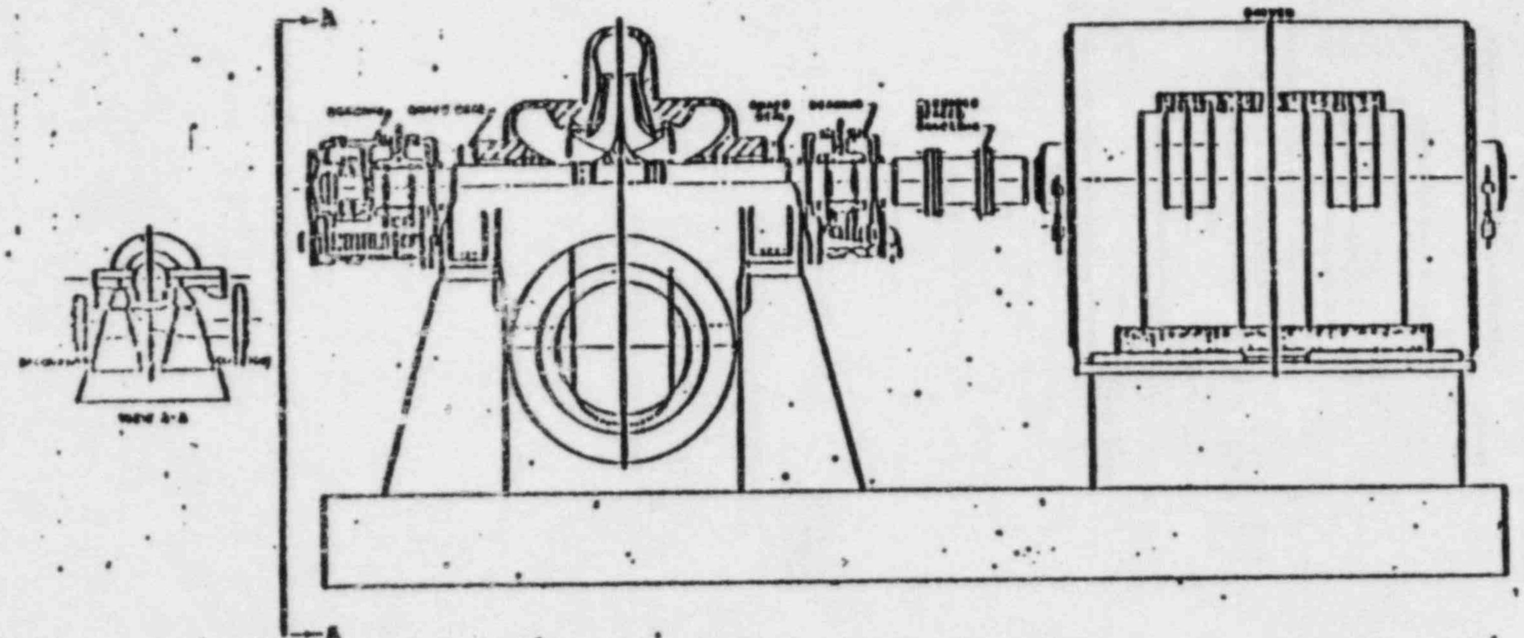


Figure 9: HORIZONTAL AXIALLY SPLIT SINGLESTAGE PUMP

Axially split applies to pressure casing joints located parallel to the centerline of the pump shaft. Horizontal shaft through pump case. Bearings in pump bearing housings. Thrust and radial bearings on one end; radial bearing on other end. Bearings are oil lubricated. Two seals--one on each end. Single stage, double suction impeller; flexible spacer coupling. Pump and driver mounted on a common baseplate. Axially split case pumps shall not be furnished if the pumping temperature is 400°F or higher. Centerline-supported pump casings shall be used for horizontal pumps with pumping fluid temperatures of 350°F or higher.

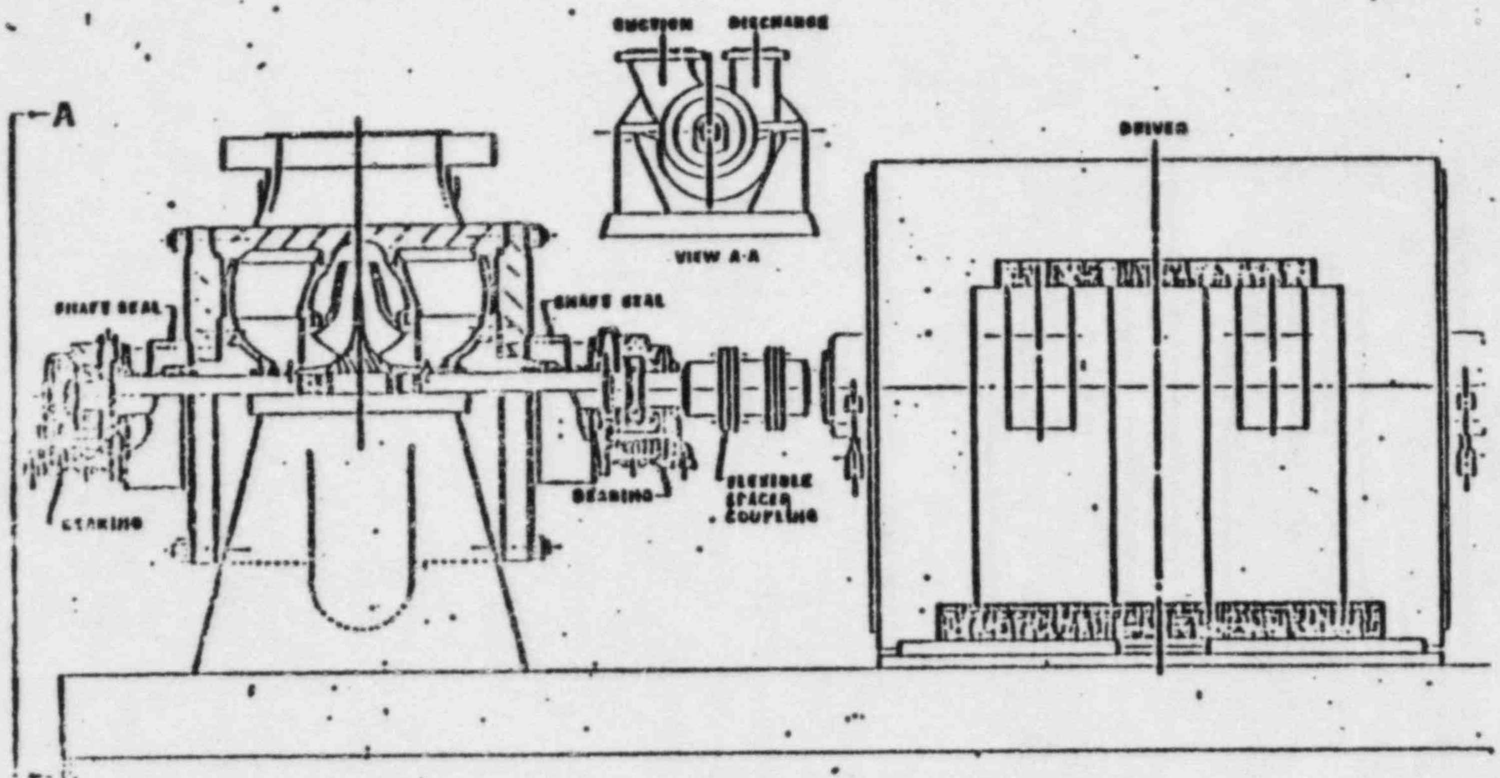


Figure 10: HORIZONTAL RADIALLY SPLIT SINGLESTAGE PUMP

Radially split applies to pressure casing joints located at right angles to the center-line of the pump shaft. Horizontal shaft through pump case. Bearings in pump bearing housings. Thrust and radial bearings on one end; radial bearing on other end. Bearings are oil lubricated. Two seals--one on each end. Single stage, double suction, impeller. Flexible spacer coupling. Pump and driver mounted on a common baseplate. Centerline-supported pump casings shall be used for horizontal pumps with pumping fluid temperatures of 350°F or higher.

APPENDIX B

DYNAMIC QUALIFICATION GUIDANCE

B.1 SCOPE

This appendix establishes guidelines and alternate methods which may be used to provide acceptable qualification for safety related pumps. It discusses possible practical deviations from ideal qualification conditions.

B.2 QUALIFICATION APPROACH

The capability of the pump to operate during and after the seismic and other dynamic events will be evaluated by testing and/or analysis. The type of qualification to be used is highly dependent on the pump size, configuration and mechanical complexity. For some pumps, the configuration and complexity may be such that testing is the most feasible method of qualification. For these cases, testing is recommended. However, for other designs, analysis may be the most reasonable approach due to the availability of accurate analytical techniques or when it is impractical to use only qualification tests. For these cases, analysis or combination of testing and analysis is recommended.

Conducting some supporting tests or analytical work, though it does not qualify the pump, may be very beneficial in simplifying the qualification procedure. For example, if a supporting test shows that the fundamental natural frequency of the installed pump is above 33 Hz, qualification by analysis could be simplified. In other cases, the supporting tests may be of static type, to determine either the stiffness or flexibility of the pump. This information would be used to develop or verify the mathematical model.

The following list of items may provide assistance in determining the dynamic qualification method. This list is not intended to be all inclusive but rather to provide guidelines concerning the choice of testing and analytical procedures.

Testing is recommended if:

a. The response of the pump to any dynamic forcing function is expected to be highly non-linear and depends on many factors other than the nature of the forcing function. Also, when the applied loads produce direct responses in different elements of the assembly,

b. The dynamic response of the rotating portion of the pump is coupled with seismic excitation, and

c. Structural portions of the pump are highly complex and beyond the capability of mechanical modeling techniques.

Analysis may be more practical if:

a. The response of the pump is linear or approximately linear,

b. The response of the rotating portion of the pump is not affected by seismic excitation,

c. The configuration and size of the pump make testing impractical,

d. The effect of attached components, such as piping, piping supports, pump supports, etc., are too complex for accurate duplication under test conditions, and

e. The superposition of loading combinations is too complex to be simulated in testing.

B.3 TESTING

Tests may be either supporting tests or qualification tests. This section discusses methods of supporting tests and provides guidelines for determining and applying some of the applicable loads for qualification tests.

B.3.1 DYNAMIC TYPE SUPPORTING TESTS

In these tests the pump shall be excited by dynamic type forcing functions by using a shake table or single-point exciter applied, at sufficient number of points. The excitation shall be of sufficient strength to excite all significant modes. Typical data obtained from these tests are:

a. Dynamic characteristics of the pump (natural frequencies, mode shapes and damping factors) or the pump parts and assemblies,

b. Cross-coupling effects (i.e., the response in any direction due to the excitation in any other direction). In the locations where installing accelerometers is impractical, the cross-coupling may be estimated based on the response of the available locations.

c. The significance of the response of the pump to vibratory motion to determine the necessity of combining the corresponding nozzle loads with seismic loads on the pump body and their effect on the stress pattern.

B.3.2 STATIC SUPPORTING TESTS

These tests are conducted by applying static forces on the pump. Typical data obtained from these tests are:

a. Static deflections and flexibility parameters that are needed for constructing a mathematical model, and

b. Distortion in casing, due to nozzle loads and deformation limits within which the pump would maintain its operability.

B.3.3 QUALIFICATION TESTS

In some cases it is not possible to apply all applicable loads simultaneously as expected to occur during the seismic and other dynamic events to satisfy the qualification criteria. In these cases some modifications to the loads and procedures may be necessary without discrediting the results of the qualification test. The following are acceptable cases for modifying the input loads.

a. Seismic Input

(1) The input motion may be applied to one vertical and one principal (or two orthogonal) horizontal axis simultaneously. The time phasing of the inputs shall be such that a purely rectilinear resultant input is avoided. An acceptable alternative is to have vertical and horizontal inputs in-phase, and then repeated with inputs 180° out-of-phase. In addition the test shall be repeated with the equipment rotated 90° horizontally.

(2) Single axis excitation may be used if the cross-coupling is considered as follows:

When performing the supporting tests, the ratio of the response in any direction due to the excitation in any other direction will be determined. To explain this, let r_{ij} be the ratio of the response in the j direction (due to the excitation in the i direction) to the excitation in the i direction, and determine r_{xy}, r_{xz}, r_{yx}, r_{yz}, r_{zx} and r_{zy}. The seismic coefficients to be used in qualification tests (separate single axis tests) will be based on the values obtained from the design response spectrum and the cross-coupling factors, r_{ij}.

The equations to determine these coefficients are expressed as follows:

$$X_t = X_s + r_{yx} Y_s + r_{zc} Zs$$

$$Y_t = r_{xy} X_s + Y_s + r_{zy} Z_s$$

$$Z_t = r_{xz} X_s + r_{yz} Y_s + Z_s$$

where X_t, Y_t, Z_t = The seismic coefficients to be used in the qualification tests in the X, Y, Z directions.

X_s, Y_s, Z_s = The seismic coefficients as determined from the design response spectrum in the X, Y, Z directions.

X, Y, Z = The three principal directions of the pump or any other set of orthogonal axes which may produce higher pump response.

b. Nozzle Loads

The nozzle loads as specified in the design specification will be simulated by dynamic-type or equivalent static-type loads to act on the pump during the test. Due to the fact that the qualification may be required before these nozzle loads are finalized in the design specification, some guidelines are given here to estimate the value of these loads. These values will be based on weight, thermal and seismic piping analysis, as well as transient dynamic and hydraulic loads, if any, and also the worst load combination during the LOCA in accordance with the appliable criteria. The estimated loads will be provided by the user and agreed upon by the manufacturer.

If the test is performed using a prepared envelope of nozzle loads, it is suggested that these loads would be based on a ratio of the allowable stresses for different plant conditions as defined by the piping design criteria. This ratio would depend on the size of the nozzle, weight of the pump, operating temperature, etc. The loads used in qualifications would be compared with the results of the piping analysis when available. If the piping analysis resulted in higher loads than those which are used in testing and could not be reduced, retesting should be done.

8.4 ANALYSIS

Analysis may also be used supporting qualification or as the only qualification means. If the analysis is used to provide data needed for qualification, it is supporting analysis. When analysis is used as confirmation of operability of the pump when subjected to all applicable loads, it is qualification analysis.

B.4.1 METHODS OF ANALYSIS

a. Static Analysis

If it can be shown that the fundamental natural frequency of the pump is equal to, or higher than 33 Hz, static analysis may be performed to determine the stresses and deflections due to dynamic loads. In this case the seismic forces will be determined by multiplying the mass of the assembly or part of the pump times the maximum floor seismic acceleration at the base of the pump (zero period acceleration from the response spectra). These forces shall be applied through the center of gravity of the assembly or the part of the pump.

b. Detailed Dynamic Analysis

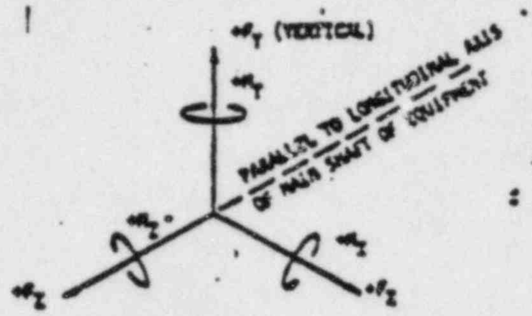
A detailed dynamic analysis shall be required unless a conservative factor is used, and justified, to count for the participation of higher modes. A mathematical model may be constructed to represent the dynamic behavior of the pump. The model will be analyzed using the response spectrum modal deflections. The various modal contributions shall be combined by taking the square root of the sum of the squares of the individual modal stresses and deflections. The closely spaced modes will be handled as described in NRC Regulatory Guide 1.92, "Combining Modal Responses and Spatial Components in Seismic Response Analysis," Rev. 1, 2/76.

c. Simplified Dynamic Analysis

When the pump assembly can be easily modeled, a simplified dynamic analysis may be performed. This method is similar to the static analysis method modified by using the acceleration from the floor response spectra correspoinding to the fundamental natural frequency of the pump and multiply it times 1.5. If the fundamental natural frequency is not known, a static analysis using 1.5 times the maximum peak acceleration of the applicable floor response spectra, as applied seismic loads, is acceptable.

APPENDIX C

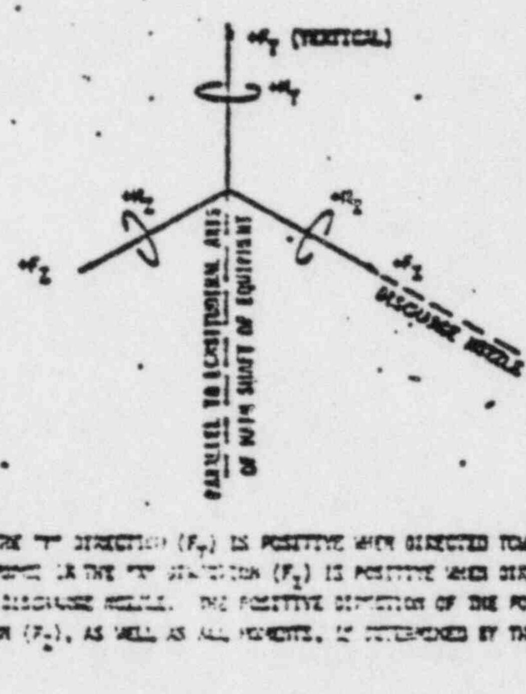
In the absence of other orientation of axes for nozzle loadings those below are recommended.



THE FORCE IN THE "X" DIRECTION (F_X) IS POSITIVE WHEN DIRECTED AWAY FROM THE DRIVER. THE VERTICAL FORCE (F_Y) IS POSITIVE WHEN DIRECTED UPWARD. THE POSITIVE DIRECTION OF THE FORCE IN THE "Z" DIRECTION (F_Z), AS WELL AS ALL MOMENTS, IS DETERMINED BY THE "RIGHT HAND RULE."

AXES ORIENTATION FOR HORIZONTAL ROTARY EQUIPMENT

FIGURE -A



THE FORCE IN THE "Y" DIRECTION (F_Y) IS POSITIVE WHEN DIRECTED TOWARD THE DRIVER. THE FORCE IN THE "X" DIRECTION (F_X) IS POSITIVE WHEN DIRECTED AWAY FROM THE DISCHARGE NOZZLE. THE POSITIVE DIRECTION OF THE FORCE IN THE Z DIRECTION (F_Z), AS WELL AS ALL MOMENTS, IS DETERMINED BY THE "RIGHT HAND RULE."

AXES ORIENTATION FOR VERTICAL ROTARY EQUIPMENT

FIGURE B

6

WANG
12-?A

AMERICAN NATIONAL STANDARD

FOR

NUCLEAR POWER PLANT EQUIPMENT

STANDARD FOR QUALIFICATION OF ASME CODE CLASS 2 & 3

PUMP ASSEMBLIES FOR SAFETY SYSTEMS SERVICE

SHAFT SEAL ASSEMBLIES

ANSI/ASME N551.3 May, 1980

SECRETARIAT

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

FOREWORD

(This Foreword is not a part of the prepared Standard for Functional Qualification of Shaft Seal Assemblies for Active Safety-Related Pump Assemblies for Nuclear Power Plants ANSI/ASME N551.3.)

This Standard is one of a series of standards written to define the design, installation and functional qualification requirements of ASME Class 2 and 3 pump assemblies installed as components of safety systems in nuclear power plants. Qualification of pump assemblies for this service requires demonstration of the adequacy of the equipment to perform its safety function in the expected range of normal, design basis event, and post design basis event service conditions. The designation of pump assemblies as "safety-related" is outside the scope of this Standard; this is to be resolved by the station owner as part of the station licensing procedure. Also, the ASME Boiler and Pressure Vessel Code establishes the rules for the pressure boundary integrity of the pump, and this standard addresses the requirements for qualification of the pump assembly for functional adequacy.

The initial development of this Standard was assigned the ANSI N-45 Committee with the project designation of N-551. Subsequentially, the ANSI N-45 Committee was dissolved and IEEE has assumed the primary responsibility for nuclear equipment qualification standards. Development of the standard is being continued by the N-551 Steering Committee with ASME sponsorship. The present intent is to develop a series of N-551 standards as follows:

N-551.1	Standard Qualification of Nuclear Power Plant Pump Assemblies for Safety Systems Service - General Requirements
N-551.2	Functional Qualification of Pumps for Active Safety Systems Pump Assemblies for Nuclear Power Plants
N-551.3	Functional Qualification of Shaft Seal Assemblies for Active Safety Systems Pump Assemblies for Nuclear Power Plants
N-551.4	Functional Qualification of Motor Drives for Safety Systems Pump Assemblies for Nuclear Power Plants
N-551.5	Functional Qualification of Turbine Drives for Safety Systems Pump Assemblies for Nuclear Power Plants

These standards are to be balloted independently and submitted for ANSI approval via the ANSI N-41 Committee which has IEEE as the Secretariat.

The Task Force responsible for this Standard included the following personnel during its development:

Name of Representative	Organization Represented
F. P. Bussick, Chairman	Sealol, Inc.
R. E. Battilana	Durametallic Corporation
W. A. Bush	Oak Ridge National Laboratory
J. A. Fickling	Westinghouse Electric Corporation
O. Giles	Borg-Warner Mechanical Seals
J. Hamaker	Crane Packing Company
J. C. Hobbs	Florida Power Corporation
R. W. Howard	General Electric Corporation
V. C. Krecicki	Combustion Engineering Incorporated
A. Taboada	Nuclear Regulatory Commission

FUNCTIONAL QUALIFICATION OF SHAFT SEAL ASSEMBLIES FOR ACTIVE SAFETY-RELATED PUMP ASSEMBLIES FOR NUCLEAR POWER PLANTS

1.0 GENERAL

1.1 Introduction

Seal systems for the safety-related active nuclear pumps may be required to operate under normal plant design conditions and may be required to operate during or after abnormal conditions arising from a postulated accident or event. For pumps designated for this service, complete specifications, special design considerations, and procedures for functional qualification of the seals are required by this Standard to provide assurance that the pump will function when required. This Standard is limited in application to pumps constructed in accordance with the requirements of the ASME Boiler and Pressure Vessel Code, Section III, Nuclear Power Plant Components for Class 2 and Class 3 components. This Standard supplements these requirements to provide assurance of operability for the time span required.

1.2 Scope

1.2.1 This Standard establishes the requirements for special design and material considerations, and the procedures for functional qualification of seal systems for nuclear pumps for safety-related service applications. The Standard covers all phases of the seal development from initial design through production testing. It is the responsibility of the owner or his authorized agent to designate those pumps which are Class 2 and Class 3 safety-related active pumps that require qualification of the seal system under this Standard.

1.2.2 Functional qualification consists of tests and/or analyses specified herein to demonstrate that the seal will perform its required safety-related function. Requirements allow qualification of a production seal by analyses which demonstrate design similarity to a seal qualified by testing.

1.2.3 Qualification to this Standard is limited to requirements for safety-related pump seal systems and their directly associated appurtenances. GENERAL REQUIREMENTS, REQUIREMENTS FOR PUMPS, PUMP DRIVES AND PUMP ASSEMBLIES ARE PROVIDED IN ANSI STANDARDS N551.1, N551.2, N551.4 AND N551.5.

1.2.4 A Seal System Functional Qualification Report is required to document compliance of a prototype test unit with this Standard. The applicability of a seal system for a specific order for a nuclear power plant is documented by a Seal System Application Report.

2.0 REFERENCES

The following references supplement those in ANSI N551.1 and form a part of this Standard.

2.1 American National Standards Institute

2.1.1 N45.2.1 Cleaning of Fluid Systems and Associated Components during Construction Phase of Nuclear Power Plants.

2.1.2 N45.2.2 Packaging, Shipping, Receiving, Storage and Handling of Items for Nuclear Power Plants

3.0 DEFINITIONS

The following definitions supplement those in ANSI N551.1.

3.1 Component Coolant

A fluid used as a heat removal medium and separated from the process fluid by a barrier.

3.2 Design Basis Condition - Seal Cavity

The design conditions to be considered in the shaft seal system. Conditions to be considered are contained in 6., Special Design Requirements.

3.3 Injection Fluid

Fluid is injected into the seal area at a pressure higher than the process fluid to lubricate and cool the seal(s) and to prevent leakage of process fluid.

3.4 Process Fluid

The fluid pumped.

3.5 Production Unit

Production units are those units that were fabricated to the same manufacturing techniques, materials, production testing and quality assurance requirements as were used for the prototypes selected for qualification. Any changes must be documented and re-tested or analysis performed to demonstrate that the performance and qualified life of the equipment has not been affected.

3.6 Prototype

The equipment fabricated for qualification testing. It may be a first article or a unit randomly selected from a production quantity. It is not a developmental unit, but must be constructed using identical [redacted] materials, fabrication techniques, production testing and quality assurance that is applied to units to be installed for power plant service. Any changes made to a prototype unit as a result of qualification testing must be documented. Sufficient re-testing and/or analysis must be performed to demonstrate the adequacy of the change.

3.7 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.

3.8 Shaft Seal System

A system of shaft seal(s) and auxiliary devices as required that limit the process fluid leakage to the atmosphere or to low pressure systems and collects and directs the leakage.

3.9 Stress Index

The ratio of the design stress to the minimum ultimate strength of the material.

4.0 FUNCTIONAL SPECIFICATIONS

The functional requirements for a shaft seal system for a safety-related pump shall be provided in a Seal Specification. This Specification shall be prepared either by the manufacturer, the owner or his authorized agent in accordance with ANSI Standard N551.1. The desired method of qualification shall be identified and included in the Specification.

5.0 SPECIAL MATERIALS REQUIREMENTS

5.1 General Requirements

5.1.1 Materials not covered by ASME Section III shall conform to ASTM Standards. Other material standards such as AISI, AMS, SAE, or military or federal specifications may be used if suitable ASTM standards are not available.

If none of the above material standards apply, the material manufacturer's designation may be used accompanied by sufficient data to demonstrate adequacy for the intended service. The material manufacturer shall certify that successive shipments have the same properties as those in the manufacturer's specification and agreed upon with the seal manufacturer.

5.1.2 The seal manufacturer shall include a certificate of compliance for all materials not requiring certification by ASME Section III or other parts of this Standard.

5.2 Permitted Material Specifications

5.2.1 Materials used for the gland plate and its bolting, defined as pressure retaining material in ASME Section III, shall be in conformance with Section III.

5.2.2 Materials used for seal mating faces shall meet the following qualifications as a minimum:

5.2.2.1 Chemical. No detrimental physical property changes shall occur when subjected to the seal cavity fluids for the times specified in Table 1.

5.2.2.2 Temperature. No detrimental physical property changes when subjected to the maximum seal cavity temperature specified in Table I.

5.2.2.3 Mechanical. Have a wear rate suitable for the service life when runs against the mating face material under the conditions specified in Table I.

5.2.2.4 Carbon Porosity. Maximum acceptable air leakage shall be one standard ml/hr/in. of ~~wall thickness~~ DIAMETER when tested under water at a minimum test pressure of ~~50~~ 30 psi.

5.2.3 Materials used for retainers, bolts, pins, bushings, and other parts which have a stress index less than 0.1 may be made from any material suitable for the intended service.

5.2.4 Materials used for springs, bolts, pins, and other metallic or brittle parts with a stress index greater than 0.1 shall meet an ASME, ASTM OR AMS, ~~[illegible]~~) specification which controls the quality of the material.

5.2.5 Proprietary materials which fall within the definition of Paragraph 5.2.4 which do not have a suitable national specification available shall be qualification tested (see Section 7.3). Such proprietary materials shall be designated by a specific indentification number by the material manufacturer and certified to meet all the Quality Assurance requirements of the originally qualified material.

6.0 SPECIAL DESIGN REQUIREMENTS

6.1 General

The seal system shall be designed to satisfy all of the requirements and operating conditions contained in the Seal Specification (6.2) unless specifically agreed to in writing by the Owner or his agent.

For normal operating conditions, the seal system shall be designed to operate without maintenance for the design life specified in Table I.

For upset, emergency, faulted, and other operating conditions, the seal system shall be designed to operate without maintenance for the specified duration and specified number of cycles. If only one cycle of a specific operating condition is specified, then it is understood that seal replacement or maintenance is allowed before resuming normal operation.

Special seal systems such as double seals, tandem seals, or other special configurations shall be specified by the purchaser or may be recommended by the seal vendor if considered desirable for the service.

6.2 Seal Specification

In accordance with the Pump Design Specification, the pump manufacturer shall supply the seal manufacturer, as a minimum, the following information.

6.2.1 The ASME Boiler and Pressure Vessel Code Section III class and the date of the applicable ASME Code Edition and applicable Addenda.

6.2.2 The design basis conditions and associated duty cycles as required by Table I.

6.2.3 The following arrangement and interface information.

6.2.3.1 The type of seal to be provided (i.e., mechanical, packing, dual, etc.).

6.2.3.2 The shaft or sleeve diameter at seal, shaft or sleeve material, shaft orientation (vert. or horiz.), and direction of rotation.

6.2.3.3 The seal cavity maximum diameter at seal and length.

6.2.3.4 Significant shaft to seal cavity misalingment conditions, including:

static eccentricity
static angularity
range of axial travel

6.2.3.5 Shaft motions (radial, axial, and angular), relative to the seal cavity, during seismic and design bases conditions as indicated in Table I.

6.2.4 The following seal external system information.

6.2.4.1 The system piping arrangement, if known. (See Piping Plans, Tables II, III, IV, AND V.)

6.2.4.2 The availability of component coolant, including the quantity, maximum temperature, pressure, available pressure drop, and chemistry.

6.2.4.3 The availability of seal injection, including the quantity, temperature, chemistry, and solids particle size.

6.2.5 Maintenance. Special provisions for seal maintenance shall be specified. This includes:

6.2.5.1 Possible inaccessibility of the pump during operation which restricts opportunities for visual inspection and preventive maintenance.

6.2.5.2 The need for assembly and maintenance features to limit personnel exposure time in radiation fields.

6.3 Mechanical Face Seals

Except as permitted by Table VI, all mechanical face seals shall be of hydraulically balanced type.

Either a sliding gasket, such as O-ring, V-ring, U-ring, or a metal or rubber bellows shall be used between the axially moving seal face and shaft sleeve or housing.

For applications involving seal face velocities over 5,000 feet per minute, it is preferred that the axially movable seal face shall be mounted on the stationary housing rather than on the shaft.

6.4 Packings

Stuffing boxes on all pumps shall be packed with sufficient amount of packings, as recommended by the packing manufacturer, plus the lantern ring. The minimum packing size permitted shall be 1/4 inch square; however, a packing size of not less than 3/8 inch is preferred.

The pump stuffing boxes shall be provided with lantern rings for the fluid injection directly into the packing. Inlet and outlet connections shall be provided for the lantern ring.

Ample space shall be provided for the packing replacement without removing or dismantling any part other than the gland and the lantern ring ~~is~~ if split.

When the stuffing box of a vertical pump is subjected to discharge pressure and a bleedoff to suction is used, this bleedoff shall be by means of internal rather than external piping.

On vertical pumps, an adequate drain shall be provided so that no liquid can collect in the driver support piece.

6.5 Shaft Sleeves

When shaft sleeves are used, they shall be sealed to prevent leakage between the ~~sleeve and shaft and~~ machined for concentric rotation.

On pumps arranged for packing, the end of the shaft sleeve assembly or nut shall extend beyond the outer face of the packing gland.

On pumps employing an auxiliary seal (other than a throttle bushing), a shaft sleeve shall extend beyond the seal gland plate. Leakage between the shaft and sleeve thus cannot be confused with leakage through the stuffing box packing or mechanical seal faces.

6.6 Auxiliary Devices

The Seal and Pump Manufacturers shall jointly establish the seal cavity recirculation rate, external cooling, filtration and fluid injection system requirements. Where possible, these systems shall be in accordance with recommended piping and piping plans as covered by Tables II, III and IV. For portions of these systems not supplied with the pump, the Owner or his agent shall be advised of all necessary requirements. These include, but are not limited to, cooling water and injection flow rates, temperatures and pressures, filtration requirements, and monitoring instrumentation. In all cases, the Owner shall be advised of the specific conditions necessary in the seal cavity to ensure proper seal operation.

When specified, sight flow indicators (open or closed as specified) shall be furnished in each cooling water outlet line.

Drains are recommended at all low points in cooling water piping to allow complete drainage of pipe and jackets. Piping shall be designed to eliminate air pockets.

7.0 VERIFICATION OF PROTOTYPE SEAL SYSTEM

Verification of prototype seal system design shall be performed by analyses, qualification test or experience. For verification, it is necessary to evaluate prototype seals and previously verified seals to which changes have been made that make functional requalification necessary. The requirements for verification are presented below.

7.1 General

The Seal Manufacturer shall demonstrate the adequacy of the seal system PRIOR TO THE SEAL SYSTEM'S APPROVAL OR USE BY THE OWNER OR HIS AUTHORIZED AGENT IN EITHER OR BOTH OF THE FOLLOWING WAYS:

7.1.1 By supplying documentation that the proposed seal system has proved itself through a comprehensive testing program. The testing program shall have included full-scale tests at design basis conditions, as defined in Table I. A detailed description of the tests, test equipment and actual test results shall be submitted.

7.1.2 By ~~providing~~ documentation showing that the proposed seal design is similar and has been used successfully for a stated length of time in similar service. This method shall not be used if the proposed seal system, or the environment in which it is to be used, differs significantly from the one to which it is being compared.

7.2 Analysis

Although a seal system may not be functionally qualified by analysis alone, analysis may be utilized to extend previous testing and/or previous experience to the design bases conditions. Types of permitted analysis include: heat generation and removal, mechanical stress, thermal stress, wear rate, interface temperature, interface pressure, interface velocity, axial movement, radial movement, angular movement, torsional natural frequency.

7.3 Qualification Testing

7.3.1 Test Plan. A Test Plan shall be prepared with appropriate inspection and test record forms to define test objectives, test fluids, conditions of the test, permissible maintenance or adjustments, and acceptance criteria.

7.3.2 Installation for Tests. A testing installation shall be utilized which provides rotation, appropriate means for pressurization, fluid thermal control, and seal leakage measurement.

7.3.3 Record Control Points. Prior to start of test sequence all system conditions shall be recorded as applicable to the test seal assembly and test installation according to the test plan. Record control points shall include surface finish, face surface, flatness, seal leakage, temperature, pressure and seal power requirements.

7.3.4 Test Sequence. Testing sequence shall progress from normal conditions with thermal transients, through abnormal conditions to safety-related function.

7.3.5 Environmental and Aging. Environmental and aging effects on the materials of construction are not required to be performed on actual seal system components, but may be authoritative reference results of material tests.

7.4 Experience

The application of a specific seal system may be justified by providing documentation showing that the history performance of a similar seal system equals or exceeds the design service condition of the proposed seal application. The following areas shall be evaluated when determining applicability of experience:

similarity of application
environment
performance data
maintenance and inspection records

7.5 Quality Assurance and Reporting

The quality assurance and reporting requirements applicable to prototype verification are given in Section 10.0.

8.0 VERIFICATION OF PRODUCTION SEAL SYSTEMS

8.1 General

8.1.1 Production seal systems shall be verified for equivalence to a prototype seal system that has already been qualified.

8.1.2 Verification of equivalency includes comparison to a qualified prototype seal system by analysis, testing and experience or a combination of these methods.

8.2 Procedures - Equivalency with Prototype

8.2.1 The manufacturer shall certify that the production seal systems are identical with the qualified prototype seal systems where it applies BY PROVIDING A QUALITY CONTROL REPORT. THE REPORT SHALL INCLUDE VERIFICATION OF THE FOLLOWING CRITICAL AREAS:

8.2.1.1 Measure and record seal face flatness.

8.2.1.2 Measure and record mating face flatness.

8.2.1.3 Leakage check secondary seal components WERE PRACTICABLE and record results OR PROVIDE DOCUMENTED PRODUCTION AND QUALITY CONTROL PROCEDURES WHICH ASSURE EQUIVALENT SECONDARY SEAL INTEGRITY.

8.2.2 Where the production seal system does not meet the equivalency of the prototype seal system, the manufacturer shall perform additional analyses and tests, provide additional experience or by a combination of these demonstrate that the production seal system or those features not meeting the equivalency test, are qualified for the specified safety-related functions.

9.0 CLEANING, PACKAGING, SHIPPING, RECEIVING, STORAGE AND HANDLING

9.1 Cleanliness

Seals shall be manufactured and assembled under conditions which allow them to be installed in fluid systems having the appropriate cleanliness classification as defined in ANSI N45.2.1. As a minimum, the mechanical seals shall be cleaned in accordance with Cleanness Classification C of N45.2.1.

9.2 Packaging, Shipping, Receiving, Storage and Handling

Packaging, shipping, receiving, storage and handling of finished seals shall, as a minimum, be in accordance with Level C of ANSI N45.2.2 as applicable.

Add (Seal Manufacturer Specify to owner storage procedures) Long and Short term

10.0 QUALITY ASSURANCE AND REPORTING

10.1 Responsibility

It shall be the responsibility of the seal assembly manufacturer to implement the quality assurance requirements of this Standard.

10.2 Applicable Standards

The quality assurance program requirements and quality control requirements are established by the Design Specification. This Standard supplements those requirements. The requirements of the ANSI N45.2 series of quality assurance standards are to be followed as applicable to the activities covered by this Standard.

10.3 Data Package

10.3.1 The Data Package is the total group of documents and records required by the Design Specification and this Standard.

10.3.2 That portion of the Data Package related to this Standard shall include as a minimum the following:

PROPRIETARY MATERIAL TO WHICH PARAGRAPHS 5.2.4. AND 5.2.5. ARE APPLICABLE SHALL BE PRODUCED UNDER A DOCUMENTED QUALITY ASSURANCE SYSTEM MEETING THE GUIDELINES OF 10-CFR-PART 50, APPENDIX B. THE PURCHASER SHALL DOCUMENT PERIODIC AUDITS OF THE PROPRIETARY MATERIAL MANUFACTURER'S QUALITY ASSURANCE SYSTEM TO VERIFY CONFORMANCE TO THIS REQUIREMENT.

10.3.2.1 A shaft seal system assembly drawing with applicable bill of materials designating the applicable Code or Standard as permitted by the Section 5 of this Standard shall be provided by the seal manufacturer. The design basis and service conditions shall be stated on the drawing with precautions noted that would preclude maloperation. Requirements for cooling water injection fluid or other auxiliary or supporting equipment should be clearly stated.

10.3.2.2 Qualification and Production Test Report.

10.3.2.3 Certificate of Compliance.

10.3.2.4 Material Certifications.

10.3.2.5 Installation, Operation and Maintenance Instruction Manual.

10.3.3 The Data Package shall be forwarded to the Owner or his agent prior to or accompanying shipment of the seal assembly.

10.3.4 The Data Package shall be reviewed by the Owner or his agent for completeness. Owner's acceptance of the Data Package does not relieve the seal manufacturer of his responsibility to comply with all the requirements of this Standard.

Table I. Shaft seal system specification.

			Design Basis Condition			
		Normal[1]	Safety Related Function[2]	In Service Tests	Hydro-Static[5]	Other[4]
Conditions at Seal Cavity	Fluid[3]					
	Pressure (PSIA)					
	Temperature (°F)				X	
	Thermal Transient Rate, Range and Direction (°F/min.)				X	
	Thermal Transient Duration (min.)				X	
	Allowable Leakage[6]					
	Radiation (Rads)				X	
	Speed (RPM)				X	
Abnormal Condition Info (Design) Life)	Number of Cycles	X				
	Duration of Cycles (Hrs)	X				
Component Coolant Conditions	Pressure (PSIA)				X	
	Temperature (°F)				X	
	Flow Rate (GPM)				X	
Design Life	Static (Hrs)		X	X	X	
	Dynamic (Hrs)		X	X	X	

NOTES

(1) Normal conditions refer to seal conditions in pump which are required to function during normal plant operation.

(2) Safety-related function conditions refer to seal conditions which occur in pumps which must function during or after a plant upset, emergency or faulted conditions.

(3) If fluid is water, specify quantity of chemicals present as additives or impurities and solids particle size.

(4) "Other" refers to conditions which may affect the seal cavity environment such as loss of component coolant or injection and which are not covered in the other categories.

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

(6) Allowable leakage refers to that leakage which can be collected as liquid at the seal operating conditions.

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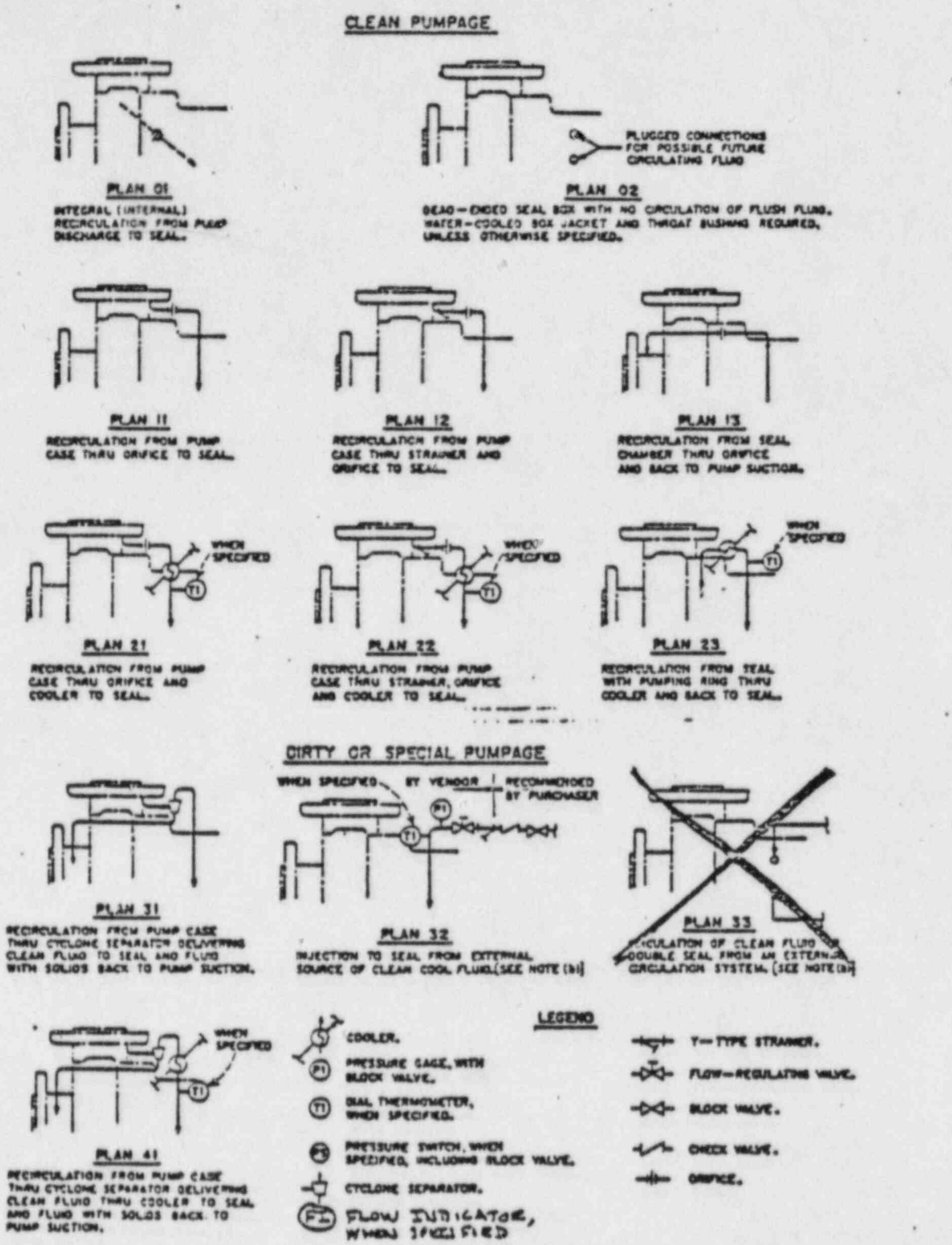
PAGE 13



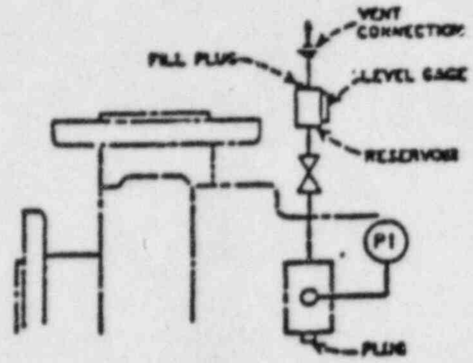
Notes:

a. These plans represent commonly used systems. Other variations and systems are available, and should be specified in detail by purchaser or as mutually agreed between purchaser and vendor.

b. For Plan 32 ~~and 33~~ purchaser shall specify the fluid characteristics, and vendor shall specify the required gallons per minute (gpm) and pounds per square inch gage (psig).

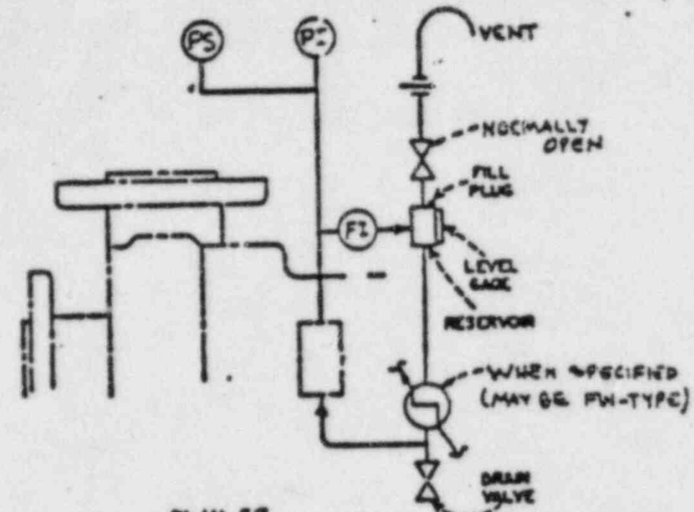
-Piping for Primary Seals.

TABLE II



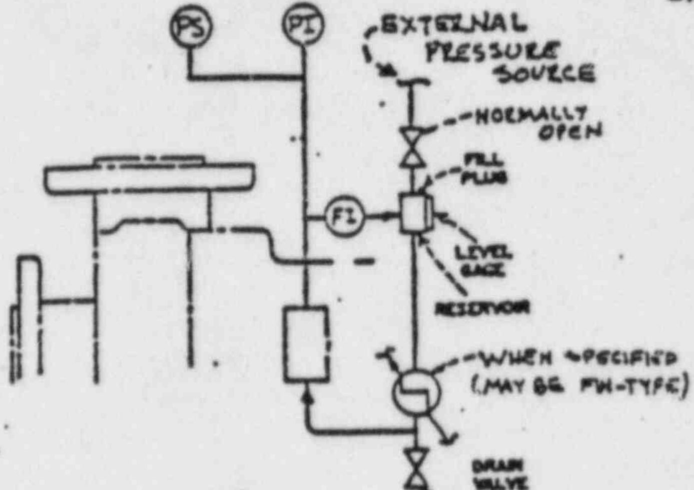
PLAN 51

DEAD ENDED BLANKET (USUALLY METHANOL) [SEE NOTE (b)]



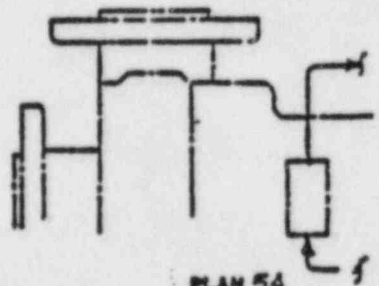
PLAN 52

EXTERNAL FLUID RESERVOIR [SEE NOTE (b)] FOR TANDEM SEALS. THERMOSYPHON OR FORCED CIRCULATION, AS REQUIRED.



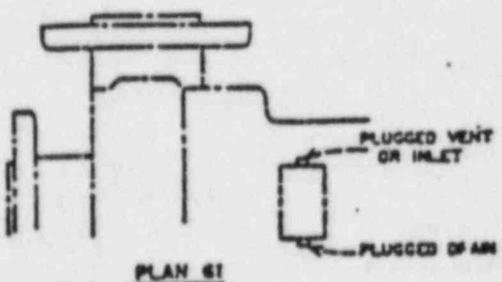
PLAN 53

EXTERNAL FLUID RESERVOIR [SEE NOTE (b)] FOR DOUBLE SEALS. THERMOSYPHON OR FORCED CIRCULATION, AS REQUIRED.



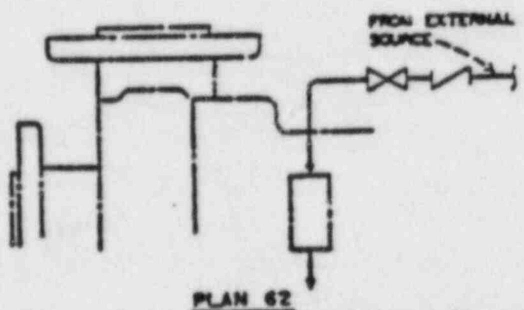
PLAN 54

CIRCULATION OF CLEAN FLUID TO TANDEM OR DOUBLE SEALS FROM AN EXTERNAL SYSTEM. [SEE NOTE (b)]



PLAN 61

TAPPED CONNECTIONS FOR PURCHASER'S USE. NOTE (b) SHALL APPLY WHEN PURCHASER IS TO SUPPLY FLUID (STEAM, GAS, WATER, OTHER) TO AUXILIARY SEALING DEVICE.



PLAN 62

EXTERNAL FLUID QUENCH (STEAM, GAS, WATER, OTHER) [SEE NOTE (b)]

Notes:

a. These plans represent commonly used systems. Other variations and systems are available, and should be specified in detail by purchaser or as mutually agreed between purchaser and vendor.

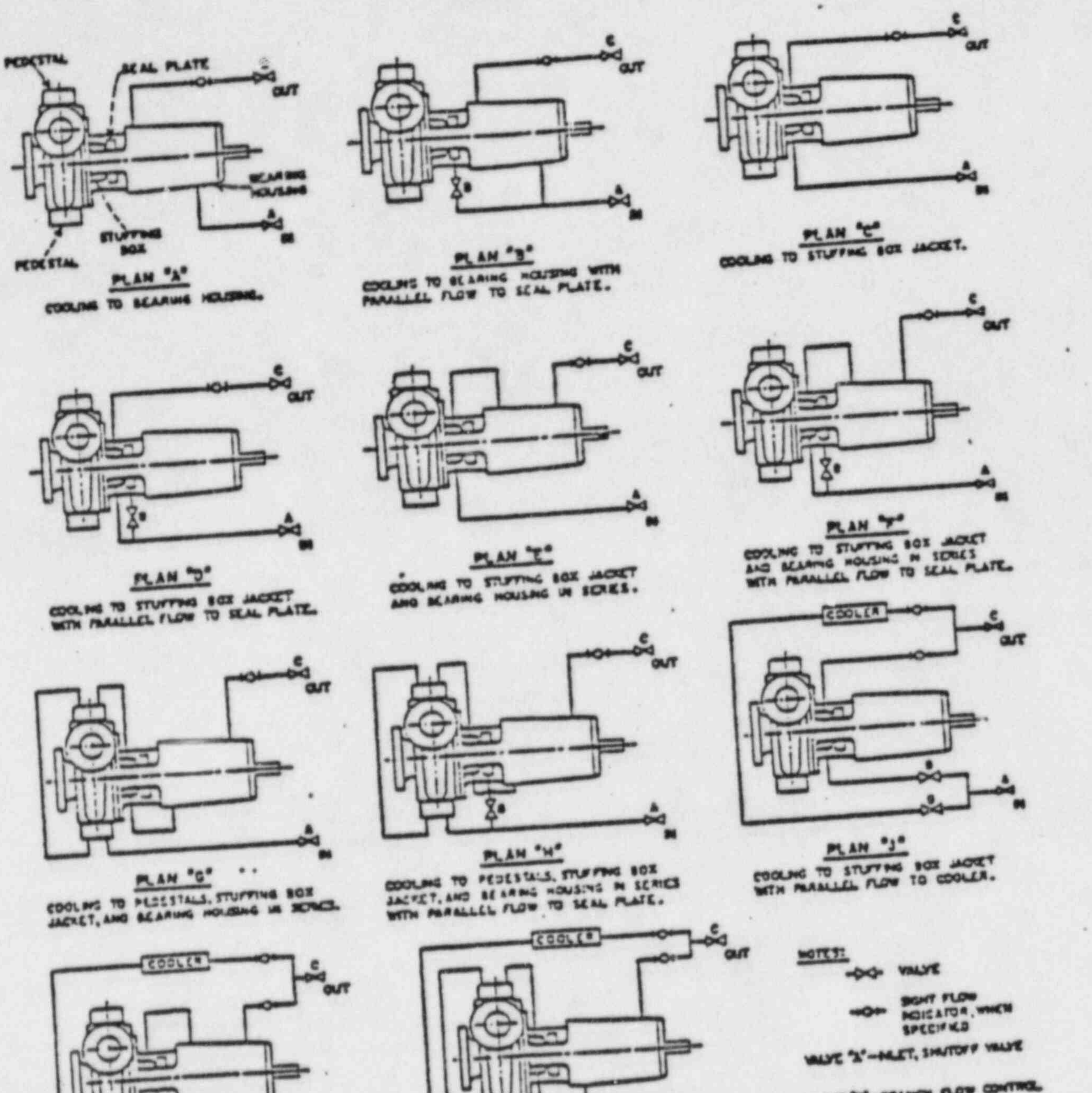
● b. For Plans 51, 52, 53, 54, 61, and 62, purchaser shall specify fluid characteristics when supplemental seal fluid is provided. Vendor shall specify the required gallons per minute (gpm) and pounds per square inch gage (psig) where these are factors, ~~for example, when auxiliary seal is of the outside mechanical type.~~

c. See Fig. C-2 for description of symbols not otherwise specified here a.

~~Piping for Throttle Bushing, or Auxiliary Seal Device,~~ TANDEM SEALS OR DOUBLE SEALS

TABLE III

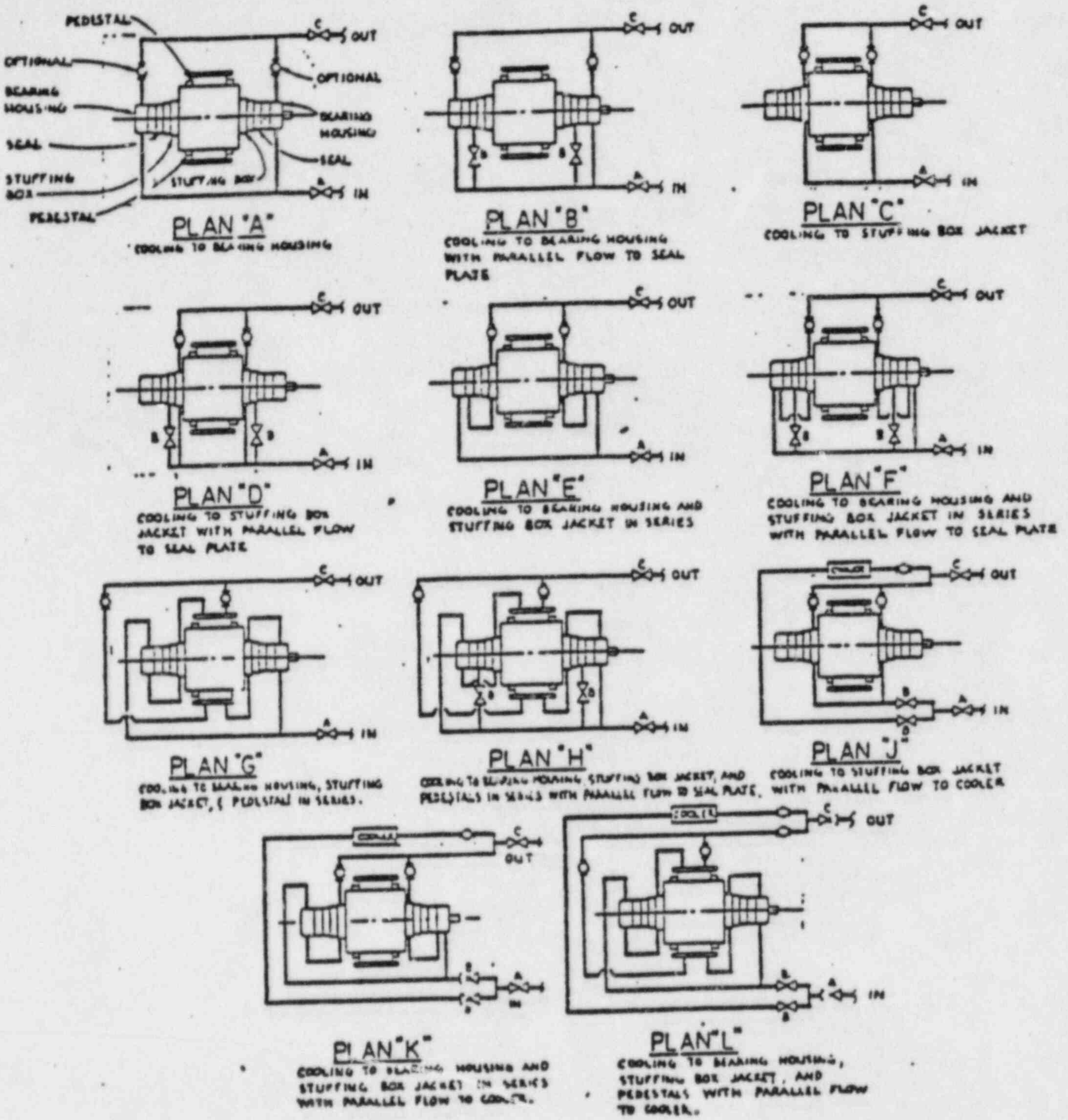
— REPRODUCE THIS PAGE



—Cooling Water Piping.

TABLE IV

PRIOR TO FINAL PRINTING OF STANDARD; PERMISSION NECESSARY FROM API



COOLING WATER PIPING

TABLE V

PRIOR TO FINAL PRINTING OF STANDARD, PERMISSION TO REPRODUCE THIS PAGE IS NECESSARY FROM API

Table VI Limits for unbalanced seals

Seal Diameter (Inches)	Maximum Shaft Speed (RPM)	Maximum Sealing Pressure (psig)
1/2 to 2	Up to 1,800 1,801 to 3,600	100 50
Over 2 to 4	Up to 1,800 1,801 to 3,600	50 25

D R A F T

CAUTION NOTICE - THIS DRAFT HAS NOT BEEN APPROVED, NOR HAS IT BEEN SUBMITTED TO ANSI OR ASME.

AMERICAN NATIONAL STANDARD

FOR

NUCLEAR POWER PLANT EQUIPMENT

Functional Qualification of Motor Drives for Safety Related Code Class 2 and 3 Pumps for Nuclear Power Plants. ASME

ANSI/ASME N45 N 551.4

MAY, 1977

Revised September 1977
January 1978
September 1978
October 1978
JANUARY, 1979

FOREWORD

This document is a composite of the December, 1976 draft of the same document and an undated three-page version derived from the concepts set forth in the December, 1976 draft.

Input for May, 1977 draft and the September 1977 revision was received from:

D. G. Cain	Electric Power Research Institute
R. H. DeLisle	Westinghouse Electric Corporation
D. J. Meraner	General Electric Company
I. U. Rodens	Westinghouse Electric Corporation
M. W. Sheets	General Electric Company

The January 1978 revision resulted from ballots received from the following members of working group 2.2 of IEEE, NPEC, SC-2:

D. G. Cain	EPRI
C. V. Fields	Westinghouse Electric Corp.
R. L. Nailen	Louis Allis
E. E. Richards	Siemens-Allis
I. U. Rodens	Westinghouse Electric Corp.
M. W. Sheets	General Electric Co.
W. G. Stiffler	Reliance Electric Co.
F. L. Unmack	General Atomic Co.
P. R. Weihsmann	Reliance Electric Co.
R. F. Gilton	Siemens-Allis, Chairman Task Force to Review ASME-N-551.4

The September, 1978 revision resulted from comments received at the June, 1978 N551 Steering Committee Meeting, from Mr. W.M. Wepfer's comments on January 1978 Draft of N551.4 and from comments received from Reliance Electric Co. Revision incorporating above by R. F. Gilton, Siemens-Allis, Inc.

The October, 1978 Revision resulted from comment received from ANSI/ASME N45 N551 Steering Committee at the September 2, 1978 Steering Committe Meeting.

THE JANUARY 1979 REVISION RESULTED FROM COMMENTS FROM R. L. NAILEN, LOUIS ALLIS.

C O N T E N T S

1.0 INTRODUCTION

The motors for ANSI Safety Class 2 and 3 safety-related pumps are relied upon to safely shut down the plant or to mitigate the consequences of an abnormal event. These pump motors are classified 1E as defined in IEEE Standard 308-1974.

2.0 SCOPE

This document lists references and outlines procedures for qualifying pump motors for Class 1E Service.

3.0 REFERENCES

3.1 American National Standards Institute (ANSI) Standards

1) NEMA MG.1 - 1978
2) ANSI N45.2 - 1977
3) ANSI N45.2.2 - 1972

3.2 Institute of Electrical & Electronic Engineers (IEEE) Standards

1) IEEE-323-1974 - Qualifying Class 1E Equipment for Nuclear Power Generating Stations.

2) IEEE-334-1974 - Standard for Type Tests of Continuous Duty Class 1E Motors for Nuclear Power Generating Stations.

3) IEEE-344-1975 - Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations.

4) IEEE-308-1974 - IEEE Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations.

5) IEEE-112-1978 - Test Procedure for Polyphase Induction Motors and Generators.

4.0 SPECIFIC DEFINITIONS

The documents referenced in 3.0 contain ~~sufficient~~ specific definitions for ~~implementation of this part of this standard~~.

5.0 SPECIAL MATERIAL REQUIREMENTS

~~Except for the following, there are no special materials requiring coverage by this part of this standard.~~

If the motor shaft is extended to also act as the pump shaft, special shaft material may be required (see Section 8.5.1). It shall be the joint responsibility of the pump manufacturer and the motor manufacturer to assure that the shaft will meet its safety function with due consideration given to the ~~requirments~~ of each piece of equipment

6.0 SPECIAL DESIGN REQUIREMENTS

6.1 In addition to meeting the ~~requirments~~ REQUIREMENTS of Nema MG.1-1978 where applicable, the motor shall be designed so that it can be qualified per the following IEEE Standards.

1) IEEE 323-1974
2) IEEE 334-1974
3) IEEE 344-1975

6.2 Interfaces

Interface loadings via physical attachments ~~of~~ TO the ~~equipment at the equipment boundary~~ MOTOR shall be specified for each operating mode. These external loads ~~must~~ SHALL be simulated or analyzed during the qualification program to ~~provide assurance~~ ENSURE that the ~~equipment~~ MOTOR can perform its required function. In the same manner, ~~motive~~ power or control signal inputs, including those that deviate from normal, ~~must~~ SHALL be specified.

7.0 QUALIFICATION SPECIFICATION CRITERIA

General

The qualification program specifications for nuclear power generating station ~~equipment~~ MOTORS incorporated in a system required to perform a safety function must describe all the criteria to be met to qualify the ~~equipment~~ MOTOR for its intended application. These criteria form the basis for development of a~~n~~ ~~equipment~~ MOTOR qualification program. As a minumum, the following shall be included:

(1) Description of the safety function(s) of the ~~equipment~~ MOTOR

(2) DESCRIPTION OF THE MOTOR AND ANY AUXILIARY COMPONENTS. ~~The equipment boundary, including components that are inside the boundary, and the equipment~~ Physical orientation OF THE MOTOR SHALL BE SPECIFIED

(3) Description of interface attachments, loads, power ~~sources~~ SUPPLY and control signals.

(4) Design codes and standards applicable to the manufacture of the ~~equipment~~ MOTOR

(5) Specific qualification standards that pertain to ~~the specific type of equipment~~ MOTORS.

(6) Definition of normal environment and normal operating loads

(7) Definition of the (normal and abnormal) service conditions for the ~~equipment~~ MOTOR and the limiting criteria for functional performance

(8) Inclusion of margin in the qualification criteria

(9) Acceptance criteria for qualification

(10) Identification of significant aging mechanisms, if applicable

(11) Requirement for documentation of the ~~equipment~~ MOTOR qualification.

7.0 Qualification Specification Criteria continued

Pre-operational or ~~surveillance~~ OPERATIONAL testing performed after installation and acceptance of the ~~equipment~~ MOTOR is outside the scope of this standard.

8.0 QUALIFICATION

8.1 Objective: The principal objective of qualification is to demonstrate that the ~~drive~~ MOTOR and essential auxiliary apparatus can perform its designated safety function. Functional capability, as opposed to reliability, is the intent of functional verification.

8.2 Qualification Methods: A suitable combination of one or more of the following methods shall be used to assure proper qualification. IEEE Std. 323-1974 shall be consulted for general details in the application of these methods. IEEE Std. 334-1974 shall also be considered.

8.2.1 Type testing is testing of a motor using simulated service conditions.

8.2.2 Operating experience utilizes auditable records of operating experience in environments at least as severe as for the ~~equipment~~ MOTOR to be qualified, or in other environments if the differences can be justified.

8.2.3 Qualification by analysis utilizes a documented process of ~~reasing~~ REASONING or tests that lead to qualification from stated premises based on prior information. It may include extrapolations from tests and/or calculations based on similar ~~units.~~ MOTORS.

8.2.4 Ongoing qualification utilizes the observations of the operation of ~~equipment~~ MOTOR which may ~~either~~ have its aging processes accelerated or its aging processes and operation started prior to the required service of the installed ~~equipment~~ MOTOR. Ongoing qualification may also be viewed and documented as a test of unusually long duration.

8.2.5 Combined qualification utilizes a combination of two or more of the methods outlined ~~above.~~ IN 8.2.1, 8.2.2 OR 8.2.3 ABOVE.

8.3 Qualification Procedures

8.3.1 In general, qualification procedures outlined in IEEE 323-1974 shall be followed.

8.3.2 The appropriate analytical procedures of IEEE 323-1974, IEEE 334-1974 and 344-1975 shall be utilized if all, or a portion, of qualification program utilizes qualification by analysis.

8.3.3 The appropriate procedures for qualification by testing of IEEE 334-1974 and ~~EIII~~ IEEE 344-1975 shall be followed whenever testing is utilized as a qualification procedure.

8.3.4 The appropriate procedures for qualification by experience of IEEE 323-1974 shall be utilized whenever experience is utilized as a qualification procedure.

8.3.5 Verification and documentation of the Qualificaton Program shall comply with the ~~requirements~~ of ANSI N45.2-1977 REQUIREMENTS ~~insofar as they apply to~~ AS APPLICABLE TO THE MANUFACTURE OF electric motors.

8.0 QUALIFICATION (continued)

8.4 Extrapolation Procedures

8.4.1 IEEE 323-1974, IEEE 334-1974 and 344-1975 shall be utilized as appropriate, to develop procedures for establishing the validity of the Qualification Program, normally performed on a prototype or on a selected production ~~units~~ models, relative to production ~~units~~ models to be used in the nuclear power plant.

8.4.2 Differences in rating, materials, processes or design between production ~~units~~ models and ~~units~~ models used in the Qualifiction Program shall be documented and justified utilizing the principles established in IEEE 323-1974, IEEE 334-1974 and IEEE 344-1975 as appropriate.

8.5 Interfaces

8.5.1 Interfaces between components in a piece of equipment, between equipments (such as motor and pump) and between equipments and other plant components (such as pump and piping) shall be considered by the organization(s) responsible for the design of components, equipment(s) or system(s). In some cases interface responsibility for items such as shaft material or qualification will be such that mutual agreement must be reached between responsible design groups. Responsibility for assuring adequacy of interface qualification shall be explicitly defined in the Specifications for the equipment or system. In general, the prime contractor for any system has the responsibility for qualification of interfaces within the system.

8.5.2 When equipment, a device or component is selected for qualification, a boundary shall be established, BY THE ORGANIZATION RESPONSIBLE FOR THE QUALIFICATION PROGRAM, which envelopes what is to be qualified. This boundary may go through interfaces.

8.5.3 In establishing the boundary for specific equipment, associated components required for installation in the field shall be identified and qualified using the principles defined in IEEE 323-1974, IEEE 334-1974 and 344-1975. Such components could include:

a. Seals for electrical cable connection boxes, cable trays and cable conduits.

~~b. Process fluid~~

b. Piping and pipe supports

c. Couplings for motor shafts

d. Mounting hold-down bolts

~~8.5.4~~ The above components, located within the interface boundary, shall be clearly defined and qualified by the organization having design responsibility for each component, to assure that the qualification maintains its validity after final installation.

9.0 SPECIAL CLEANING, SHIPPING AND STORAGE REQUIREMENTS

9.1 Cleaning shall be accomplished in accordance with the [REQUIREMENTS] ~~requirments~~ of ANSI N45.2.2-1972 ~~insofar~~ as ~~they apply~~ [APPLICABLE] to the manufacture of electric motors.

9.2 Packaging and shipment shall be accomplished in accordance with the Quality Assurance program established to comply with the requirments of ANSI N45.2.2-1972 ~~insofar~~ as ~~they~~ [APPLICABLE TO] ~~apply to electric motors.~~ [THE MANUFACTURE OF ELECTRIC MOTORS]

9.3 Storage of the motor at any intermediate destination for a period not to exceed one (1) month shall be per the motor manufacturers recommended commercial storage procedures. Motors at intermediate destinations shall be kept in "as shipped" condition or restored to "as shipped" condition prior to reshipment.

9.4 Storage of the motor at any intermediate destination if such storage exceeds one (1) month or at the plant site shall be Level B per ANSI N45.2.2-1972 except that any additional requirements specified by the motor manufacturer shall be met. (This would normally include energized space heaters, addition of lubricant, and rotation of shafts on a periodic basis)

10.0 QUALIFICATION DOCUMENTATION AND RECORD RETENTION

10.1 A specific statement of qualification shall be ~~stated~~ [INCLUDED] as required by IEEE 323-1974, Section 8.1.

10.2 Qualification records shall be retained as required by IEEE 323-1974, Section 8.2.

11.0 QUALITY ASSURANCE

11.1 Quality Assurance for the manufacture of motors shall be as specified in ANSI N45.2-1977, Quality Assurance Program requirements for Nuclear Power Plants ~~insofar~~ as ~~they apply~~ [APPLICABLE] to the manufacture of electric motors.

11.2 The Quality Assurance program to be followed shall be detailed by the motor manufacturer in writing through the use of published manuals, specifications and procedures.