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LICENSING TOPICAL REPORT

Advanced Boiling Water Reactor (ABWR) With Alternate RCIC Turbine-Pump Design

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1.0 Introduction

The purpose of this Licensing Topical Report (LTR) is to obtain US Nuclear Regulatory Commission approval of a generic change in the design certification for the U.S. Advanced Boiling Water Reactor (ABWR) design, in accordance with planned revisions to 10 CFR 52.63. The design change involves replacement of certain portions of the present Reactor Core Isolation Cooling (RCIC) turbine and pump system design with an integrated alternate turbine-pump system design. These proposed changes are to both Tier 1 and Tier 2 of the ABWR Design Control Document (DCD) revision 4, US NRC Docket #52-001. These proposed changes were developed during performance of first-of-a-kind-engineering for the ABWR.

As the regulatory processes for generic amendment of approved and certified reactor designs such as the ABWR (10CFR52 Appendix A) are currently in a state of flux, GE understands that a generic change may not be feasible for the NRC to grant until the planned revision to 10 CFR 52.63 becomes effective. If NRC does not make the planned revisions to 10 CFR 52.63, future COLA applicant(s) would then intend to seek site-specific departures from the DCD based on the content of this licensing topical report. NRC review of the technical content of this LTR is requested with the understanding that this LTR and subsequent discussions between GE and NRC staff may form the basis for site-specific departures requested in one or more future Combined Operating License Applications.

2.0 Description Of Certified Design

The Reactor Core Isolation Cooling (RCIC) System is a single train, divisional safety system consisting of a steam turbine, pump, piping, valves, accessories, and instrumentation and controls designed to provide emergency makeup water to the Reactor Pressure Vessel (RPV) for transient or Loss of Coolant Accident (LOCA) events to maintain coolant inventory and permit adequate core cooling. It is also used for inventory makeup during hot standby conditions. The certified design description is principally found in Tier 1, section 2.4.4 with additional descriptive information in Tier 2, sections 5.4.6 and 6.3.

3.0 Description Of Proposed Departure

The DCD does not specify the type of turbine or pump to be used in the RCIC, and the RCIC design as described in the DCD was structured to support the types of turbine and pumps then on the market and in common use within the US nuclear power industry. In performing first-of-a-kind-engineering, GE determined that an alternate turbine-pump set using a monoblock design is available that provides superior reliability and meets US nuclear codes and standards yet does not need all of the supporting functions and components certified in the DCD. The proposed changes to the DCD involve deletion of supporting components that are not needed for the RCIC turbine/pump selected during first-of-a-kind-engineering. Changes to the pertinent ITAAC are also proposed.

The alternate turbine/pump design is simple and compact in comparison with the turbine and pump combination contemplated at the time of the certified design. The concept and the performance of the alternate design is based on the Turbine Water Lubricated (TWL) technology and represents, in the opinion of the General Electric Company, a substantial increase in reliability over the DCD design.

The proposed design meets all safety-related system performance requirements per the commitments in the ABWR DCD. Further, none of the accident analyses in the DCD are adversely affected by the proposed design.

The following are the DCD Tier 1 changes in section 2.4.4 requested by this LTR. Specific markups of the DCD text and figure are in Appendix C.

To ensure timely startup while reducing risk of overspeed trip and a pressure spike in the steam supply line, the DCD design specified a small DC-powered motor-operated valve in the steam admission line, bypass loop, parallel to the main steam admission motor-operated valve. The bypass valve will be deleted as no longer required because of superior speed regulation of the proposed design. Not removing it would allow unnecessary failure modes and leakage paths. Per COL action item 1.12, a start-up test of the RCIC System will be run during plant start-up.

Manufacturing limitations prevented the DCD design from fully complying with ASME Section III, Class 2. The ABWR certification requested and was granted an exception for the turbine. The DCD design identifies the turbine as non-safety and non-ASME Code section III component, where the alternate design is safety-related and complies with ASME Code Section III, Class 2 requirements. It is proposed that Tier 2 be changed to identify the turbine as an ASME Code Section III, Class 2 component. Attached markups in Appendix C for Tier 2, section 3.2, table 3.2-1 would update the turbine listing and remove footnote (m) listing the otherwise necessary exemptions.

With the proposed monoblock construction of the turbine/pump, shaft seals are no longer required. Hence, there is no possibility of leakage of radioactive steam into the RCIC pump room within the secondary containment. Therefore, the barometric condenser specified in the DCD will no longer be needed, and changes are proposed to Tier 1 and Tier 2 to delete reference to the barometric condenser.

To support the proposed integrated turbine/pump design, a mechanism for ensuring a continuous flow of water through the encased TWL bearing is required. This requirement is satisfied through a leakoff line from the bearing to a separate drain tank where a small pump returns the leakoff water to the main pump suction lines. Head is provided to the main pump by gravity feed from the condensate storage tank (CST) or by the RCIC keepfill pump on the suction line from the suppression pool. The drain tank also captures steam condensate in the turbine exhaust line to the suppression pool.

The following lists a summary of design simplifications based on changes from the DCD turbine/pump to the proposed TWL alternate design;

Simplifications:

3.1 Monoblock Design The monoblock (turbine and pump within same casing) design eliminates risk of coupling misalignment and reduces the installation space by approximately 50%.

Safety Impact: There is no adverse safety impact from integrated turbine/pump configuration with turbine and pump within one sealed casing.

3.2 No Shaft Seal No shaft seals are used in turbine/pump design, since the pump and turbine are in a common casing and the shaft does not extend outside the casing, thus no rotating shaft seal is needed and no steam leakage control is required. The short, stiff shaft, to which both the pump impeller and turbine wheel are attached is fully enclosed within the casing. Based on this feature, no field alignment is necessary nor is field misalignment between turbine and pump credible.

Safety Impact: There is no adverse safety impact from removal of the shaft seal. This eliminates a potential radioactive leakage path from primary containment.

3.3 Bearings location The shaft bearings in the alternate design are in the center between the pump and turbine rotors and are completely within the single casing. In the DCD design, the turbine and pump are each hung between the bearings in their respective casings with special oil passages provided to lubricate the various bearings and to the control components.

Safety Impact: There is no adverse safety impact from locating the shaft bearings inside the single turbine-pump casing.

3.4 Controls The flow control mechanism is an integral part of the proposed turbine/pump assembly. No external control devices are used or necessary. Pump discharge flow passes through an internal venturi. The pressure differential between the venturi inlet and throat work together with a balance piston and spring to control the steam flow to the turbine, which, in turn adjusts the pump speed and flow. In the DCD design the flow control is performed external to the pump and turbine, where flow is measured in a flow element and evaluated in a flow controller to generate an electrical signal to an electro-hydraulic flow control valve to signal a servo to adjust the position of the control valve.

In the alternate (TWL type) turbine-pump design, control is completely internal to the pump and turbine with fewer control components. No external electrical control devices or connections are required for flow control–operation is not dependent on AC electrical power.

Safety Impact: There is no adverse safety impact from changing to the proposed flow control design. Per COL Action Item 1.12, a start-up test of the RCIC System will be ran during plant start-up to confirm that the design protects from turbine overspeed and excessive steam supply line pressure surges.

3.5 Start Transients The normally open control valve in the alternate design operates quickly in response to the pressure differential to adjust the steam flow to the turbine in the required amount to allow the pump to provide the required water flow rate to the reactor pressure vessel. A typical transient is smooth and achieves the full rated speed and flow in approximately 10 seconds. Typical start transient is shown in figure 2. In contrast, the bypass starting option in the DCD design with its associated complex controls, which adds complexity to the system from present design, is eliminated in the alternate (TWL type) design and further simplifies the RCIC System design.

With the DCD design, the normally open governor valve reacts to the initial steam entry through hydraulic actuation. A shaft driven pump provides the pressure for the actuation. To provide time for the hydraulic pump to provide actuator control and to prevent initial start up speed transients, a small steam bypass is provided in the steam supply line. The turbine is brought to an idle speed, which allowed it to stabilize. A command is then given to open the main steam admission valve to permit turbine to increase speed based on an electronic ramp signal. When the bypass has been open for approximately 10 seconds, the main steam valve is opened and speed is increased to achieve rated flow within a maximum time of approximately 30 seconds. Typical start transient for this system is shown in figure 3. The curve labeled "conventional start" is the idealized start transient without the steam bypass.

This start has been shown to result in an over speed trip if there is any delay in the control valve movement during the initial startup. The control valve stem sticking caused from stem and packing corrosion further exacerbates an over speed trip. This caused excessive non-representative frictional force in the valve stem kinematics, resulting in valve opening delay. The alternate (TWL type) turbine-pump design provides turbine protection on "over-speed", based on the 120 % (maximum) of rated speed limit with a mechanical trip design as well as a an electronic over-speed trip which automatically shuts down the turbine upon receipt of any signal indicating turbine over-speed at 115% of rated speed.

The improved reliability of the alternate design provides higher confidence in starting of the pump when needed.

Safety Impact The improved controls and resultant start transient have no adverse safety impact. The quicker response time from alternate (TWL type) turbine/pump meets RCIC system response time requirement (<30 seconds). There is no impact on safety analysis (e.g. PRA, RPV thermal cycle, etc.).

3.6 Lubrication The pump main process water lubricates the bearings in the alternate (TWL type) pump and turbine. The water flows through the bearings after passing through a internal filter. The pump and turbine require no oil lubrication. Because there is no oil lubrication system, there is no need for the oil coolers or the cooling water flow to the bearings. During system standby, a small amount of water flow keeps the bearings lubricated. The water is drained from the turbine exhaust to a drain tank. Then the water is returned to the suction side of the pump.

With the DCD design, both the pump and turbine bearings are oil lubricated. A cooling subsystem is required with oil pump, filter, and cooler for the turbine oil to prevent breakdown of the oil. The oil requires changing and protection from water contamination. The maximum lubricating oil temperature is one of the limiting factors for not pumping high temperature water.

The alternate (TWL type) turbine-pump design has eliminated the oil cooling subsystem.

Safety Impact There is no adverse impact on safety from elimination of the oil cooling subsystem. Elimination of the oil reduces fire hazard and lowers the combustible loading in the RCIC room.

3.7 Sealing System The alternate design turbine-pump set is contained within a single casing. There is no rotating shaft to penetrate the casing requiring sealing and leakage control. The non-rotating stem on control valve is double sealed and any unlikely leakage is piped to the turbine exhaust and hence to the suppression pool.

With the DCD design, rotating shafts exit from the pump and turbine cases. These shafts require seals to contain the water and steam. On the turbine, leakage from seals is captured and piped to the barometric condenser to be condensed. Leakage from the packing seals on the governor control valve and on the trip and throttle valve are also piped to the barometric condenser. The alternate (TWL type) turbine-pump design has no external leakage paths.

Safety Impact: There is no adverse impact on safety from simplified sealing system design.

3.8 Barometric Condenser The barometric condenser is not required for the alternate (TWL type) turbine-pump design.

The barometric condenser is however, required for the DCD turbine-pump design to collect the shaft leakage and the lubricating oil cooling water. Process water is used to condense the steam with the condensate being pumped back to the pump suction piping. A vacuum pump is used to maintain the barometric condenser at a pressure below atmospheric by removing any non-condensable gases and returning them to primary containment.

The elimination of the barometric condenser and lube oil cooling in the alternate TWL type) turbine-pump design significantly reduces the amount of the equipment that could potentially malfunction. In addition, the barometric condenser has the potential of introducing oxygen to the inerted containment via in-leakage at the shaft seals.

Safety Impact; No adverse safety impact from removal of the auxiliary sub-systems resulting from design simplification. Elimination of barometric condenser improves the system reliability and availability and prevents a potential dilution of the containment inert gas.

3.9 Maintenance With a simplified design for the TWL type turbine-pump set, compared to the present design, the maintenance scope is reduced with less maintenance time required, further minimizing impact on any outage critical path. Smaller footprint allows additional laydown area and working space within the ABWR design.

Safety Impact; There is no adverse safety impact from reduced required maintenance.

3.10 Intersystem LOCA (ISLOCA) The alternate turbine-pump design meets the ISLOCA requirements identified in DCD Tier 2 section 3, Appendix 3M. The RCIC system analysis in Appendix 3MA is revised to show deletion of piping formerly subject to ISLOCA pressure and uprated to the "rupture" design pressure otherwise above expected normal design pressure

Safety Impact: There is no adverse safety impact from alternate RCIC turbine-pump design for the ISLOCA considerations. The amount of piping potentially exposed to reactor coolant pressures is substantially reduced.

4.0 Justification for Departure

The proposed changes to the DCD design are justified based on the following reasons:

- All RCIC system nuclear safety performance criteria continue to be met.
- All safety-related pressure boundary components now are ASME N-stamped.
- Reduced amount of piping subject to design pressure uprating due to ISLOCA.
- Reduced RCIC pump room combustible fire loading due to elimination of lubricating oil.
- Eliminated potential radioactive bypass leakage path with elimination of turbine shaft seals.
- Reduces number of active safety-related components (steam bypass valve, electronic governor, flow transmitter).
- Elimination of a potential dilution path for inerted primary containment atmosphere with deletion of the barometric condenser and its return line to the suppression pool.
- Reduces safety-related battery drain from reduced DC power demand during station blackout scenarios with elimination of the bypass startup MOV and electronic flow controls and instruments.

5.0 Qualification Information

The alternate (TWL type) turbine/pump design is environmentally qualified in accordance with IEEE Standard 323 requirements for the environment conditions inside the reactor building for normal and accident conditions. It is also seismically qualified to the requirements of IEEE

Standard 344. The TWL type design meets the environmental and seismic qualification requirements identified in the DCD sections 3.10 and 3.11.

6.0 Description Of The TWL Type Alternate Design

Description of the TWL type alternate design turbine/pump is provided in Appendix A.

7.0 Operating Experience

The alternate (TWL type) turbine/pump design has been used for approximately 30 years in commercial and marine (including naval) as well as nuclear applications. Experience in civilian nuclear power plant applications as the auxiliary feed water pumps for pressurized water reactors in Asia (Ko Ri 1, Ulchin 3 & 4, Yonggwang 5 & 6, Quinshan 2) and in Europe (Ringhals 2, 3 & 4, and Sizewell B.) The utility operator experience comments collected by GE with the alternate turbine-pump design is very positive in all aspects of operation and maintenance, Additional TWL type turbine-pump experience information is provided in Appendix B.

8.0 Nuclear Safety Review

The change from the present turbine-pump design to the alternate (TWL type) turbine-pump design will increase plant safety and will improve plant operation and availability. Maintenance and surveillance/inspection requirements will be reduced, because of simplified design and the reduced numbers of active components. Improved turbine reliability will increase plant safety and reduce risk.

The RCIC system has been shown to comply with General Design Criteria 2, 17, 35, 36, and 37 in Tier 2 section 5.4.6.1. The changes proposed in this LTR will have no effect on GE's evaluation of GDC compliance.

RCIC system performance assumptions used in accident analysis in Tier 2 are shown in figure 6.3-5. The proposed change will meet or exceed the range of pumped flow versus steam pressure in that figure.

The RCIC system has been credited in the accident analysis in section 15.6.5 for a loss of coolant accident. The proposed design will comply with the assumptions for RCIC performance for flow rate, pressure, and response time with no reservation.

The ATWS evaluation in Appendix 15E also credits RCIC with operation following a loss of feedwater with a failure to scram. This is essentially RCIC's non-safety function of isolation makeup during hot standby and is not impacted by the proposed change.

No changes are proposed to containment isolation functions associated with RCIC on the steam supply, suppression pool suction, or water injection lines.

9.0 Consistency with ABWR Design Control Document (DCD)

The design changes described in this LTR are changes in Tier 1 and Tier 2 in Design Control Document (DCD) revision 4. This includes the piping and instrumentation diagram (figure 5.4-8) and the process flow diagram (figure 5.4-9) changes that are marked in Appendix C.

A further detailing of proposed changes to the DCD are described in the next section.

10.0 Descriptions of DCD Markups

Appendix C contains markups to the DCD to account for the changes discussed in this LTR. Changes to text, tables, and figures in Tier 2 will be subject to verification and a written safety evaluation on accordance with section X.A.3 of Appendix A to 10CFR52. A markup to the fire hazard analysis report in Appendix 9A to reflect the reduction in combustible loading is not provided at this time since the current text is bounding.

Tier 1

The proposed change to Tier 1 text involve deletion on page 2.4.4-3 of the reference to the barometric condenser as subject to ISLOCA design pressure requirements.

The revision to figure 2.4.4a will delete the steam bypass valve. Further, note 1 is restated to show compliance with ASME Code Section III for the turbine and the ASME Code and safety classification breaks at the turbine inlet and outlet are removed.

The proposed ITAAC in section 2.4.4 will delete the acceptance criteria pertaining to the steam bypass valve in 3.c, 3.e, and 3.f as the steam bypass valve will be deleted as unnecessary.

In ITAAC acceptance criteria 3.i (2), turbine torque is deleted as this parameter can not be directly measured in the integrated turbine/pump configuration encased in the monoblock design. Delivered flow rate against head is the critical system safety performance parameter in any case.

Tier 2

Table 3.2-1, pages 3.2-28 and 29 provide the classification summary of the RCIC components and subsystems. Reference to the barometric condenser is deleted and the turbine safety classification is upgraded to Quality Group B. The footnote "(m)" is no longer required and is removed on page 3.2-29 and on pages 3.2-57 and 58.

Section 3.9 of Tier 2, "Special Topics" discusses qualification of the pump and turbine as separate components in several places. These words are changed to note the integrated design of the turbine-pump. Section 3.9.3.1.8, page 3.9-34, discussing how the a non-ASME turbine conforms to ASME requirements is deleted in its entirety. Components no longer required are removed from the listing of items subject to in-service testing (IST) in Table 3.9-8 on multiple pages.

Appendix 3MA, pages 3MA-15 and 16, documents the results of the original ISLOCA system analysis for RCIC. With this change, piping and components to be removed are struck from the analysis results. Note that the markups to these pages are preliminary as the ISLOCA system-level analysis will be revisited in the first COLA submittal following further design detailing and review. Note that the drain tank added to support water lubrication is a vented tank and is not subject to over-pressurization per application of the criteria in Tier 2, Appendix 3M.

The two DCD piping and instrumentation diagrams (P&IDs), DCD section 5.4, figures 5.4-8 and 9 are included with general "bubbles" to indicate the equipment to be removed. The actual proposed P&IDs will be included in the first COLA submittal.

Markups to section 5.4.6.2 incorporating details of construction and operation within pages 5.4-23, 24, and 27 are also attached.

The design parameters for the RCIC system are covered in table 5.4-2. The listings for the components for the barometric condenser, the vacuum pump, restricting orifices, and the steam bypass valve are deleted on pages 5.4-61, 62, and 63.

Section 6.3.2.2.3 contains a reference to a RCIC dependency on an external cooling water supply. This is dependency is no longer needed so the text is deleted on page 6.3-8.

11.0 Conclusions

- Use of the alternate turbine-pump set design will improve plant safety and will fully meet the RCIC System design and performance requirements identified in the ABWR Design Control Document.
- All DCD Tier 2 changes have been evaluated under the criteria in Section VIII.B.5 of the ABWR design certification rule and no unreviewed safety question is created by the proposed departure.

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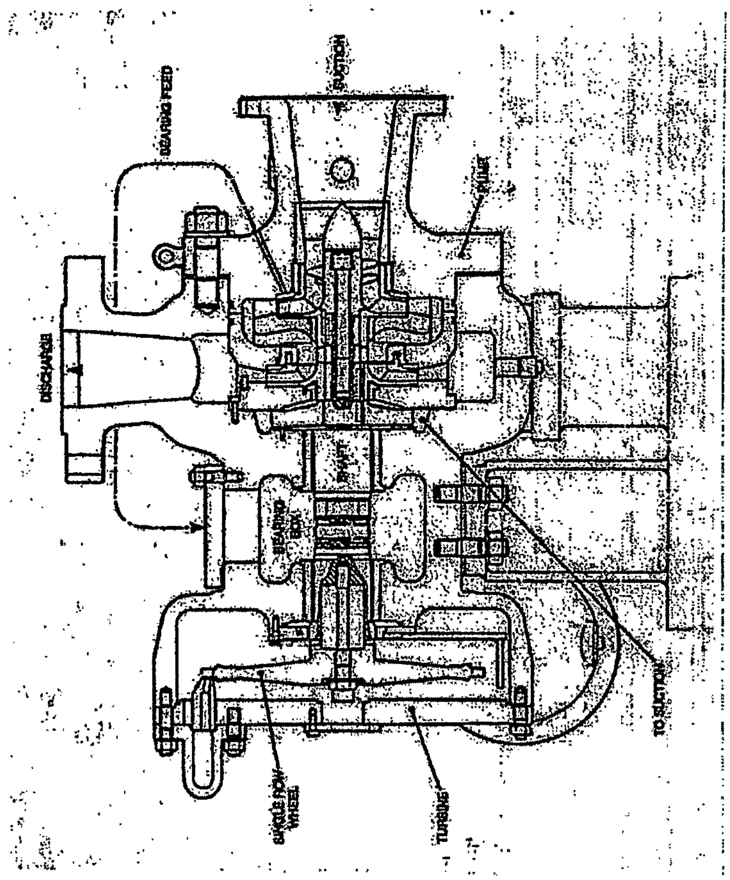


Figure 1: TWL Type Turbine-Pump Assembly

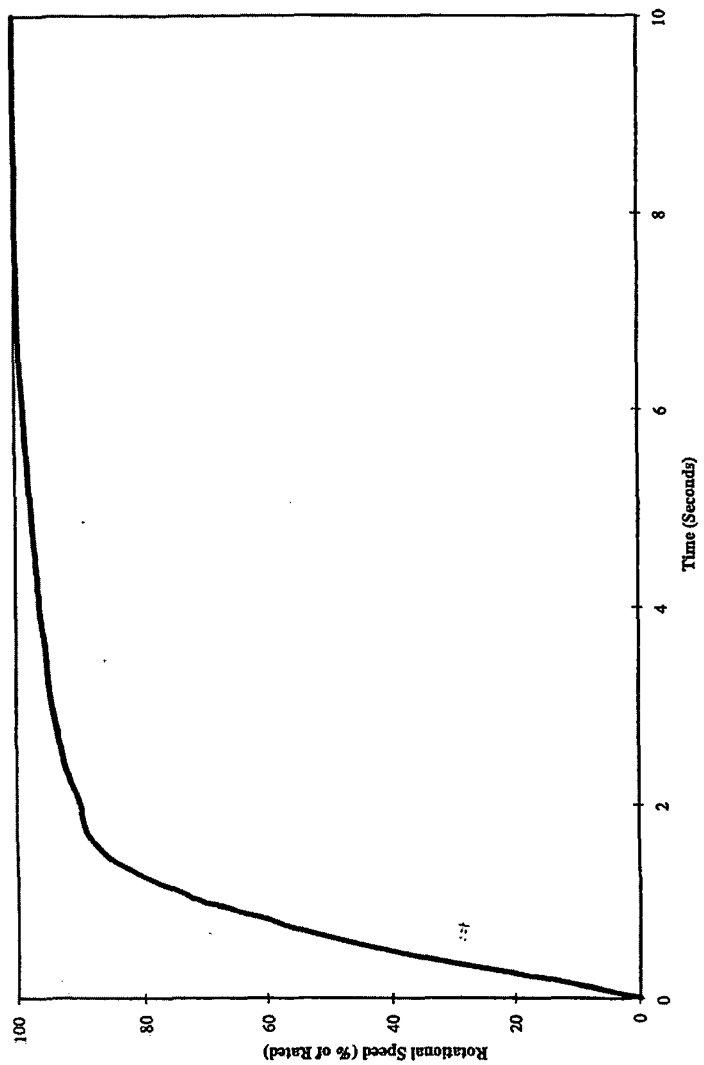


Figure 2: Typical Start Transient

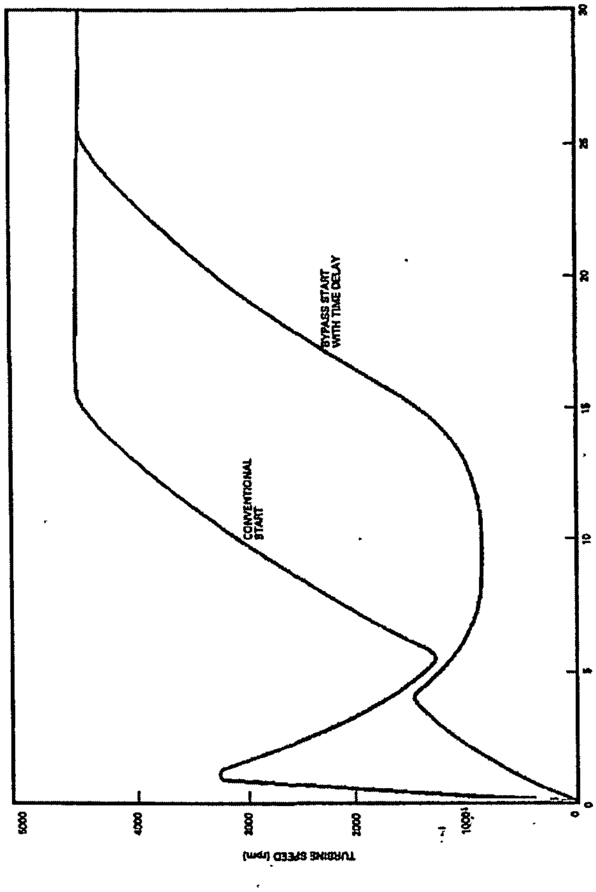


Figure 3: Conventional Start With Bypass

Appendix A

DESCRIPTION OF TWL TYPE ALTERNATE DESIGN

Introduction

The type TWL pumps are of horizontal, two-stage centrifugal design driven by a steam turbine contained in a turbine casing integral with the pump casing. The turbine wheel has a single row of blades. The pump impellers, turbine wheel and inducer are mounted on a common shaft which is supported on two water lubricated journal bearings. The bearings are housed in a central water chamber between the turbine and pump casings, and are lubricated by a supply of water taken from the discharge of the first stage impeller and led to the bearings through a water strainer. The pump is supported on the pedestals of a fabricated steel base plate by feet formed on the pump casing and central water chamber. The monoblock construction of the pump eliminates the need for alignment between the pump and the turbine.

The operating speed of the pump is governed by the turbine control gear which regulates the quantity of steam to the turbine. The main elements of the control gear are the steam stop valve, the throttle valve and the pressure governor. The pump is also provided with electrical and mechanical over speed trip mechanisms which close the steam stop valve when the speed reaches predetermined levels. Speed measurement is provided by an electronic tachometer.

Description

Pump and Turbine

Pump/Turbine Casing and Covers

The pump/turbine casing is integral and incorporates, at one end, the turbine casing with a flanged exhaust branch and, at the other end, the pump casing and the pump discharge branch. The reduced diameter central portion of the casting forms the housings for the water-lubricated journal bearings, the over speed trip gear and a central water chamber.

The turbine end is closed by the turbine cover, which is spigotted to the casing and secured by studs, nuts and washers. Leakage between the cover and the casing is prevented by a fiber joint. The steam nozzle box forms part of the turbine cover casting, to which the steam chest is welded. The nozzle box accepts the steam from the throttle valve in the steam chest and distributes it to the nozzle segment which is secured to the cover by socket head screws. The turbine is an (all round) admission machine and the nozzle segment comprises twenty equally spaced supersonic nozzles of convergent/divergent cross section. These nozzles convert the pressure energy of the steam into velocity energy and direct the high velocity steam to the turbine blades.

The pump end is closed by the pump cover which incorporates the flanged pump suction branch, and houses the nose cone and the other wear ring for the first stage impeller. The pump cover is spigotted to the pump casing and secured against the ring section/diffuser by studs, nuts and washers. Leakage is prevented by an 'O' ring and a back-up ring set in a groove in the pump cover spigot.

To eliminate axial thrust due to a differential pressure across the turbine wheel, a balance return pipe is secured to the centre of the turbine cover by studs, nuts and washers and is led to the turbine exhaust branch.

The central portion of the casing incorporates a central water chamber, the housings for the two water-lubricated journal bearings, facings for the attachment of the bearing lubricating water inlet pipe, the lubricating water control orifice, the over speed trip gear, the probe for the electronic tachometer and an inspection cover.

The pump/turbine casing is supported on the pedestals of a fabricated baseplate on feet formed on the pump casing and central water chamber, while the turbine casing is overhung to allow for expansion.

Fixed Elements

Pump End

The fixed elements in the pump end casing consist of the ring section, diffusers, balance ring and the thrust ring.

The ring section and diffusers form the transfer passages from the first stage impeller outlet to the second stage impeller inlet and from the second stage impeller outlet to the discharge annulus, the diffusers being designed to convert the kinetic energy of the water into pressure. The integral ring section/diffuser casting is located in the bore of the pump casing and held against the balance ring by the pump cover. Leakage is prevented by an 'O' ring set in a groove in the ring section spigot, and an anti-rotation pin is fitted between the last stage diffuser and the balance ring. Leakage between the stages is restricted by an interstage wear ring and an inner ring shrunk into the ring section and retained by grub screws.

The balance ring acts in conjunction with a balance piston mounted on the shaft to affect the hydraulic balance of the pump and is secured in a recess in the pump casing by cap screws. Leakage between the balance ring and the casing is prevented by an 'O' ring set in a groove in the back face of the ring. A restriction bush is shrunk into the bore of the ring and retained by three grub screws.

The thrust ring is located in a recess in the pump casing, and acts in conjunction with the balance piston to accommodate thrust reversals, which may occur during start-up. The thrust ring is retained in the recess by a countersunk head screw, the head of which is below the thrust ring surface.

Turbine End

The fixed elements in the turbine casing are the restriction bush, distance piece and baffle plate.

The restriction bush is located in the bore of the distance piece and retained by grub screws.

The baffle plate, together with the distance piece and restriction bush, prevents water leaking through the turbine end journal bearing and impinging on the turbine wheel. The plate and distance piece are secured to the casing by hexagon head screws locked by lock-washers.

Rotating Assembly

The rotating assembly consists of the shaft, inducer, impellers, balance piston, magnetic plugs, over speed trip bolt, turbine wheel, keys, impeller locknut and the impeller and turbine bolts.

The balance piston is prevented from rotating on the shaft by a balance piston drive button. The last stage impeller is keyed to the shaft and retained against the balance piston by the impeller lock nut. Leakage between the balance piston and the shaft is prevented by an 'O' ring set in a groove in the bore of the balance piston. The first stage impeller is keyed to the shaft, and the inducer is located in the bore of the impeller hub. The first stage impeller abuts the second stage impeller lock nut and, together with the inducer, is retained by the impeller bolt, which is secured in the hub of the inducer by a locking plate and a circlip.

The turbine wheel is located on the shaft by a Hirth coupling, which transmits the turbine power to the shaft, and permits a small amount of diametral expansion while retaining accurate alignment. The turbine wheel is secured to the shaft by the turbine bolt, which extends through a hollow portion of the shaft. This forms a heat barrier between the adjacent journal bearing and the turbine. The bolt is locked to the turbine wheel by a lock-washer retained by a circlip.

The centre portion of the shaft, between the journal bearings, is reduced in diameter and contains the relay type over speed trip bolt. The trip bolt assembly consists of the trip bolt body, piston, spacer, inner and outer springs, end cap and fixed and adjusting plugs. The piston, spacer and inner spring are contained within the trip bolt body. The centre of gravity of the piston is on the side of the shaft axis in the direction in which the trip bolt moves to strike the trigger, while the combined centre of gravity of the piston and bolt lies on the other side of the shaft axis. Thus, when the shaft begins to rotate, the piston will tend to move outwards against the inner spring and the trip bolt to move outwards against the adjusting plug. When the tripping speed is reached, the piston will have moved far enough outwards to move the combined centre of gravity to the other side of the shaft axis, thus causing the trip bolt to move against the outer spring until it strikes the trigger. The tripping speed can be adjusted through the inspection cover in the pump/turbine casing by turning the adjusting plug and re-locking it. Two magnets 180° apart provide the necessary signal for the operation of the electronic speed probe screwed into the side of the casing.

Bearings

The rotating assembly is supported by two water-lubricated carbon journal bearings. The bearings are installed in the casing with the housings retained by hexagon head screws at their outer ends.

The bearings are lubricated by a supply of water taken from the discharge of the first stage impeller and led, through a connection on the pump cover and a water strainer mounted on the pump base plate, to the central water chamber between the bearings.

The pressure in the central water chamber is regulated by the lubricating water orifice valve mounted on the outside wall of the chamber. Excess flow is returned to the pump suction through a leak-off pipe connected to the balance return pipe.

Hydraulic Balance

The rotating assembly is subject to varying thrust forces due to the differential pressure forces acting on the impellers and to any differential pressure across the turbine wheel.

The thrust caused by the discharge pressure acting on the area outside the impeller wear ring on the inlet side of each impeller is balanced by the same pressure acting on an equal area on the outlet side of the impeller. The thrust caused by the suction pressure acting on the area inside the wear ring is overcome by the discharge pressure acting on an equal area on the outlet side of the impeller. The resultant thrust force due to the different pressures acting on these areas tends to move the rotating assembly towards the suction end of the pump casing and this thrust force is increased by the thrust generated by the axial inducer and by the thrust due to differential pressure across the turbine wheel.

To control the axial movement of the rotating assembly, a balance piston is employed to counteract the effect of this thrust. Water at approximately pump discharge pressure passes between the hub of the last stage impeller and the balance ring restriction bush and into the annular space between the balance ring and the balance piston, at a lower pressure. This pressure, acting on the balance piston, tends to push the rotating assembly toward the turbine end of the pump. When the thrust on the balance piston overcomes the turbine/impeller thrust, the gap between the piston and ring widens, causing the pressure to drop and allowing the rotating assembly to move back towards the pump end, and the cycle is repeated, with smaller movements each time, until the balance system stabilizes and any axial movement of the rotating assembly is negligible.

The leakage past the balance piston enters a balance chamber formed between the balance ring and a recess in the pump casing and is maintained at pump suction pressure by the balance pipe which returns the water to the pump suction. A second balance return pipe, connected between the turbine cover and the turbine exhaust branch, prevents the build-up of steam pressure on the inlet side of the turbine wheel.

During start-up only, the direction of the thrust may reverse briefly, pushing the rotating assembly towards the turbine end of the pump, and bringing the back face of the balance piston into contact with the thrust ring secured to the pump casing. As the pump speed rises, however, all thrust is towards the pump end and is accommodated by the hydraulic balance arrangement.

Over-Speed Trip Gear

Two separate types of over speed trip are provided for the safety of the turbine driven pump, namely: a primary electronic over speed trip which operates via speed sensed by the electronic tachometer, and a secondary mechanical trip which is actuated by a trip bolt contained in the pump shaft. In each case, the trip operates by releasing the steam pressure on the underside of the stop valve piston, allowing the steam pressure on the upper side of the piston to close the valve, thus stopping the pump.

Electronic Trip

The electronic trip operates independently from the mechanical trip by opening a solenoid-operated valve connected between the steam pipe from the stop valve to the meter valve and the meter valve outlet to the steam exhaust. When the electronic trip is actuated, the solenoid valve opens, thus allowing steam pressure to be released to exhaust, thus causing the stop valve to close and bringing the pump to rest.

The operation of the electronic trip is automatic by means of a signal from the electronic tachometer, and will trip the pump. Manual push buttons under operator control are provided on the local control panel and main control room. Reset push buttons are also provided at the local control panel and main control room.

For testing the mechanical trip, a push-button is provided on the local control panel which, when pressed, overrides the electronic trip to allow the pump to reach the mechanical tripping speed. When the push-button is released, the electronic trip is re-activated. Should the mechanical trip fail to operate, releasing the override push-button will automatically trip the pump, since the speed will be above the preset level for the electronic trip.

Mechanical Over-Speed Trip Gear

The over speed trip gear assembly is located on a facing on the side of the casing central water chamber and is secured by studs, nuts and washers. Leakage is prevented by a joint interposed between the trip gear casing flange and the facing on the central water chamber.

A spring-loaded trigger, carried on brackets on the trip gear casing, protrudes into the central water chamber. In the set position, the trigger maintains a close clearance with the over speed trip bolt mounted in the shaft, and is held in this position by a trip level carried on a cross spindle in the trip gear casing. A reset lever is mounted on the end of the trip lever spindle where it extends outside the casing, which is closed at its outer end by a combined casing cover and cylinder secured to the casing by screws and washers. Leakage is prevented by a joint between the casing and the cover. The cylinder contains a meter valve carried on a valve spindle and held against a seating in the bore of the cylinder cover by a spring. The cylinder cover is screwed into the top of the cylinder, sealing being effected by a joint. From the flanged top of the cylinder cover, a pipe is led to the underside of a piston in the stop valve body.

The spring is contained in a spring carrier, which protrudes through the lower end of the cylinder and rests on the hand reset lever. As the spring is in compression, the reset lever and the trip lever are held in the set position. A manual knock-out knob extends through the trip gear cover and casing, and is spring-loaded to hold it clear of the trigger.

When the pump reaches tripping speed, the trip bolt in the shaft is thrown outwards to strike the trigger and knock it away from the shaft. The movement of the trigger releases the trip lever, which swings upwards, under the action of the spring in the meter valve cylinder. This, in turn, causes the hand reset lever to move downwards, thus releasing the compression on the spring and allowing the meter valve to fall open.

The steam pressure in the pipe leading to the underside of the stop valve piston is released to the turbine exhaust branch through a pipe connected to a port in the cylinder wall, and the pressure on the upper side of the stop valve piston causes the stop valve to close, cutting off the steam supply to the turbine and bringing the pump to rest.

To actuate the trip manually, the knock-out knob is struck by hand, thus causing the end of the knock-out spindle to strike the trigger and disengage the trip lever. Once the trip level is released, the trip gear operates as described above.

The over speed trip is reset by raising the lever, which closed the meter valve and lowers the trip level until it engages with the trigger and holds it clear of the shaft.

Stop Gear and Pressure Governor

Steam Stop Valve

The steam stop valve cuts off the steam flow to the turbine and is designed to be closed automatically by the over speed trip gear when the turbine reaches a predetermined speed.

The cast steel stop valve chest, which also houses the throttle valve assembly, is welded to the nozzle box forming part of the turbine cover. The valve chest is closed at one end by the stop valve cover secured to the valve chest by studs, nuts and washers, and sealed by a spiral-wound metal joint. The stop valve cover incorporates a neck ring and a stuffing box containing soft packing retained by a gland held on the cover by studs and nuts, through which the stop valve spindle passes. The stop valve guide bush located in the bearing cover, spigotted to the inner face of the stop valve cover and secured by socket head cap screws, provides a location for an extension of the stop valve spindle. A steam strainer, consisting of a perforated steel plate, is located in the bore of the steam inlet branch and secured by grub screws. Opposite the stop valve cover, a piston liner is shrunk into a cylinder formed in the valve chest, and the cylinder is closed by the steam chest cover secured to the valve chest by studs, nuts and washer and sealed by a spiral-wound metal joint. From a flange formed on the steam chest cover, a pipe is led to a similar flange on the cover of the over speed trip gear cylinder.

The stop valve seat is formed within the valve chest, and an extension of the valve carries a piston, which operates within the piston liner in the valve chest. The piston carries two piston rings to limit leakage, and is secured to a shoulder on the valve extension by a lock-nut and lock-washer.

During normal operation, the valve side of the piston is subjected to the full steam pressure being led to the turbine nozzle box. The underside of the piston receives the same steam pressure by means of controlled leakage through a drilled hole in the stop valve and an orifice screwed into the end of the valve extension and retained under the piston lock-nut.

The piston diameter is larger than that of the valve seat, and the difference in areas will keep the stop valve closed until the steam is admitted to the underside of the piston. As the steam pressure is maintained in the cylinder by the closed meter valve in the over speed trip gear cylinder, the piston is now subjected to the same pressure on both sides.

It therefore has no effect on valve action, but because the outlet side of the stop valves is at exhaust pressure, there will be a net force acting on the valve, causing it to open.

Steam will now be admitted to the turbine, which will begin to rotate. When the over speed trip is operated, the meter valve opens, the steam pressure on the underside of the piston is released and the pressure on the upper side cause the piston to move in that direction, thus closing the stop valve. As the meter valve will remain open until the trip gear is reset, the steam leakage past the piston is led to the turbine exhaust, through the port in the trip gear cylinder. The pressure on the underside of the stop valve piston cannot build up and the stop valve will remain closed. When the meter valve is closed, the steam pressure will again build up under the piston and the turbine will re-start.

Throttle Valve

The throttle valve is operated by the differential pressure governor to control the steam flow to the turbine and thus regulate the output from the pump to satisfy operational requirements.

The throttle valve cage is located in the lower part of the stop valve chest, which is closed by the throttle valve cover secured to the valve chest by studs, nuts and washers, and sealed by a spiral-wound metal joint. The throttle valve cover incorporates a neck ring and a stuffing box containing soft packing retained by a gland held on the cover by studs and nuts. An extension of the throttle valve cover carries a spindle guide plate incorporating a spindle guide bush. The guide plate is secured to the throttle valve cover by screws and washers. The throttle valve spindle extends through the guide plate to connect to the operating linkage between the throttle valve and the pressure governor.

The throttle valve is a semi-balanced spool sliding within the cage, and steam entering the throttle valve splits into two streams. The first flows through the control ports in the cage to the nozzle box while the second flows through a transfer passage to a second set of control ports at the bottom of the cage. The steam flows through these ports into an annulus around the centre of the spool and then exits to the nozzle box. The transfer passage, annulus and transfer port are sized to ensure that the control of the steam flow is governed by the two sets of control ports. The semi-balanced design of the spool ensures that the only residual force is that exerted on the control spindle, which passes through the cover gland to atmosphere.

The position of the throttle valve within the cage is determined by the movement of the pressure governor in response to the pump discharge pressure, pump flow and steam pressure. This movement is transferred to the throttle valve spindle through the linkage.

Leakage of steam past the bottom of the throttle valve is reduced in pressure by a series of serrations in the cover neck ring, and is then led from the throttle valve cover to the turbine exhaust.

Differential Pressure Governor

The pressure governor controls the power output of the turbine by operating the throttle valve in the stop valve chest through a linkage connected between the pressure governor and throttle valve spindles.

Four inlet connections are provided on the differential pressure governor. Full pump discharge pressure from a connection on the pump casing is led through a strainer to the governor cylinder above the pressure governor lower piston. The pressure taken from the throat of the Venturi in the pump discharge branch is led through a second strainer to the cylinder below the lower piston. The full pump discharge pressure is also led through a solenoid operated 4-way crossover valve which in normal operation passes the discharge pressure to the bottom of the upper piston via a strainer. The top of the upper piston is connected through the crossover valve to vent.

The resultant differential pressure on the lower main piston, together with the venture throat pressure on the lower piston rod produces a total downward hydraulic force. This downward force is opposed by an adjustable spring stack, held between spring carriers in the governor casing assembly, and by the unbalanced steam force on the throttle valve spindle.

The governor senses steam supply pressure, pump discharge pressure and venture throat pressure and is therefore sensitive to both pressure and flow. At any point in the operating envelope, the governor is in balance such that: Steam force + Spring force = Total hydraulic force. The spring force arising from the above equation determines the spring compression and therefore the governor stroke.

The governor stroke determines the area of the steam control ports exposed to the steam flow and by careful profiling of these parts is arranged to pass the necessary steam flow to produce the turbine power required at that particular condition.

As the steam pressure reduces to the decay value, the pump discharge pressure is insufficient to significantly compress the spring and the throttle valve tends toward the full open position to maximize the turbine power.

When the pump is required to give a reduced or partial flow, the crossover valve is activated from the main control room. The valve transfers full discharge pressure from the bottom of the upper piston to the top and the vent to the bottom. Downward thrust on the pressure governor spindle is increased causing the throttle valve spindle to rise and reduce the steam flow and turbine power. This results in a reduced output from the pump.

Control Panel

The control and instrumentation equipment for each pumpset is mounted in a local control panel.

The panel provides overspeed control and pump turbine operational status for the pumpsets including monitoring turbine speed, operation of the turbine trip solenoid, operation of the DC reset solenoid, local panel annunciation, local and remote trip and reset functions and other control components necessary to provide a complete system.

Design Data

Pump

Type	Horizontal two-stage centrifugal pump with inducer and water –lubricated bearings, turbine-driven on a common shaft.
No. of stages	2
Liquid pumped	Condensate
Suction temperature °C	77
Specific gravity	0.974
Suction pressure, Bar a	4.8 (Max)
NPSHR at pump centre-line, m	7.3
NPSHA at pump centre-line, m	7.3
Discharge pressure, bar a	99.49 (Max RPV), 20.47 (Min RPV)
Differential head, m	991(Max RPV) 164 (Min RVP)
Flow, m^3/h	195
Speed, rev/min.	6000 (Max RPV), 3210 (Min RPV)
Pump efficiency, %	63
Direction of rotation	Clockwise looking on suction end

Turbine

Inlet steam pressure, bar a	84.77 (Max RPV), 11.0 (Min RPV)
Inlet steam temperature, °C	296.7 (Max RPV), 184.9 (Min RPV)
Inlet steam condition	Saturated
Exhaust pressure, bar a	1.55 (Max RPV), 1.21 (Min RPV)
Mechanical overspeed trip speed	7200 (Max), 7080 (Min)
Electrical overspeed trip speed	6900 (Max), 6780 (Min)

Bearings

Type	Carbon

Lubrication

Liquid	Pumped fluid
Pressure, bar g	67.7
Temperature, °C	77 (Max)
Lubrication flow, US gal/min	5 (Max) (Standby mode only)

Bearing Water Filter

Type	Strainer

Appendix B

OPERATING EXPERIENCE INFORMATION

Operating Experience of TWL Type Design

(As Reported by Operating Plants)

(1). Preventive Maintenance

Vibration measurements	Every year
Check of movement in overspeed trip bolt	Every year
Overhaul of governor	Every three years
Overhaul of turbine and pump	Every six years

(2). No Failure Reported on Start/Run when required. The overall reliability and operability of the TWL when compared to convention Turbine Auxiliary Feedwater design is rated as good.

(3). Opinion of Senior Operations Personnel (i.e.: Shift Supervisor) of this equipment with regard to ease of operation and operability: Very simple to operate. No operational problems.

TWL Type Pumps Experience in Auxiliary Feedwater and Emergency Core Cooling Pumps In Nuclear Power Stations

Location	Driver	# Offered	Status C = Commissioned S = Supplied M = Being Manufactured
Torness	Motor	4	C
Haysham	Motor	4	C
Yonggwang 3 & 4	Diesel	4	C
Yonggwang 3 & 4	Motor	4	C
Vandellos	Motor	2	S
Wolsong 2, 3 & 4	Motor	9	C
Ringhalls 2, 3 & 4	Turbine	3 (TWL)	C
Ko Ri 1	Turbine	1 (TWL)	C
Hinkley 'B'	Motor	2	C
Hunterson 'B'	Motor	2	C
Sizewell 'A'	Motor	2	C
Sizewell 'B'	Motor	2	C
Sizewell 'B'	Turbine	2 (TWL)	C
Ulchin 3, 4, 5 & 6	Motor	8	C
Ulchin 3, 4, 5 & 6	Turbine	8 (TWL)	C
Yonggwang 5 & 6	Motor	4	C
Yonggwang 5 & 6	Turbine	4 (TWL)	C
Qinshan 2	Motor	2	C
Qinshan 2	Turbine	2 (TWL)	C
Dungeness 'B'	Diesel	3	C
Kola	Diesel	3	C
Lungmen 1 & 2	Turbine	2 (TWL)	S
Shin Kori	Motor	2	S
Shin Kori	Turbine	2 (TWL)	S
Qinshan II Ext	Motor	2	M
Qinshan II Ext	Turbine	2 (TWL)	M
Ling Ao 2	Motor	2	M
Ling Ao 2	Turbine	2 (TWL)	M
	TOTAL	89 Pumpsets	

Appendix C

ABWR DCD Tier 1 and Significant Tier 2 Marked Changes

Outside the primary containment, except for the piping from the CST, the RCIC System shown on Figure 2.4.4a is physically separated from the two divisions of the High Pressure Core Flooder (HPCF) System.

The RCIC System has the following displays and controls in the main control room (MCR):

(1) Parameter displays for the instruments shown on Figure 2.4.4a.

(2) Controls and status indication for the active safety-related components shown on Figure 2.4.4a.

(3) Manual system level initiation capability for RPV water makeup mode.

(4) Manual override of the automatic CST to S/P suction transfer.

The safety-related electrical components (including instrumentation and control) shown on Figure 2.4.4a located inside primary containment and in the Reactor Building are qualified for a harsh environment.

The motor-operated valves (MOVs) shown on Figure 2.4.4a have active safety-related functions to open, close, or both open and close, and performs these functions under differential pressure, fluid flow, and temperature conditions.

The check valves (CV's) shown on Figure 2.4.4a have active safety-related functions to open, close, or both open and close under system pressure, fluid flow, and temperature conditions.

The RCIC turbine is tripped if a low pump suction pressure condition is present.

The following RCIC System components:

(1) Piping and components from the pump suction MOV's up to the pump inlet,

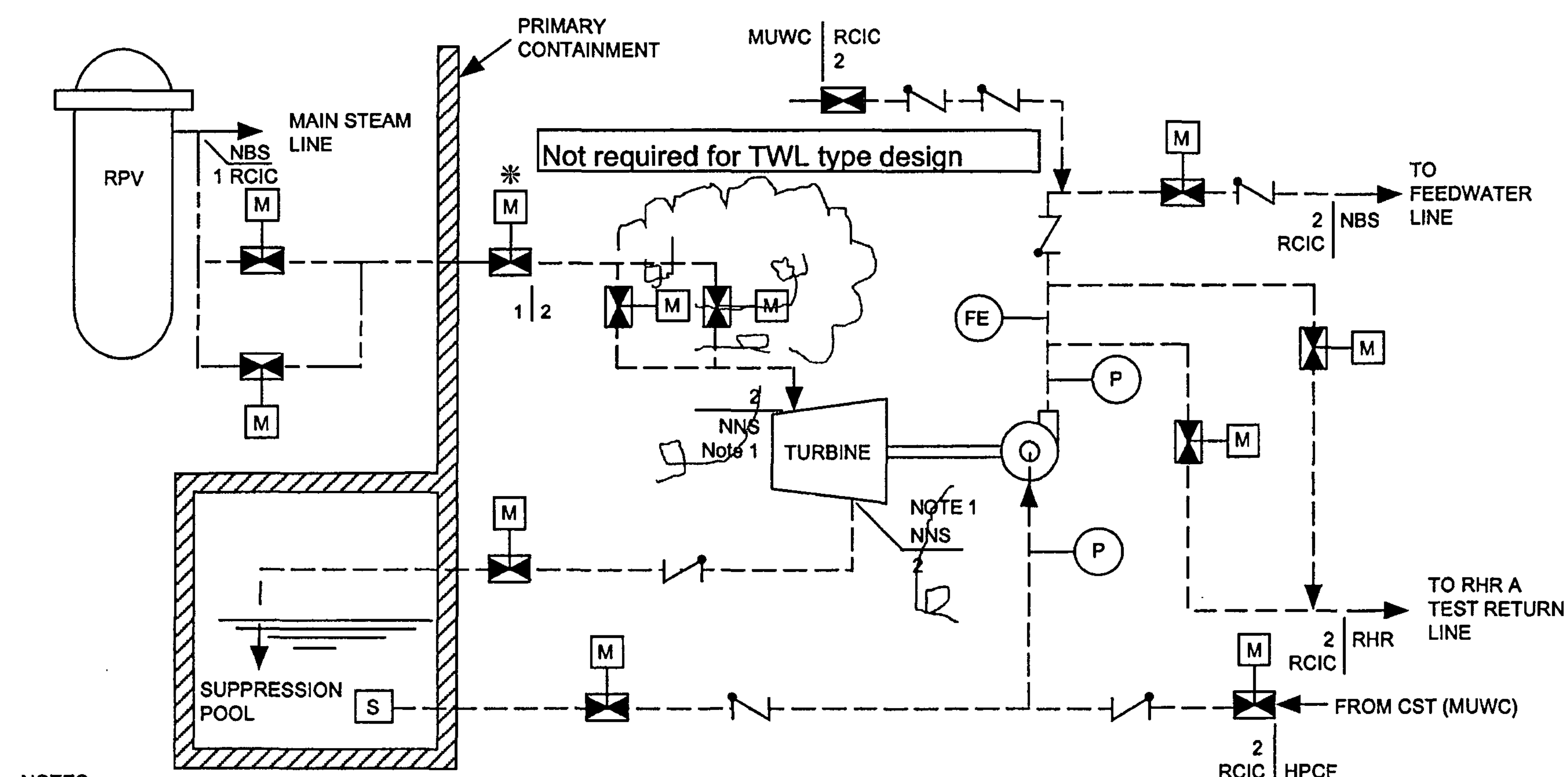
~~(2) Barometric condenser and associated equipment~~

Not required for TWL turbine

have a design pressure of 2.82 MPaG for intersystem loss-of-coolant accident (ISLOCA) conditions.

Inspections, Tests, Analyses and Acceptance Criteria

Table 2.4.4 provides a definition of the inspections, test and/or analyses, together with associated acceptance criteria, which will be undertaken for the RCIC System.



NOTES:

1. RCIC TURBINE IS ~~NOT~~ COVERED BY ASME CODE SECTION III ~~BUT IS DESIGNED, FABRICATED, AND INSTALLED TO SAFETY-RELATED STANDARDS AND IS CONSISTENT WITH THE ASME CODE SECTION III REQUIREMENTS. THE TURBINE INCLUDES THE TURBINE TRIP AND THROTTLE VALVE.~~

TWL turbine is designed & fabricated to ASME Code Section III

2. ALL RCIC SYSTEM COMPONENTS SHOWN ON THIS FIGURE ARE POWERED FROM CLASS 1E DIVISION I EXCEPT FOR THE OUTBOARD CONTAINMENT ISOLATION VALVE (✻) WHICH IS CLASS 1E DIVISION II.

3. ALL RCIC SYSTEM COMPONENTS SHOWN ON THIS FIGURE EXCEPT THE INBOARD CONTAINMENT ISOLATION VALVES, ARE POWERED FROM DC SOURCES.

Figure 2.4.4a Reactor Core Isolation Cooling System

Table 2.4.4 Reactor Core Isolation Cooling System (Continued)

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	**Inspections, Tests, Analyses**	**Acceptance Criteria**
c. Following receipt of an initiation signal, the RCIC System automatically initiates and operates in the RPV water makeup mode.	c. Tests will be conducted on the RCIC System using simulated initiation signal. Not required for TWL type design	c. Upon receipt of a simulated initiation signal, the following occurs: (1) ~~Steam supply bypass valve receives open signal.~~ (2) Test return valves receive close signal. (3) CST suction valve receives open signal. (4) ~~Injection valve receives open signal after a 10-second time delay.~~ (5) ~~Steam admission valve receives open signal after a 10-second time delay.~~
d. The RCIC System automatically shuts down when a high reactor water level condition exists.	d. Tests will be conducted using simulated high reactor water level signals to cause trip conditions in two, three, and four instrument channels of water level variable.	d. RCIC System receives shutdown signal.
e. Following receipt of shutdown signal, the RCIC System automatically terminates the RPV water makeup mode.	e. Tests will be conducted on RCIC System using simulated shutdown signal.	e. Upon receipt of simulated shutdown signals, the following occurs: (1) Steam supply bypass valve receives close signal. (2) RCIC initiation logic resets. (3) Injection valve receives close signal. (4) Steam admission valve receives close signal.

Table 2.4.4 Reactor Core Isolation Cooling System (Continued)

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	**Inspections, Tests, Analyses**	**Acceptance Criteria**
f. Following RCIC shutdown on high reactor water level signal, the RCIC System automatically restarts to provide RPV water makeup if low reactor water level signal recurs.	f. Tests will be conducted using simulated low reactor water level signals. Not required for TWL type design	f. Upon receipt of simulated low reactor water level signals, the following occurs: (1) ~~Steam supply bypass valve receives open signal.~~ (2) Test return valves receive close signal. (3) CST suction valve receives open signal. (4) ~~Injection valve receives open signal after a 10 second time delay.~~ (5) ~~Steam admission valve receives open signal after a 10 second time delay.~~
g. The RCIC System automatically initiates suction transfer from the CST to the suppression pool when either a low CST water level or a high suppression pool water level exists.	g. Tests will be conducted using simulated input signals for each process variable to cause trip conditions in two, three, and four instrument channels of the same process variable.	g. The RCIC System receives suction transfer initiation signal.
h. Following receipt of suction transfer initiation signal, the RCIC System automatically switches pump suction. This transfer can be manually overridden from the MCR.	h. Tests will be conducted using simulated suction transfer initiation signals.	h. Upon receipt of simulated suction transfer initiation signals, the following occurs: (1) Suppression pool suction valve opens. (2) CST suction valve closes. The suction transfer can be manually overridden from the MCR.

Table 2.4.4 Reactor Core Isolation Cooling System (Continued)

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	**Inspections, Tests, Analyses**	**Acceptance Criteria**
i. In the RPV water makeup mode, the RCIC pump delivers a flow rate of at least 182 m^3/h against a maximum differential pressure (between the RPV and the pump suction) of 8.12 MPa.	i. Tests will be conducted in a test facility on the RCIC System pump and turbine. Not a feature of TWL design	i. (1) The RCIC pump delivers a flow rate of at least 182 m^3/h against a maximum differential pressure (between the RPV and the pump suction) of 8.12 MPa. (2) The RCIC turbine delivers the speed ~~and torque~~ required by the pump at the above conditions.
j. The RCIC System pump has sufficient NPSH.	j. Inspections, tests, and analyses will be performed based upon the as-built system. NPSH tests of the pump will be performed at a test facility. The analyses will consider the effects of: (1) Pressure losses for pump inlet piping and components. (2) Suction from suppression pool with water level at the minimum value. (3) 50% blockage of pump suction strainers. (4) Design basis fluid temperature (77°C). (5) Containment at atmospheric pressure.	j. The available NPSH exceeds the NPSH required by the pump.

Table 3.2-1 Classification Summary (Continued)

Principal Component[a]		Safety Class[b]	Location[c]	Quality Group Classification[d]	Quality Assurance Requirement[e]	Seismic Category[f]	Notes
6.	Instrument lines	3	C,SC	B	B	I	
7.	Sample lines[f]	2/N	C,SC	C/D/—	B/E	I/—	
8.	Flow transmitters	N	SC	—	E	—	
9.	Electrical modules	3/N	SC,RZ,X	—	B/E	I/—	
10.	Cables	3/N	SC,RZ,X	—	B/E	I/—	
E4 RCIC System							
1.	Piping including supports within outermost isolation valves	1	C,SC	A	B	I	
2.	Piping including supports~~—discharge line from vacuum pump to containment isolation valves, and~~ discharge line from condensate pump to the first globe valve	N	SC	C	E	—	(g)
	Not required for TWL turbine type design						
3.	Piping including supports beyond outermost isolation valves up to the turbine exhaust line to the suppression pool, including turbine inlet and outlet drain lines	2/3	C,SC	B/C	B	I	(g)
4.	RCIC Pump and piping including support, CST suction line from the first RCIC motorized valve, S/P suction line to the pump, discharge line up to the FW line "B" thermal sleeve	2	SC, M	B	B	I	(g)

Notes and footnotes are listed on pages 3.2-54 through 3.2-61

Table 3.2-1 Classification Summary (Continued)

Principal Component[a]		Safety Class[b]	Location[c]	Quality Group Classification[d]	Quality Assurance Requirement[e]	Seismic Category[f]	Notes
	5. Other Pump motors (Support Systems)	N	SC	—	E	I	
	6. Valves—outer isolation and within	1	C,SC	A	B	I	(g)
	7. Valves—outside the PCV (except item 8)	2	SC	B	B	I	(g)
	8. Valves—beyond turbine inlet drain line second shutoff	N	SC	C	E	I	(g)
	9. Turbine including supports	2	SC	~~—~~ B	B	I	~~(m)~~
	10. Electrical modules with safety-related functions	3	SC,X,RZ	—	B	I	
	11. Cable with safety-related functions	3	C,SC,X, RZ	—	B	I	
	12. Other mechanical and electrical modules	N	SC,X	—	E	—	
F1	**Fuel Servicing Equipment**	N/2	SC	—/B	E/B	—	(x)
F2	**Miscellaneous Servicing Equipment**	N	SC,RZ	—	E	—	
F3	**RPV Servicing Equipment**	N/2	SC	—/B	E/B	—/I	(gg)
F4	**RPV Internal Servicing Equipment**	N	SC	—	E	—	
F5	**Refueling Equipment**						
	1. Refueling equipment machine assembly	N	SC	—	E	I	(bb)

Notes and footnotes are listed on pages 3.2-54 through 3.2-61

larger subassembly/module. Nuclear safety-related devices are Seismic Category I. Fail-safe devices are non-Seismic Category I.

j. The control rod driver insert lines from the drive flange up to and including the first valve on the hydraulic control unit are Safety Class 2, and non-safety-related beyond the first valve.

k. The hydraulic control unit (HCU) is a factory-assembled engineered module of valves, tubing, piping, and stored water which controls two control rod drives by the application of pressures and flows to accomplish rapid insertion for reactor scram.

Although the hydraulic control unit, as a unit, is field installed and connected to process piping, many of its internal parts differ markedly from process piping components because of the more complex functions they must provide. Thus, although the codes and standards invoked by Groups A, B, C, and D pressure integrity quality levels clearly apply at all levels to the interfaces between the HCU and the connection to conventional piping components (e.g., pipe nipples, fittings, simple hand valves, etc.), it is considered that they do not apply to the specialty parts (e.g., solenoid valves, pneumatic components, and instruments).

The design and construction specifications for the HCU do invoke such codes and standards as can be reasonably applied to individual parts in developing required quality levels, but of the remaining parts and details. For example: (1) all welds are LP inspected; (2) all socket welds are inspected for gap between pipe and socket bottom; (3) all welding is performed by qualified welders; and (4) all work is done per written procedures. Quality Group D is generally applicable because the codes and standards invoked by that group contain clauses which permit the use of manufacturer standards and proven design techniques which are not explicitly defined within the codes for Quality Groups A, B, or C. This is supplemented by the QC technique described.

l. The turbine stop valve is designed to withstand the SSE and maintain its integrity.

designed and fabricated to ASME Code Section III.

TWL turbine is designed and fabricated to ASME Code Section III.

m. The RCIC turbine is ~~not included in the scope of standard codes. To assure that the turbine is fabricated to the standards commensurate with safety and performance requirements, General Electric has established specific design requirements for this component which are as follows:~~

~~1. All welding shall be qualified in accordance with Section IX, ASME Boiler and Pressure Vessel Code.~~

2. All pressure containing castings and fabrications shall be hydrotested at 1.5 times the design pressure.

3. All high pressure castings shall be radiographed according to:

ASTM E 94	
E 141	
E 142	Maximum feasible volume
E 446, 186 or 280	Severity level 3

4. As cast surfaces shall be magnetic particle or liquid penetrant tested according to ASME Code, Section III, Paragraphs NB 2545, NC 2545, or NB 2546, and NC 2546.

5. Wheel and shaft forgings shall be ultrasonically tested according to ASTM A 388.

6. Butt welds in forgings shall be radiographed and magnetic particle or liquid penetrant tested according to the ASME Boiler and Pressure Vessel Code, Section III Paragraph NB 2575, NC 2575, NB 2545, NC 2545, NB 2546, NC 2546 respectively. Acceptance standards shall be in accordance with ASME Boiler and Pressure Vessel Code Section III, Paragraph NB 5320, NC 5320, NB 5340, NC 5340, NB 5350, NC 5350, respectively.

TWL turbine is designed and fabricated to ASME Code Section III

7. Notification shall be made on major repairs and records maintained thereof.

8. Record system and traceability shall be according to ASME Section III, NCA 4000.

9. Quality control and identification shall be according to ASME Section III, NCA 4000.

10. Authorized inspection procedures shall conform to ASME Section III, NB 5100 and NC 5100.

11. Non destructive examination personnel shall be qualified and certified according to ASME Section III, NB 5500 and NC 5500.

n. All cast pressure-retaining parts of a size and configuration for which volumetric methods are effective are examined by radiographic methods by

3.9.2.2.2.5 Reactor Internal Pump and Motor Assembly

The reactor internal pump (RIP) and motor assembly, including its appurtenances and support, is classified as Seismic Category I, but not active, and is designed to withstand the seismic forces, including other RBV loads. The qualification of the assembly is done analytically and with a dynamic test.

3.9.2.2.2.6 ECCS Pump and Motor Assembly

A prototype ECCS (RHR and HPCF) pump motor assembly is qualified for seismic and other RBV loads via a combination of dynamic analysis and dynamic testing. The complete motor assembly is qualified via dynamic testing in accordance with IEEE-344. The qualification test program includes demonstration of startup capability as well as operability during dynamic loading conditions (see Subsection 3.9.3.2.1.4 for details).

The pump and motor assemblies, as units operating under seismic and other RBV load conditions, are qualified by dynamic analysis, and results of the analysis indicate that the pump and motor are capable of sustaining the above loadings without exceeding the allowable stresses (see Subsections 3.9.3.2.1.1 and 3.9.3.2.1.2 for details).

3.9.2.2.2.7 RCIC Pump and Turbine Assembly

Not required per TWL type design, since Monobloc integrated deisgn feature of RCIC-Pump set assembly.

~~The RCIC pump construction is a horizontal, multistage type and is supported on a pedestal. The RCIC pump assembly is qualified analytically by static analysis for seismic and other RBV loadings, as well as the design operating loads of pressure, temperature, and external piping loads. The results of this analysis confirm that the stresses are less than the allowable (Subsection 3.9.3.2.2).~~

-pump

The RCIC turbine is qualified for seismic and other ~~RBV loads~~ via a combination of static analysis and dynamic testing (Subsection 3.9.3.2.1.5). The turbine assembly consists of rigid masses (wherein static analysis is utilized) interconnected with control levers and electronic control systems, necessitating final qualification via dynamic testing. Static loading analyses are employed to verify the structural integrity of the turbine assembly and the adequacy of bolting under operating, seismic, and other RBV loading conditions. The complete turbine assembly is qualified via dynamic testing in accordance with IEEE-344. The qualification test program includes a demonstration of startup capability, as well as operability during dynamic loading conditions. ~~Operability under normal load conditions is assured by comparison to the operability of similar turbines in operating plants.~~

Addressed by qualification test of TWL type design

3.9.2.2.2.8 Standby Liquid Control Pump and Motor Assembly

The SLCS positive displacement pump and motor assembly, which is mounted on a common base plate, is qualified analytically by static analysis of seismic and other RBV loadings, as well as the design operating loads of pressure, temperature, and external

III, Class 1 component. The motor cover is a part of the pump/motor assembly and is constructed as an ASME Class 1 component. These pumps are not required to operate during the SSE or after an accident.

3.9.3.1.6 Standby Liquid Control (SLC) Tank

The standby liquid control tank is constructed in accordance with the requirements of a ASME Code Section III, Class 2 component.

3.9.3.1.7 RRS and RHR Heat Exchangers

The primary and secondary sides of the RRS are constructed in accordance with the requirements of an ASME Code Section III, Class 1 and Class 2 component, respectively. The primary and secondary side of the RHR System heat exchanger is constructed as ASME Class 2 and Class 3 component, respectively.

RCIC Turbine-Pump

~~3.9.3.1.8 RCIC Turbine~~

The RCIC turbine-pump is constructed in accordance with the requirements of...................................

~~Although not under the jurisdiction of the ASME Code, the RCIC turbine is designed and evaluated and fabricated following the basic guidelines of~~ ASME Code Section III for Class 2 components.

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3.9.3.1.9 ECCS Pumps

The RHR, RCIC, and HPCF pumps are constructed in accordance with the requirements of an ASME Code Section III, Class 2 component.

3.9.3.1.10 Standby Liquid Control (SLC) Pump

The SLC System pump is constructed in accordance with the requirements for ASME Code Section III, Class 2 components.

3.9.3.1.11 Standby Liquid Control (SLC) Valve (Injection Valve)

The SLC System injection valve is constructed in accordance with the requirements for ASME Code Section III, Class 1 components.

3.9.3.1.12 Main Steam Isolation and Safety/Relief Valves

The MSIVs and SRVs are constructed in accordance with ASME Code Section III, Subsection NB-3500, requirements for Class 1 components.

3.9.3.1.13 Safety/Relief Valve Piping and Quencher

The SRV discharge piping in the drywell extending from the relief valve discharge flange to the diaphragm floor penetration and the SRV discharge piping in the wetwell, extending from the diaphragm floor penetration to and including the quencher, is constructed in accordance with ASME Code Section III requirements for Class 3 number of vibratory tests, and then to the abnormal environmental condition possible during and after a LOCA. The test plans for the type test are as follows:

(1) Thermal aging of the motor electrical insulation system (which is a part of the stator only) is based on extrapolation in accordance with the temperature life characteristic curve from IEEE-275 for the insulation type used on the ECCS motors. The amount of aging equals the total estimated operation days at maximum insulation surface temperature.

(2) Radiation aging of the motor electrical insulation equals the maximum estimated integrated dose of gamma during normal and abnormal conditions.

(3) The normal operational induced current vibration effect on the insulation system is simulated by 1.5g horizontal vibration acceleration at current frequency for one hour duration.

(4) The dynamic load deflection analysis on the rotor shaft is performed to ensure adequate rotation clearance, and is verified by static loading and deflection of the rotor for the type test motor.

(5) Dynamic load aging and testing is performed on a biaxial test table in accordance with IEEE-344. During this test, the shake table is activated to simulate the maximum design limit for the SSE and other RBV loads with as many motor starts and operation combinations consistent with the plant events of Table 3.9-1 and the ECCS inadvertent injections and tests planned over the life of the plant.

(6) An environmental test simulating a LOCA condition with a duration of 100 days is performed with the test motor fully loaded, simulating pump operation. The test consists of startup and six hours operation at 100°C ambient temperature and 100% steam environment. Another startup and operation of the test motor after one hour standstill in the same environment is followed by sufficient operation at high humidity and temperature based on extrapolation in accordance with the temperature life characteristic curve from IEEE-275 for the insulation type used on the ECCS motors.

3.9.3.2.1.5 RCIC Turbine

-pump

TWL type design feature

The RCIC turbine is qualified by a combination of static analysis and dynamic testing as described in Subsection 3.9.2.2.2.7. The turbine assembly consists of rigid masses (wherein static analysis is utilized) interconnected with control levers and electronic control systems, necessitating final qualification by dynamic testing. Static loading analysis has been employed to verify the structural integrity of the turbine assembly, and the adequacy of bolting under operating and dynamic conditions. The complete turbine assembly is qualified via dynamic testing, in accordance with IEEE-344. The qualification test program includes demonstration of startup capability, as well as operability during dynamic loading conditions. Operability under normal load conditions is assured by comparison to operability of similar turbines in operating plants.

Turbine-

3.9.3.2.2 SLC Pump and Motor Assembly and RCIC Pump Assembly

These equipment assemblies are small, compact, rigid assemblies with natural frequencies well above 33 Hz. With this fact verified, each equipment assembly is qualified by the static analysis for seismic and other RBV loads. This qualification assures structural loading stresses within Code limitations, and verifies operability under seismic and other RBV loads (Subsections 3.9.2.2.2.8 and 3.9.2.2.2.7).

3.9.3.2.3 Other Active Pumps

The active pumps not previously discussed are ASME Class 2 or 3 and Seismic Category I. They are designed to perform their function including all required mechanical motions during and after a dynamic (seismic and other RBV) loads event and to remain operative during the life of the plant.

The program for the qualification of Seismic Category I components conservatively demonstrates that no loss of function results either before, during, or after the occurrence of the combination of events for which operability must be assured. No loss of function implies that the pressure boundary integrity will be maintained, that the component will not be caused to operate improperly, and that components required to respond actively will respond properly as appropriate to the specific equipment. In general, operability assurance is established during and after the dynamic loads event for active components.

3.9.3.2.3.1 Procedures

Procedures have been established for qualifying the mechanical portions of Seismic Category I pumps such as the body which forms a fluid pressure boundary, including the suction and discharge nozzles, shaft and seal retainers, impeller assembly (including blading, shaft, and bearings for active pumps), and integral supports.

All active pumps are qualified for operability by first being subjected to rigid tests both prior to installation and after installation in the plant. Electric motors for active pumps and instrumentation, including electrical devices which must function to cause the pump to accomplish its intended function, are discussed separately in Subsection 3.9.3.2.5.1.3.

3.9.3.2.3.1.1 Hydrostatic Test

All seismic-active pumps shall meet the hydrostatic test requirements of ASME Code Section III according to the class rating of the given pump.

strength of the skirt. The permissible skirt loads at any elevation, when simultaneously applied, are limited by the following interaction equation:

$$\left(\frac{P}{P_{crit}}\right)+\left(\frac{q}{q_{crit}}\right)+\left(\frac{\tau}{\tau_{crit}}\right)<\left(\frac{1}{S.F.}\right) \quad (3.9\text{-}1)$$

where:

q	=	Longitudinal load
P	=	External pressure
τ	=	Transverse shear stress
S.F.	=	Safety factor
	=	3.0 for design, testing, service levels A & B
	=	2.0 for Service Level C
	=	1.5 for Service Level D.

3.9.3.4.3 Reactor Pressure Vessel Stabilizer

The RPV stabilizer is designed as a Safety Class 1 linear type component support in accordance with the requirements of ASME Code Section III, Subsection NF. The stabilizer provides a reaction point near the upper end of the RPV to resist horizontal loads due to effects such as earthquake, pipe rupture and RBV. The design loading conditions and stress criteria listed in Tables 3.9-1 and 3.9-2 show that calculated stresses meet the Code allowable stresses in the critical support areas for various plant operating conditions.

3.9.3.4.4 Floor-Mounted Major Equipment (Pumps, Heat Exchangers, and RCIC Turbine)

Since the major active valves are supported by piping and not tied to building structures, valve "supports" do not exist (Subsection 3.9.3.4.1).

-pump

The HPCF, RHR, ~~RCIC~~, SLC, FPCCU, SPCU, and CUW pumps; RCW, RHR, CUW, and FPCCU heat exchangers; and RCIC turbine are all analyzed to verify the adequacy of their support structure under various plant operating conditions. In all cases, the load stresses in the critical support areas are within ASME Code allowables.

Seismic Category I active pump supports are qualified for dynamic (seismic and other RBV) loads by testing when the pump supports together with the pump meet the following test conditions:

(1) Simulate actual mounting conditions.

Table 3.9-8 Inservice Testing Safety-Related Pumps and Valves (Continued)

No.	Qty	Description (h) (i)	Safety Class (a)	Code Cat. (c)	Valve Func (d)	Test Para (e)	Test Freq (f)	Tier 2 Fig. (g)
F702	4	RCIC instrument line isolation excess flow check valve(h3)	2	A, C	I,A	L,S	RO	5.2-8 sh. 6
F703	4	RCIC instrument line manual maintenance valve	2	B	P		E1	5.2-8 sh. 6
F704	4	RCIC instrument line isolation excess flow check valve (h3)	2	A, C	I, A	L,S	RO	5.2-8 sh. 6
E51 Reactor Core Isolation Cooling System Valves								
F001	1	Condensate Storage Tank (CST) suction line MOV	2	B	A	P S	2 yr 3 mo	5.4-8 sh. 1
F002	1	CST suction line check valve	2	C	A	S	3 mo	5.4-8 sh. 1
F003	1	RCIC pump discharge line check valve	2	C	A	P S	2 yr 3 mo	5.4-8 sh. 1
F004	1	RCIC System injection valve (h6)	2	A	A	L,P S	RO CS	5.4-8 sh. 1
F005	1	RCIC System discharge line testable check valve	2	C	A	L,P S	RO 3 mo	5.4-8 sh. 1
F006	1	Suppression Pool (CSP) suction line MOV	2	A	I,A	L,P S	RO 3 mo	5.4-8 sh. 1
F007	1	Suppression Pool (CSP) suction line check valve	2	C	A	S	3 mo	5.4-8 sh. 1
F008	1	RCIC System suppression pool test return line MOV	2	A	A	P S	2 yr 3 mo	5.4-8 sh. 1
F009	1	RCIC System suppression pool test return line MOV	2	A	I,A	L,P S	RO 3 mo	5.4-8 sh. 1
F010	1	RCIC System minimum flow bypass line check valve	2	C	A	P S	2 yr 3 mo	5.4-8 sh. 1
F011	1	RCIC System minimum flow bypass line MOV	2	A	I,A	L,P S	RO 3 mo	5.4-8 sh. 1
~~F012~~	~~1~~	~~RCIC turbine accessories cooling water line MOV~~	~~2~~	~~B~~	~~A~~	~~P~~ ~~S~~	~~2 yr~~ ~~3 mo~~	~~5.4-8 sh. 3~~
~~F013~~	~~1~~	~~RCIC turbine accessories cooling water line PCV~~	~~2~~	~~B~~	~~A~~		~~E1~~	~~5.4-8 sh. 3~~

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Table 3.9-8 Inservice Testing Safety-Related Pumps and Valves (Continued)

No.	Qty	Description (h) (i)	Safety Class (a)	Code Cat. (c)	Valve Func (d)	Test Para (e)	Test Freq (f)	Tier 2 Fig. (g)
~~F015~~	~~1~~	~~Barometric condenser condensate pump discharge line valve~~	~~2~~	~~B~~	~~P~~		~~E1~~	~~5.4-8 sh. 3~~
~~F016~~	~~1~~	~~Barometric condenser condensate pump discharge line check valve~~	~~2~~	~~C~~	~~P~~	~~P~~ ~~S~~	~~2 yr~~ ~~3 mo~~	~~5.4-8 sh. 3~~
F017	1	RCIC pump suction line relief valve	2	C	A	R	5 yr	5.4-8 sh. 1
F018	1	Valve in the bypass line around check valve E51-F003	2	B	P		E1	5.4-8 sh. 1
F019	1	Pump discharge line test line valve	2	B	P		E1	5.4-8 sh. 1
F020	1	Pump discharge line test line valve	2	B	P		E1	5.4-8 sh. 1
F021	1	Pump discharge line fill line shutoff valve	2	B	P		E1	5.4-8 sh. 1
F022	1	Pump discharge line fill line check valve	2	C	A	S	3 mo	5.4-8 sh. 1
F023	1	Pump discharge line fill line check valve	2	C	A	S	3 mo	5.4-8 sh. 1
F024	1	Pump discharge line test line valve	2	B	P		E1	5.4-8 sh. 1
F025	1	Pump discharge line test line valve	2	B	P		E1	5.4-8 sh. 1
F026	1	Valve in pressure equalizing line around E51-F005	2	B	P		E1	5.4-8 sh. 1
F027	1	Suppression Pool (S/P) suction line test line valve	2	B	P		E1	5.4-8 sh. 1
F028	1	Minimum flow bypass line test line valve	2	B	P		E1	5.4-8 sh. 1
F029	1	Minimum flow bypass line test line valve	2	B	P		E1	5.4-8 sh. 1
~~F030~~	~~1~~	~~Turbine accessories cooling water line relief valve~~	~~2~~	~~C~~	~~A~~	~~R~~	~~5 yr~~	~~5.4-8 sh. 3~~
~~F031~~	~~1~~	~~Barometric condenser condensate discharge line AOV to HCW~~	~~2~~	~~B~~	~~P~~		~~E1~~	~~5.4-8 sh. 3~~

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Table 3.9-8 Inservice Testing Safety-Related Pumps and Valves (Continued)

No.	Qty	Description (h) (i)	Safety Class (a)	Code Cat. (c)	Valve Func (d)	Test Para (e)	Test Freq (f)	Tier 2 Fig. (g)
~~F032~~	~~1~~	~~Barometric condenser condensate discharge line AOV to HCW~~	~~2~~	~~B~~	~~P~~		~~E1~~	~~5.4-8 sh. 3~~
~~F033~~	~~1~~	~~Discharge line fill line bypass line shutoff valve~~	~~2~~	~~B~~	~~P~~		~~E1~~	~~5.4-8 sh. 3~~
~~F034~~	~~1~~	~~Barometric condenser condensate pump discharge line test line valve~~	~~2~~	~~B~~	~~P~~		~~E1~~	~~5.4-8 sh. 3~~
F035	1	Steam supply line isolation valve	1	A	I,A	L,P S	RO 3 mo	5.4-8 sh. 2
F036	1	Steam supply line isolation valve	1	A	I,A	L,P S	RO 3 mo	5.4-8 sh. 2
F037	1	Steam admission valve	2	B	A	P, S	2 yr 3 mo	5.4-8 sh. 2
F038	1	Turbine exhaust line check valve (h3)	2	A, C	I,A	L S	2 yr RO	5.4-8 sh. 2
F039	1	Turbine exhaust line MOV	2	A	I,A	L,P S	2 yr 3 mo	5.4-8 sh. 1
F044	1	Steam admission valve bypass line maintenance valve	2	B	P		E1	5.4-8 sh. 2
~~F045~~	~~1~~	~~Steam admission valve bypass line MOV~~	~~2~~	~~B~~	~~A~~	~~P S~~	~~2 yr 3 mo~~	~~5.4-8 sh. 2~~
~~F046~~	~~1~~	~~Barometric condenser vacuum pump discharge line check valve (h3)~~	~~2~~	~~A, C~~	~~I, A~~	~~L,S~~	~~RO~~	~~5.4-8 sh. 1~~
~~F047~~	~~1~~	~~Barometric condenser vacuum pump discharge line MOV~~	~~2~~	~~A~~	~~I,A~~	~~L,P S~~	~~RO 3 mo~~	~~5.4-8 sh. 1~~
F048	1	Steam supply line warm-up line valve	1	A	I,A	L,P S	RO 3 mo	5.4-8 sh. 2
F049	1	Steam supply line test line valve	2	B	P		E1	5.4-8 sh. 2
F050	1	Steam supply line test line valve	2	B	P		E1	5.4-8 sh. 2
~~F051~~	~~1~~	~~Turbine exhaust line drain line valve~~	~~2~~	~~B~~	~~P~~		~~E1~~	~~5.4-8 sh. 3~~

Table 3.9-8 Inservice Testing Safety-Related Pumps and Valves (Continued)

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No.	Qty	Description (h) (i)	Safety Class (a)	Code Cat. (c)	Valve Func (d)	Test Para (e)	Test Freq (f)	Tier 2 Fig. (g)
~~F052~~	~~1~~	~~Turbine exhaust line drain line valve~~	~~2~~	~~B~~	~~P~~		~~E1~~	~~5.4-8 sh. 3~~
F053	1	Turbine exhaust line test line valve	2	B	P		E1	5.4-8 sh. 1
F054	1	Turbine exhaust line vacuum breaker (h1)	2	C	A	R	RO	5.4-8 sh. 1
F055	1	Turbine exhaust line vacuum breaker (h1)	2	C	A	R	RO	5.4-8 sh. 1
F056	1	Steam supply line drain pot drain line test line valve	2	B	P		E1	5.4-8 sh. 1
F057	1	Steam supply line drain pot drain line test drain line	2	B	P		E1	5.4-8 sh. 2
~~F059~~	~~1~~	~~Barometric condenser vacuum pump discharge line test line valve~~	~~2~~	~~B~~	~~P~~		~~E1~~	~~5.4-8 sh. 1~~
F500	1	Pump discharge line vent line valve	2	B	P		E1	5.4-8 sh. 1
F501	1	Pump discharge line vent line valve	2	B	P		E1	5.4-8 sh. 1
F502	1	Pump discharge line drain line valve	2	B	P		E1	5.4-8 sh. 1
F503	1	Pump discharge line drain line valve	2	B	P		E1	5.4-8 sh. 1
F700	1	Pump suction line pressure instrumentation instrument root valve	2	B	P		E1	5.4-8 sh. 1
F701	1	Pump suction line pressure instrumentation instrument root valve	2	B	P		E1	5.4-8 sh. 1
F702	1	Pump discharge line pressure instrumentation instrument root valve	2	B	P		E1	5.4-8 sh. 1
F703	1	Pump discharge line pressure instrumentation instrument root valve	2	B	P		E1	5.4-8 sh. 1
F704	1	Pump discharge line pressure instrumentation instrument root valve	2	B	P		E1	5.4-8 sh. 1

Table 3.9-8 Inservice Testing Safety-Related Pumps and Valves (Continued)

No.	Qty	Description (h) (i)	Safety Class (a)	Code Cat. (c)	Valve Func (d)	Test Para (e)	Test Freq (f)	Tier 2 Fig. (g)
F705	1	Pump discharge line pressure instrumentation instrument root valve	2	B	P		E1	5.4-8 sh. 1
F706	1	Pump discharge line flow instrument root valve	2	B	P		E1	5.4-8 sh. 1
F707	1	Pump discharge line flow instrument root valve	2	B	P		E1	5.4-8 sh. 1
F708	1	Pump discharge line flow instrument root valve	2	B	P		E1	5.4-8 sh. 1
F709	1	Pump discharge line flow instrument root valve	2	B	P		E1	5.4-8 sh. 1
F710	1	Pump discharge line pressure instrument root valve	2	B	P		E1	5.4-8 sh. 1
F711	1	Pump discharge line pressure instrument root valve	2	B	P		E1	5.4-8 sh. 1
~~F712~~	~~1~~	~~Turbine accessories cooling water line instrument root valve~~	~~2~~	~~B~~	~~P~~		~~E1~~	~~5.4-8 sh. 3~~
~~F713~~	~~1~~	~~Turbine accessories cooling water line instrument root valve~~	~~2~~	~~B~~	~~P~~		~~E1~~	~~5.4-8 sh. 3~~
~~F714~~	~~1~~	~~Turbine accessories cooling water line instrument root valve~~	~~2~~	~~B~~	~~P~~		~~E1~~	~~5.4-8 sh. 3~~
F716	1	Steam supply line pressure instrument root valve	2	B	P		E1	5.4-8 sh. 2
F717	1	Steam supply line pressure instrument root valve	2	B	P		E1	5.4-8 sh. 2
F718	1	Steam supply line drain pot instrument root valve	2	B	P		E1	5.4-8 sh. 2
F719	1	Steam supply line drain pot instrument root valve	2	B	P		E1	5.4-8 sh. 2
F720	1	Steam supply line drain pot instrument root valve	2	B	P		E1	5.4-8 sh. 2
F721	1	Steam supply line drain pot instrument root valve	2	B	P		E1	5.4-8 sh. 2

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	* 20A-RCIC-061-S Pipe	8.62 MPaG, 302°C,3B,As	Was 0.981 MPaG
	** 20A-RCIC-064-S Pipe	8.62 MPaG, 302°C,3B,As	Was 0.981 MPaG

* RCIC Trip and Throttle Valve leakoffs are piped to Condensing Chamber.
** RCIC Turbine Condensate Drain connects to the Condensing Chamber

~~RCIC turbine valve leakoffs are piped to the barometric condenser~~

Not required for TWL type design

~~Reference~~	~~Components~~	Press./Temp./Design/ ~~Seismic Class~~	~~Remarks~~
~~Sheet 3~~	~~* 25A-RCIC-058-S Pipe~~	~~2.82 MPaG, 184°C,4D,As~~	~~Was 0.981 MPaG~~
	~~** 25A-RCIC-059-S Pipe~~	~~2.82 MPaG, 184°C,4D,As~~	~~Was 0.981 MPaG~~
	~~Barometric Condenser~~	~~2.82 MPaG, 184°C,4D,As~~	~~Was 0.755 MPaG~~
	~~*** 25A-RCIC-065-S Pipe~~	~~2.82 MPaG, 184°C,4D,As~~	~~Was 0.755 MPaG~~
	~~25A-RCIC Relief Valve~~	~~2.82 MPaG, 121°C,4D,As~~	~~Was 0.755 MPaG~~
	~~25A-RCIC-066-S Pipe~~	~~0 MPaG, 121°C,4D,As~~	~~No change~~

* ~~RCIC Trip and Throttle Valve Stem leakoff is piped to the Barometric~~
~~** RCIC Turbine Governor Valve Stem is piped to the to Barometric Condenser.~~
~~*** Barometric Condenser Press. relief and piping.~~

~~RCIC pump cooling water piping for pump and turbine lube oil coolers~~

Reference	Components	Press./Temp./Design/ Seismic Class	Remarks
Sheet 3	50A-RCIC-011-W Pipe	2.82 MPaG,77°C,3B,As	Was 0.863 MPaG
	50A-RCIC-028-W Pipe	2.82 MPaG, 77°C,3B,As	Was 0.863 MPaG
	50A-RCIC-F030 Relief V.	2.82 MPaG, 77°C,3B,As	Was 0.863 MPaG
	50A-RCIC-029-W Pipe	2.82 MPaG, 77°C,3B,As	Was 0.863 MPaG
	20A-RCIC-713-W Pipe	2.82 MPaG, 77°C,3B,As	Was 0.863 MPaG
	20A-RCIC-PX018 Press	2.82 MPaG, 77°C,3B,As	Was 0.863 MPaG
	50A-RCIC-Turb.LO Cooler	2.82 MPaG, 77°C,3B,As	Was 0.863 MPaG
	50A-RCIC-Pump LO Cooler	2.82 MPaG, 77°C,3B,As	Was 0.863 MPaG
	15A-RCIC-TX019 Temp.Pt.	2.82 MPaG, 77°C,3B,As	Was 0.863 MPaG
	20A-RCIC-714-W Pipe	2.82 MPaG, 77°C,3B,As	Was 0.863 MPaG
	20A-RCIC-F714 Valve	2.82 MPaG, 77°C,3B,As	Was 0.863 MPaG
Not required for TWL type design	20A-RCIC-PX020 Press.Pt.	2.82 MPaG, 77°C,3B,As	Was 0.863 MPaG
	15A-RCIC-012-W Pipe	2.82 MPaG, 77°C,3B,As	Was 0.863 MPaG
	15A-RCIC-013-W Pipe	2.82 MPaG, 77°C,3B,As	Was 0.863 MPaG
	15A-RCIC-014-W Pipe	2.82 MPaG, 77°C,3B,As	Was 0.863 MPaG
	15A-RCIC-015-W Pipe	2.82 MPaG, 77°C,3B,As	Was 0.863 MPaG
Sheet 3	~~Barometric Condenser~~	~~2.82 MPaG, 121°C,4D,As~~	~~Was 0.755 MPaG~~

RCIC vacuum tank and condensate pump piped to RCIC pump suction pipe.

Reference	Components	Press./Temp./Design/ Seismic Class	Remark
Sheet 3	RCIC Vacuum Tank	2.82 MPaG, 77°C,4D,As	Was 0.755 MPaG
	RCIC Press. Switch H	2.82 MPaG, 121°C,4D,As	Was 0.755 MPaG
	RCIC Level Switch H	2.82 MPaG, 121°C,4D,As	Was 0.755 MPaG
	RCIC Level Switch L	2.82 MPaG, 121°C,4D,As	Was 0.755 MPaG
	RCIC Cond. Pump	2.82 MPaG, 88°C,4D,As	Was 1.37 MPaG
	50A-RCIC-F014 Check V.	2.82 MPaG, 88°C,4D,As	Was 1.37 MPaG
	50A-RCIC-016-W Pipe	2.82 MPaG, 88°C,4D,As	Was 1.37 MPaG
	20A-RCIC-715-W Pipe	2.82 MPaG, 88°C,4D,As	Was 1.37 MPaG

Reference	Components	Press./Temp./Design/ Seismic Class	Remarks
	350A-RCIC-Cond. Pot	8.62 MPaG, 302°C,3B,As	Was 0.981 MPaG
	350A-RCIC-038-S Pipe	8.62 MPaG, 302°C,3B,As	Was 0.981 MPaG
	20A-RCIC-721-S Pipe	8.62 MPaG, 302°C,3B,As	Was 0.981 MPaG
	20A-RCIC-F723 Valve	8.62 MPaG, 302°C,3B,As	Was 0.981 MPaG
	20A-RCIC-722-S Pipe	8.62 MPaG, 302°C,3B,As	Was 0.981 MPaG
	20A-RCIC-PT013A P.Trans	8.62 MPaG, 302°C,3B,As	Was 1.37 MPaG
	20A-RCIC-PT013E P.Trans	8.62 MPaG, 302°C,3B,As	Was 1.37 MPaG
	~~** 25A-RCIC-051-S Pipe~~	~~8.62 MPaG, 302°C,3B,As~~	~~Was 0.981 MPaG~~
	~~** 25A-RCIC-F051 Valve~~	~~8.62 MPaG, 302°C,3B,As~~	~~Was 0.981 MPaG~~
	~~** 25A-RCIC-D012 Strainer~~	~~8.62 MPaG, 302°C,3B,As~~	~~Was 0.981 MPaG~~
	~~** 25A-RCIC-D013 S.Trap~~	~~8.62 MPaG, 302°C,3B,As~~	~~Was 0.981 MPaG~~
	~~** 25A-RCIC-F052 Valve~~	~~8.62 MPaG, 302°C,3B,As~~	~~Was 0.981 MPaG~~
Sheet 3	~~** 25A-RCIC-052-S Pipe~~	~~2.82 MPaG, 184°C,4D,As~~	~~Was 0.981 MPaG~~
Sheet 1	350A-RCIC-F038 Check	8.62 MPaG, 302°C,3B,As	Was 1.37 MPaG
	20A-RCIC-053-S Pipe	8.62 MPaG, 302°C,3B,As	Was 0.981 MPaG
	20A-RCIC-F053 T.Valve	8.62 MPaG, 302°C,3B,As	Was 0.981 MPaG
	350A-RCIC-F039 Valve	8.62 MPaG, 302°C,3B,As	Was 0.981 MPaG
	A-RCIC-F069 T.Valve	2.82 MPaG, 184°C,3B,As	Was 10.981 MPaG
	350A-RCIC-039-S Pipe	0.981 MPaG, 184°C,3B,As	No change
Sheet 1	Suppression Pool		

* ~~Vent via Rupture Disks.~~

** ~~RCIC Turbine Condensate Piping to the Barometric Condenser.~~

Not required for TWL type design

~~**RCIC vacuum tank condensate piping to the suppression pool.**~~

~~Reference~~	~~Components~~	~~Press./Temp./Design/ Seismic Class~~	~~Remarks~~
~~Sheet 3~~	~~50A-RCIC-Vacuum Pump~~	~~2.82 MPaG, 121°C,4D,As~~	~~Was 0.755 MPaG~~
	~~50A-RCIC-044-S Pipe~~	~~2.82 MPaG, 88°C,4D,As~~	~~Was 0.310 MPaG~~
	~~50A-RCIC-067-S Pipe~~	~~2.82 MPaG, 88°C,4D,As~~	~~Was 0.310 MPaG~~
	~~50A-RCIC-PCV Valve~~	~~2.82 MPaG, 121°C,4D,As~~	~~Was 0.755 MPaG~~
~~Sheet 3~~	~~20A-RCIC-068-S Pipe~~	2.82 MPaG, 121°C,4D,As	Was 0.981 MPaG
~~Sheet 1~~	~~50A-RCIC-F046 Check V.~~	~~2.82 MPaG, 104°C,3B,As~~	~~Was 0.310 MPaG~~
	~~20A-RCIC-057-S Pipe~~	~~2.82 MPaG, 104°C,3B,As~~	~~Was 0.310 MPaG~~
	~~20A-RCIC-F059 T.Valve~~	~~2.82 MPaG, 104°C,3B,As~~	~~Was 0.310 MPaG~~
	~~50A-RCIC-F047 MO Valve~~	~~2.82 MPaG, 104°C,3B,As~~	~~Was 0.310 MPaG~~
	~~50A-RCIC-045-S Pipe~~	~~0.981 MPaG, 104°C,3B,As~~	~~No change~~
~~Sheet 1~~	~~Suppression Pool~~		

RCIC steam drains from trip and throttle valve piping and turbine to condensate chamber.

Reference	Components	Press./Temp./Design/ Seismic Class	Remarks
Sheet 3	* 20A-RCIC-063-S Pipe	8.62 MPaG, 302°C,3B,As	Was 0.981 MPaG

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Figure 5.4-8 REACTOR CORE ISOLATION COOLING SYSTEM P&ID (Sheet 3 of 3)
ABWR DCD/Tier 2 *Rev 3* *21-100*

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Figure 5.4-9 REACTOR CORE ISOLATION COOLING SYSTEM PFD (Sheet 1 of 2)
ABWR DCD/Tier 2 *Rev 0* *21-101*

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5.4.6.2.1.2 Diagrams

The following diagrams are included for the RCIC System:

(1) Figure 5.4-8 is a schematic diagram showing components, piping, points where interface system and subsystems tie together, and instrumentation and controls associated with subsystem and component actuation.

(2) Figure 5.4-9 is a schematic showing temperature, pressure and flows for RCIC operation and system process data hydraulic requirements.

5.4.6.2.1.3 Interlocks

The following defines the various electrical interlocks:

Valve F045 is not required for TWL type design

(1) Valves F039 and F047 are two key-locked open valves with individual keylocks.

(2) The F001 limit switch activates when not fully closed and closes F008 and F009.

(3) The F039 limit switch activates when fully open and clears the permissive for F037 ~~and F045~~ to open.

(4) The F037 and turbine trip and throttle valve limit switches activate when not fully closed to initiate the turbine governor valve signal ramp generator and to clear permissives for F004 to open.

(5) The F037 limit switch activates when fully closed and permits F031, F032, F040 and F041 to open and closes F004 and F011.

(6) The turbine trip throttle valve (part of C002) limit switch activates when fully closed and closes F004 and F011.

(7) High reactor water level (Level 8) closes F037, F012, ~~F045~~ and, subsequently, F004 and F011. This level signal is sealed in and must be manually reset. It will automatically clear if a low reactor water level (Level 2) reoccurs.

(8) High turbine exhaust pressure, low pump suction pressure, 110% turbine electrical overspeed, or an isolation signal actuates the turbine trip logic and closes the turbine trip and throttle valve. When the signal is cleared, the trip and throttle valve must be reset from the control room.

(9) Overspeed of 125% trips the mechanical trip, which is reset at the turbine.

(10) An isolation signal closes F035, F036, F048, and other valves as noted in Items (6) and (8).

Not required for TWL type design

(11) An initiation signal opens F001 and F004, F037, F012 ~~and F045~~ when other permissives are satisfied, starts the gland seal system, and closes F008 and F009.

(12) High- and low-inlet RCIC steamline drain pot levels respectively open and close F058.

(13) The combined signal of low flow plus pump discharge pressure opens and, with increased flow, closes F011. Also see Items (5), (6) and (7).

5.4.6.2.2 Equipment and Component Description

5.4.6.2.2.1 Design Conditions

Operating parameters for the components of the RCIC System are shown in Figure 5.4-9. The RCIC components are:

(1) ~~One 100% capacity turbine and accessories.~~

One 100% capacity, turbine, pump set and accessories.

~~(2) One 100% capacity pump assembly and accessories.~~

(3) Piping, valves, and instrumentation for:

(a) Steam supply to the turbine

(b) Turbine exhaust to the suppression pool

(c) Makeup supply from the condensate storage tank to the pump suction

(d) Makeup supply from the suppression pool to the pump suction

Not required for TWL type design

(e) Pump discharge to the feedwater line, a full flow test return line, a minimum flow bypass line to the suppression pool, ~~and a coolant water supply to accessory equipment~~

The basis for the design conditions is ASME B&PV Code Section III, Nuclear Power Plant Components.

Analysis of the net positive suction head (NPSH) available to the RCIC pump in accordance with the recommendations of Regulatory Guide 1.1 is provided in Table 5.4-1a.

5.4.6.2.2.2 Design Parameters

Design parameters for the RCIC System components are given in Table 5.4-2. See Figure 5.4-8 for cross-reference of component numbers.

Not required for TWL type design

~~On RCIC System startup, bypass valve F045 (provided to reduce the frequency of turbine overspeed trips) opens to accelerate the turbine to an initial peak speed of approximately 157 rad/s; now under governor control, turbine speed is returned to the low limit turbine speed demand of 73.3 rad/s to 104.7 rad/s. After a predetermined delay (5 to 10 s), the steam supply valve leaves the full closed position and the ramp generator is released. The low signal select feature selects and sends this increasing ramp signal to the governor. The turbine increases in speed until the pump flow satisfies the controller setpoint. Then the controller leaves saturation, responds to the input error, and integrates the output signal to satisfy the input demand.~~

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Design feature of TWL type design

The operator has the capability to select manual control of the governor, and ~~adjust~~ speed and flow (within hardware limitations) to match decay heat steam generation during the period of RCIC operation.

The RCIC pump delivers the makeup water to the reactor vessel through the feedwater line, which distributes it to obtain mixing with the hot water or steam within the reactor vessel.

The RCIC turbine will trip automatically upon receipt of any signal indicating turbine overspeed, low pump suction pressure, high turbine exhaust pressure, or an auto-isolation signal. Automatic isolation occurs upon receipt of any signal indicating:

(1) A high pressure drop across a flow device in the steam supply line equivalent to 300% of the steady-state steam flow at 8.22 MPaA.

(2) A high area temperature.

(3) A low reactor pressure of 0.34 MPaG minimum.

(4) A high pressure in the turbine exhaust line.

Not required for TWL type design

The steam supply valve F037, ~~steam supply bypass valve F045~~ and cooling water supply valve F012 will close upon receipt of signal indicating high water level (Level 8) in the reactor vessel. These valves will reopen (auto-restart) should an indication of low water level (Level 2) in the reactor vessel occur. Water Level 2 automatically resets the water level trip signal. The RCIC System can also be started, operated, and shut down remote-manually provided initiation or shutdown signals do not exist.

5.4.6.2.5.3 Test Mode

A design functional test of the RCIC System may be performed during normal plant operation by drawing suction from the suppression pool and discharging through a full flow test return line back to the suppression pool. The discharge valve to the vessel remains closed during test mode operation. The system will automatically return from

Table 5.4-2 Design Parameters for RCIC System Components

(1) RCIC Pump Operation (C001)	
Flow rate	Injection flow – 182 m^3/h
	Cooling water flow – 4 to 6 m^3/h
	Total pump discharge – 188 m^3/h (includes no margin for pump wear)
Water temperature range	10° to 60°C, continuous duty 40° to 77°C, short duty
NPSH	7.3m minimum
Developed head	900m at 8.22 MPaA reactor pressure
	186 m at 1.14 MPaA reactor pressure
Maximum pump shaft power	675 kW at 900m developed head 125 kW at 186m developed head
Design pressure	11.77 MPaG

	High Pressure Condition	Low Pressure Condition
(2) RCIC Turbine Operation (C002)		
Reactor pressure (saturated temperature)	8.19 MPaA	1.14 MPaA
Steam inlet pressure	8.12 MPaA, minimum	1.03 MPaA, minimum
Turbine exhaust pressure	0.11 to 0.18 MPaA, maximum	0.11 to 0.18 MPaA, maximum
Design inlet pressure	8.62 MPaG at saturated temperature	
Design exhaust pressure	8.62 MPaG at saturated temperature	

~~(3) RCIC leakoff orifices (D017, D018)~~	~~Sized for 3.2 mm diameter minimum to 4.8 mm diameter maximum~~
Flow element (FE007)	
Flow at full meter differential pressure	250 m^3/h
Normal temperature	10 to 77°C
System design pressure/temperature	8.62 MPaG/302°C
Maximum unrecoverable loss at normal flow	0.031 MPa
Installed combined accuracy (Flow element, Flow transmitter and Flow indicator)	±2.5% at normal flow and normal

Not required since TWL type design

Table 5.4-2 Design Parameters for RCIC System Components (Continued)

(4) Valve Operation Requirements	
Steam supply valve (F037)	Open and/or close against full differential pressure of 8.12 MPa within 15 seconds
Pump discharge valve (F004)	Open and/or close against full differential pressure of 9.65 MPa within 15 seconds
Pump minimum flow bypass valve (F011)	Open and/or close against full differential pressure of 9.65 MPa within 5 seconds
RCIC steam isolation valve (F035&F036)	Open and/or close against full differential pressure of 8.12 MPa within 30 seconds
Cooling water pressure control valve (F013)	Self-contained downstream sensing control valve capable of maintaining constant downstream pressure of 0.52 MPa
Pump suction relief valve (F017)	1.48 MPaA setting; 2.3 m^3/h at 10% accumulation
Cooling water relief valve (F030)	Sized to prevent overpressuring piping, valves, and equipment in the coolant loop in the event of failure of pressure control valve F013
Pump test return valve (F008)	Capable of throttling control against differential pressures up to 7.58 MPa and closure against differential pressure at 9.65 MPa
Pump suction valve, suppression pool (F006)	Capable of opening and closing against 1.37 MPa differential pressure
Testable check valve equalizing valve (F026)	Open and/or close against full differential pressure of 8.12 MPa
Outboard check valve (F005)	Accessible during plant operation and capable of local testing
Turbine exhaust isolation valve (F039)	Opens and/or closes against 1.10 MPa differential pressure at a temperature of 170°C, physically located in the line on a horizontal run as close to the containment as practical
Isolation valve, steam warmup line (F048)	Opens and/or closes against differential pressure of 8.12 MPa
~~Barometric condenser condensate drain Line isolation valves (F031 & F032)~~ Not required for TWL type design	~~These valves operate only when RCIC System is shutdown, allowing drainage to CUW System and they must operate against a differential pressure of 0.52 MPa~~
Condensate storage tank isolation valve (F001)	This valve isolates the condensate storage tank so that suction may be drawn from the suppression pool; valve must operate against a differential pressure of 1.37 MPa

Table 5.4-2 Design Parameters for RCIC System Components (Continued)

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Vacuum breaker check valves (F054 & F055)	Full flow and open with a minimum pressure drop (less than 3.92 kPa across the valves)
Steam inlet drain pot system isolation (F040 & F041)	These valves allow for drainage of the steam inlet drain pot and must operate against a differential pressure of 8.12 kPa
Steam inlet trip bypass valve (F058)	This valve bypasses the trap D008 and must operate against a differential pressure of 8.12 kPa
Cooling loop shutoff valve (F012)	This valve allows water to be passed through the auxiliary equipment coolant loop and must operate against a differential pressure of 9.65 MPa
Pump test return valve (F009)	This valve allows water to be returned to the suppression pool during RCIC system test and must operate against a differential pressure of 9.65 MPa
~~Steam supply bypass valve (F045)~~	~~Open and/or close against full differential of 8.12 MPa within 5 seconds~~
Turbine exhaust check valve (F038)	Capable of with standing impact loads due to "flapping" during startup.
~~Vacuum pump discharge isolation valve (F047)~~	~~Open and/or close against 0.314 MPa differential pressure at a temperature of 170°C.~~
~~Vacuum pump discharge check valve (F046)~~	~~Located at the highest point in the line.~~

(5) Instrumentation – For instruments and control definition, refer to Subsection 7.4.1.1.

(6) Condensate Storage Requirements

Total reserve storage for RCIC and HPCF System is 570 m^3.

(7) Piping RCIC Water Temperature
The maximum water temperature range for continuous system operation shall not exceed 60°C; however, due to potential short-term operation at higher temperatures, piping expansion calculations were based on 77°C.

(8) Turbine Exhaust Vertical Reactor Force
The turbine exhaust sparger is capable of withstanding a vertical pressure unbalance of 0.137 MPa. This pressure unbalance is due to turbine steam discharge below the suppression pool water level.

(9) Ambient Conditions	Relative Temperature	Humidity(%)
Normal plant operation	10 to 40°C	10 to 90

(10)Suction Strainer Sizing

The suppression pool suction shall be sized so that:

(a) Pump NPSH requirements are satisfied when strainer is 50% plugged; and particles over 2.4 mm diameter are restrained from passage into the pump and feedwater sparger.

Full flow functional tests of the HPCF System can be performed during normal plant operation or during plant shutdown by manual operation of the HPCF System from the control room. For testing during normal plant operation, the pump suction is transferred to the suppression pool, the pump is started, and the test discharge line to the suppression pool is opened. A reverse sequence is used to terminate this test. Upon receipt of an automatic initiation signal while in the flow testing mode, the system will automatically return to injection mode and flow will be directed to the reactor vessel.

Appendix 6D outlines the HPCF flow analysis.

6.3.2.2.2 Automatic Depressurization System (ADS)

If the RCIC and HPCF Systems cannot maintain the reactor water level, the ADS, which is independent of any other ECCS, reduces the reactor pressure so that flow from the RHR System operating in the low pressure flooder mode enters the reactor vessel in time to cool the core and limit fuel cladding temperature.

The ADS employs nuclear system pressure relief valves to relieve high pressure steam to the suppression pool. The design number, location, description, operational characteristics and evaluation of the pressure relief valves are discussed in detail in Subsection 5.2.2. The instrumentation and controls for ADS are discussed in Subsection 7.3.1.1.1.2.

6.3.2.2.3 Reactor Core Isolation Cooling System (RCIC)

The RCIC System consists of a steam-driven turbine which drives a pump assembly. The system also includes piping, valves, and instrumentation necessary to implement several flow paths. The RCIC steam supply line branches off one of the main steamlines (leaving the reactor pressure vessel) and goes to the RCIC turbine with drainage provision to the main condenser. The turbine exhausts to the suppression pool with vacuum breaking protection. Makeup water is supplied from the CST and the suppression pool with the preferred source being the CST. RCIC pump discharge lines include the main discharge line to the feedwater line, a test return line to the suppression pool, a minimum flow bypass line to the pool, ~~and a cooling water supply line to auxiliary equipment.~~ The piping configuration and instrumentation is shown in Figure 5.4-8. The process diagram is given in Figure 5.4-9.

Not required for TWL type design

Following the reactor scram, steam generation in the reactor core will continue at a reduced rate due to the core fission product decay heat. The turbine bypass system will divert the steam to the main condenser, and the feedwater system will supply the makeup water required to maintain reactor vessel inventory.

In the event that the reactor vessel is isolated, and the feedwater supply is unavailable, relief valves are provided to automatically (or remote manually) maintain vessel pressure within desirable limits. The water level in the reactor vessel will drop due to