Technical Report

Application of Turbine Water Lubricated (TWL) Pump
to South Texas Project Units 3&4 RCIC Turbine-Pump

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1. Introduction

The purpose of this Technical Report (TR) is to describe the Reactor Core Isolation Cooling (RCIC) turbine-pump design change from the Terry type to the Clyde type in the South Texas Project Units 3&4 (STP-3&4). Certain features of the certified ABWR RCIC system design were based on the turbine and pump being of the Terry type. Some of these features are no longer needed by the more integrated and simplified Clyde-type pump.

The Clyde type is also called the Turbine Water Lubricated (TWL) pump, and it is a combined pump & turbine with single shaft and has integrated flow control. The TWL pump is compact, simple, reliable and suitable to the RCIC system. This document describes the TWL pump characteristics and suitability to the RCIC system/equipment requirements and also compares the TWL pump (Clyde type) to the Terry type pump that was the basis for the features of the certified RCIC system.

2. About Clyde Pump Ltd

Clyde Pump Ltd (CPL), one of the largest manufacturers of pumps in the world, has over 125 years experience in supplying major items of capital equipment to the power generation industry as well as over 50 years experience supplying pumps to the nuclear industry worldwide (PWR, ABWR).

CPL has the following capability, from their nuclear plant experiences.

<Nuclear Capability>

- All nuclear and turbine island pumps
- High efficiency and proven reliability of nuclear pump designs
- Dedicated nuclear design department
- In-house seismic, environmental and operability qualification
- **Commitment to quality - ASME 'N', 'NPT' and 'NA'**
- Compliance with international standards
- Qualified welders and NDE operators in-house
- Modern manufacturing and extensive test facilities
- Prompt after-sales service
- Installation and commissioning capability
- Large, innovative in-house research and development facilities
- Comprehensive in-house software and analytical capability
- Access to local shaker test facility

<Service (support) in US>

- Local service capability from "Houston Service Center".

3. TWL Pump Major Characteristics

The TWL pump is a combined single wheel steam turbine and two-stage pump, for which both the turbine and impellers are mounted on a single rigid shaft supported by a central bearing assembly, and all of which are integral within a monoblock turbine/pump casing. (See Figure 1) This compact design is proven, requires no external services or electrical supplies to operate, is about half the size of a conventional pump and turbine unit, and is designed to ASME III Class 2 & 3 requirements.

The TWL pump and turbine design has advantages over a separate turbine & barrel pump set. The TWL pump design:

- Is compact, simple, robust, reliable, inherently safe and proven in nuclear applications.

- Requires:
  - No external lubrication
  - No External cooling water
  - No Mechanical seals
  - No electrical connections
  - No drive coupling
  - No barometric condenser or vacuum pump
- Can accept water slugs in steam line during start-up and running conditions.
- Has product-lubricated bearings – no separate lubrication system is required.
- Is quick acting & quick starting.
- Is diverse – has no generic design faults.
- Gives a governing range of 75% - tuneable to give constant head or system resistance duty.
- Has high runaway speed capability (>3 times running speed).
- Has a single stiff shaft – 1st critical well in excess of trip speed.
- Has low heat emission.
- Has all qualifications performed by CPL only.
- Is easy to use and maintain.
- Has the ability to operate over a wide range of steam conditions.
- Can be installed later in site construction program due to small size.
- Has reduced costs to contractor due to not requiring service.

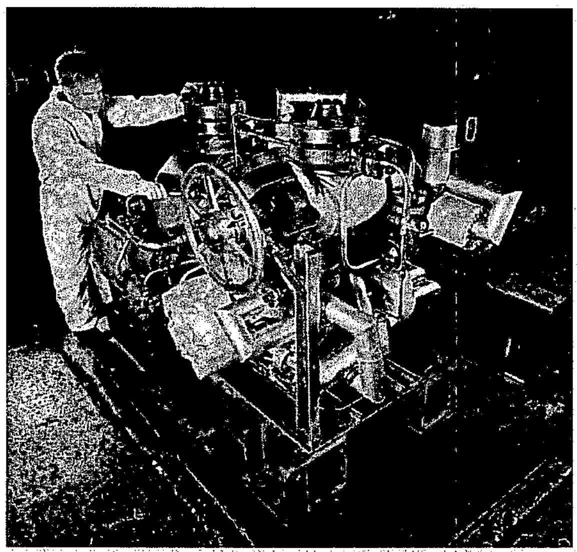


Photo: TWL Pump

Details of TWL pump design are described in Appendix A.

4. Operating Experience

The Clyde integrated turbine-pump design has been used for approximately 30 years in commercial and naval applications. Successful experiences in civilian nuclear power plants are outlined in Appendix B and these include auxiliary feed water pumps and emergency core cooling pumps (e.g., Ko Ri 1, Quinshan 2, Ringhals 2, 3 & 4, Sizewell B, Ulchin 3 & 4 and Yonggwang 5 & 6 in pressurized water reactors).

5. Description of RCIC System Design

The RCIC turbine and pump system design is a single train, divisional safety system consisting of a steam turbine, a pump, piping, valves, instrumentation, controls, supporting subsystems and accessories whose purpose is to provide emergency makeup water to the Reactor Pressure Vessel (RPV) for transient and Loss of Coolant Accident (LOCA) events in order to maintain coolant inventory and to permit adequate core cooling. It is also used for inventory makeup during hot standby conditions (include Station Black Out). The description of the certified design is found in Tier 1, Section 2.4.4 of the ABWR Design Control Document (DCD) with additional information in Tier 2, Sections 5.4.6 and 6.3.

Basic design requirements for the RCIC system pump include the following:

(1) The RCIC pump shall be designed to meet all functional requirements with the containment pressure between atmospheric and the maximum design value and with the suppression pool (S/P) water temperature less than or equal to 77°C (170°F).

(2) The RCIC pump shall supply a minimum of 182 m^3/h (800 gpm) of water into the RPV when the pressure differential between the reactor and the air space of the compartment containing the source water for the pump is between 8.12 MPaD (1177 psid) and 1.035 MPaD (150 psid).

(3) The maximum allowable time from the receipt of one of the actuation signals to the time of rated flow entering the RPV shall be no more than 29 seconds.

System requirements for STP-3&4 Applications:

<RCIC Pump>

Number of Pumps	1
Developed head	>900 m (2953 ft) @ 8.22 MPaA (1192 psia) of reactor pressure >186 m (611 ft) @ 1.14 MPaA (165 psia) of reactor pressure

Flow rate	>182 m^3/h (800 gpm)
Water temperature range	10°C to 77°C (50°F to 170°F)
Av. Net Positive Suction Head (NPSH)	7 m (23 ft) @ 182 m^3/h (Reference level of NPSH is "1m" upper pump floor level)

<RCIC Turbine>

Reactor pressure	8.22 MPaA (1192 psia) (Max RPV)
	1.14 MPaA (165 psia) (Min RPV)
Steam inlet pressure	8.11 MPaA (1176 psia)
	1.03 MPaA (149 psia)

6. TWL Pump Performance

In 2000, Toshiba conducted a study of the TWL pump to verify its applicability to the RCIC pump in an ABWR plant.

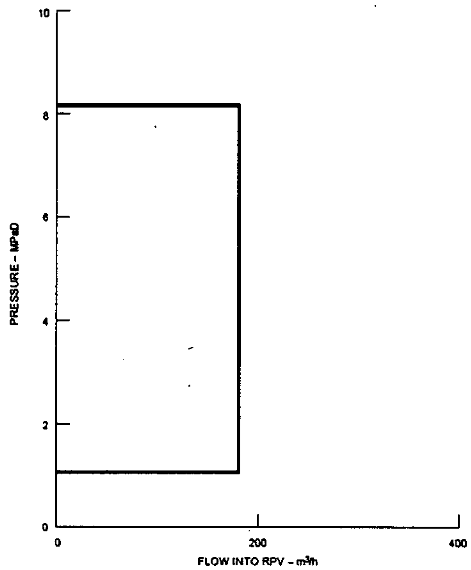
As a result of this study, the performance of the TWL pump has been shown to be applicable to the ABWR RCIC and also to STP-3&4 (US-ABWR).

6.1 Analysis Requirements in COLA

The RCIC capacity is determined by the analysis of accidents and transients and is the same value as STP-3&4 Combined License Application (COLA) Tier 2 Table 6.3-1 and Figure 6.3-5 shown below.

Vessel Pressure at which flow may commence	MPaD (vessel to pump suction)	8.12
Minimum Rated Flow at Vessel Pressure	m^3/h MPaD (vessel to the air space of the compartment containing the water source for the pump suction)	182 1.035 to 8.12

(COLA Tier 2 Table 6.3-1)



(COLA Tier 2 Figure 6.3-5)

6.2 System Specifications

System specifications include the pump rated flow and the rated developed head based on analysis requirements, which are described in Section 6.1.

<Flow rate>

Flow rate is the same as analysis flow rate (182 m^3/h). This is because the TWL pump is not required to supply cooling water from pump discharge line to the barometric condenser which used to be mounted on the former RCIC turbine.

<Developed head>

The developed head for each reactor condition is as follows;

High pressure condition: 900 m
Low pressure condition: 186 m

These values are specified by RPV pressure in analysis, static head and system friction loss, and are the Toshiba ABWR standard design.

However, as shown in the following table, the minimum required value of pump developed head that satisfies the analysis requirements is [ ] at high pressure and [ ] at low pressure conditions.

( )

6.3. Pump Performance Curves

Appendix C contains the TWL pump performance curves for STP-3&4 RCIC which indicate that the TWL pump can meet the plant design requirements.
Therefore, the analytical curve currently in COLA Tier 2 Figure 6.3-5 does not need to be changed due to application of the TWL pump to the RCIC.

7. Comparison of Design Characteristics of Clyde TWL Pump to Conventional (Terry Type) Pump

Comparison of TWL pump to conventional pump used in past BWRs is shown in the following table. In addition, the impact on safety of using the TWL pump design is described.

1.Configuration	TWL (STP-3&4) design	Figure 1 provides a cross-sectional view of the TWL pump and turbine. Both the pump and the turbine are contained within an integrated monoblock casing. The pump impeller and the turbine wheel are both attached to a single, common shaft within the casing and the bearings are located in the center of the shaft between the pump impeller and the turbine wheel. 1) The integrated monoblock casing and single shaft design eliminate the risk of coupling misalignment. The integrated design reduces the space required for the pump and turbine by about half. (Figure 3 compares the general arrangement in a reactor building.) 2) The use of a monoblock casing eliminates the need for shaft seals since the shaft does not extend outside the casing. With no shaft seals, there is no need to control shaft seal steam leakage. This single shaft design also eliminates the need for field alignments.
	Conventional design	Figure 2 provides a sketch of the previous RCIC pump and turbine concept. The pump and turbine are in separate casings. In each, a shaft extends out of the casing and a coupling joins the two shafts. Field alignment of the units is required. The pump and the turbine are each attached to individual shafts which are supported by the bearings in their respective casings. Special lubrication passages are required to direct lubrication flow to and from an exterior oil lubrication system to the various bearing locations and to control components.
	Safety Impact	There is no adverse impact on safety. No field alignment of the TWL pump and turbine is required. Therefore, the single shaft results in less potential for vibration problems. There are no rotating shaft seals for which steam leakage control is required.
2.Control	TWL (STP-3&4) design	No external electrical power or control devices are required to maintain the desired pump flow. Flow control is an integral part of the pump and turbine design, as follows: Pump discharge flow passes through a venturi and the differential pressure across the venturi (inlet to throat) acts on opposite sides of a balance piston to move the piston against a spring. The movement of the balance piston changes the position of the control valve which adjusts the steam flow to the turbine. This steam flow adjusts the pump speed and flow. Figure 4 provides a sketch of flow control. Instrumentation that indicates turbine-pump speed, pump discharge pressure, and system flow will be displayed in the control room.

2.Control	Conventional design	Flow control is performed external to the pump and turbine. Flow is measured in a flow element, and the result is evaluated in the flow controller. A difference to a reference value is generated, and an electrical signal is sent to the electro-hydraulic control valve actuator to signal a servo to adjust the position of the control valve. The control valve will regulate the steam flow to the turbine which, in turn, adjusts the pump speed and flow. Figure 5 provides a sketch of flow control.
	Safety Impact	There is no adverse impact on safety. Flow control functions that are self adjusting and self-contained within the integrated turbine-pump increase operational reliability since there are no external control components or software required that could be a source of trouble for proper operations.
3.Start transient	TWL (STP-3&4) design	The TWL pump design initiates operation very quickly with the operation of a single control valve. The control valve is self adjusting and operates rapidly to bring the turbine-pump to rated conditions and prevent speed overruns. A typical start transient achieves full rated speed and flow in approximately 10 seconds. See Figure 6a for a typical start transient. No bypass piping is required which simplifies the RCIC system.
	Conventional design	Upon initial steam entry to the turbine, a shaft-driven hydraulic pump provides pressure necessary to actuate the governor valve and control the turbine speed. Prior to the hydraulic pressure actuating the governor, a steam-bypass line connected to the steam supply line prevents overspeed of the turbine and a resulting trip. Once the turbine is brought to idle speed and stabilized, after 10 seconds with the bypass valve open, a control system command opens the main steam admission valve and the turbine commences a controlled ramp-up in speed to reach rated flow within about 30 seconds. A typical starting transient for this system is shown in Figure 6b. The curve labeled "conventional start" is the idealized start transient without the steam bypass. This start has been shown to result in an overspeed trip if there is any delay in control valve movement during the initial startup.
	Safety Impact	There is no adverse impact on safety. The TWL pump design has increased reliability due to a simpler, one-step startup method and self-actuation, with no dependence on exterior piping systems and control systems. Rated flow is achieved in much shorter times with less risk of overspeed trip.

4.Control at Partial flow	TWL (STP-3&4) design	The pump flow rate needs to be controlled at the rated flow (800 gpm) initially and then at the partial flow rate (about 400 gpm) indefinitely. An analysis was performed to determine the length of time that the RCIC would have to operate continuously at rated flow until the RPV water level approached Level 8, and following this it could be switched to the 400 gpm flow needed to keep water level at the value for decay heat removal (about 1 hour). (See Figure 7) Figure 8 indicates the kick down method.
	Conventional design	The flow rate is infinitely controllable over the normal allowable flow range. For extended operation time, the minimum allowable flow is approximately 50% (400 gpm) of the rated flow (800 gpm). All RCIC systems have about 10% (80 gpm) minimum flow bypass piping system to provide pump protection during startups and shutdowns where there might be no flow. These are, however, limited to a very short time duration (less than 1 minute).
	Safety Impact	There is no adverse impact on safety. The RCIC system can provide rated flow. The amount of time that the RCIC could run without being shut down is approximately the same. The TWL pump flow rate step-down design is simpler and avoids the need for repeated operator action to adjust flow. The improved reliability of the turbine- pump design provides improved confidence that the pump will restart when needed.
5. Lubrication	TWL (STP-3&4) design	The pump and turbine bearings are lubricated by the RCIC process water, which is driven by internal first-pass pressure differentials through an external filter. During RCIC standby conditions, some flow is maintained for lubrication by gravity feed from the condensate storage tank (CST) or the suppression pool (S/P) through the bearings and into a drain tank, from which it is pumped to the suction side of the pump by a drain pump to prevent overflow of the drain tank. Therefore, the drain pump performs no safety-related function and is not needed for TWL pump operation. The pump and turbine require no oil lubrication system or the support coolers and cooling water flow associated with such systems. Figure 9 provides a sketch of lubrication flow. The drain pump is designed as non-ASME code pump that performs non-safety-related function. Therefore, the drain pump is not required for either PST or IST.

5. Lubrication	Conventional design	Both the pump and turbine bearings are lubricated by oil. A lubricating oil subsystem is therefore required to support this function and this system includes a pump, piping, filter, heat exchanger and a cooling water subsystem for the heat exchanger. In addition, the lubricating oil requires protection from water and other contamination. The maximum lubricating oil temperature is one of the limiting factors for not pumping high temperature water.
	Safety Impact	There is no adverse impact. The TWL pump design is a substantial improvement and simplification over the current system and it eliminates the need for complex subsystems for lubrication cooling and water/oil separation.
6. Sealing system	TWL (STP-3&4) design	The pump impeller and the turbine wheel are attached to a common shaft and integrated within a single casing. There are no rotating shaft penetrations through the monoblock casing and therefore there are no rotating shaft seals and no systems for accommodating their steam leakage outside the casing. There is a control valve stem double seal which provides for possible leakage to return to the turbine exhaust region.
	Conventional design	Both the pump impeller rotating shaft and the turbine wheel rotating shaft penetrate their respective casings and require systems to accommodate seal leakage. These shafts have double seals and captured steam leakage is piped to the barometric condenser where it is condensed and returned to the RCIC water. The governor valve stem and the trip and throttle valve stem are also double sealed and any leakage is piped to the barometric condenser.
	Safety Impact	There are no adverse impacts for safety. The TWL pump is a substantial improvement with the absence of major rotating shaft penetrations of the casings. It has virtually no leakage and the small potential leakage that might occur is contained within the system itself.
7.Barometric condenser	TWL (STP-3&4) design	Since the TWL pump has no shaft seal steam leakage, there is no need for a barometric condenser. There is, however, a drain tank and drain pump system for catching water leakage by non-rotating stems/shafts. Water leakage occurs by design for the pump and wheel shaft bearings to keep them lubricated during standby and to provide lubrication for startup. The water which goes through the bearings during standby is drained to the drain tank, from which it is pumped back to the pump suction piping. Figure 10 provides P&ID for the TWL pump. Figure 11 provides sketch of a drain tank.

7.Barometric condenser	Conventional design	Shaft seal steam leakage from the casing double seals on the rotating impeller and turbine shafts are directed by piping system to the barometric condenser, where it is condensed and pumped back to the RCIC pump suction piping. A vacuum pump is used to keep the barometric condenser at a pressure below atmospheric and to remove the noncondensibles. RCIC process water is used to cool the condenser. RCIC cooling water for the oil coolers is directed to the hotwell of the barometric condenser.
	Safety Impact	There are no adverse impacts on safety. The TWL pump is an improvement in that it does not require the barometric condenser or the lube oil cooling system, which increases the reliability of the RCIC system.
8.Maintenance	TWL (STP-3&4) design	The pump and turbine should be inspected every 60 (sixty) months. After access to the machine has been cleared, (a pipe spool piece needs to be removed at the pump suction which is on the pump centerline.) the rotating element can be removed in two hours. A complete replacement of the bearings and rotating element could be accomplished in 12 hours.
	Conventional design	Inspection intervals are on the order of 60 (sixty) months. To be able to dismantle, inspect, and reassemble the RCIC turbine within a 12 hour period would be a best possible time frame. The actual time would be expected to be somewhat higher than the 12 hour value.
	Safety Impact	There are no adverse impacts on safety. The simpler system associated with the TWL pump would be likely to require less maintenance; however, maintenance is expected to be done during an outage, which should provide an adequate amount of time to handle maintenance or repair needs.
9.Licensability	TWL (STP-3&4) design	Current nuclear applications worldwide show that this equipment is fully licensable as an emergency core cooling system.
	Conventional design	Fully licensable as shown in the ABWR DCD.
	Safety Impact	No safety impact. The RCIC using TWL pump will be confirmed as a Tier 2 specific component. System overall design and functionality are unchanged.

8. Comparison of TWL Pump to Conventional Pump on RCIC System/Equipment Requirements

Comparison of TWL pump (basic design) to conventional pump on RCIC system/equipment requirements is shown in the following table.

Equipment	Item	Requirement	Conventional Pump (DCD)	TWL Pump
Common	Environment	To function under normal / accident conditions.	Satisfied	Satisfied

Common	EQ	IEEE-323	Satisfied	Satisfied
	Seismic Category	I	Satisfied	Satisfied
	Seismic test	IEEE-344	Satisfied	Satisfied
	Casing	Pump: ASME III Class2 Turbine: N/A	Satisfied	Satisfied Pump/Turbine: ASME III Class 2 (Monoblock design)
	Operating term at SBO	2h	8h	8h
	Unit size	-	L: 5.1 m W: 2.0 m H: 2.2 m	L: 2.2 m W: 1.4 m H: 1.7 m
Pump	Flow	182 m^3/h (System)	188 m^3/h (include barometric condenser cooling water 6m^3/h)	>182 m^3/h (High pressure condition can get more flow capacity by balance piston.)
	Developed head	>900m @ 8.22 MPaA (RPV) >186 m (611ft) @1.14 MPaA (RPV)	>900 m @ 8.22 MPaA (RPV) >186 m @ 1.14 MPaA (RPV)	>900 m @ 8.22 MPaA (RPV) >186 m @ 1.14 MPaA (RPV)
	Design temperature	10-77°C	10-77°C	10-77°C
	Design pressure	Discharge: 11.80 MPaG Suction: 2.82 MPaG	Discharge: 11.80 MPaG Suction: 2.82 MPaG	Discharge: 11.80 MPaG Suction: 2.82 MPaG
	Casing	-	Pump/Turbine separate type	Monoblock type
	Shaft	-	Pump/Turbine separate type	Pump/Turbine common type
	Impeller	-	Double suction, 5-stage	Single suction, 2-stage
	Inducer	-	Not used	Used
	Bearing/ Lubrication	-	Stainless steel/oil Thrust bearing: Ball type	Carbon/water Thrust bearing: Turbine side: Hydro balance piston Anti turbine side: N/A
	Steam supply inlet pressure	8.11 MPaA (1176 psia) 1.03 MPaA (149 psia)	8.11 MPaA (1176 psia) 1.03 MPaA (149 psia)	8.11 MPaA (1176 psia) 1.03 MPaA (149 psia)
Turbine	Steam flow	-	High: 16.4 t/h Low: 5.4 t/h	Depends on detail design. Less than conventional turbine.

Turbine	Power	-	At high reactor pressure: 675kW At low reactor pressure: 125kW	Depends on detail design. Higher than conventional pump (depends on pump efficiency)
	Rated Speed	-	-	Depends on detail design (Max 7870 rpm) Higher than conventional pump
	Turbine exhaust pressure	-	0.11 to 0.18 MPaA	Depends on detail design
	Design pressure	8.62 MPaG	8.62 MPaG	8.62 MPaG
	Design temperature	302°C	302°C	302°C
	Critical speed	-	-	More than 125% rated speed
	Pre heat	-	Not required	Not required
	Sealing	-	Grand seal and barometric condenser	Pump side: Water Anti pump side: Not required
Turbine controller	Flow rate measurement	-	Using system flow element	Using pump outlet venturi
	Governor	-	EHC	Mechanical
	Trip	Electrical and Mechanical	Electrical and Mechanical	Electrical and Mechanical
	Manual control	Controllable from the main control room	Satisfied	Satisfied (Kick down for reduced flow)
	Startup time	Less than 29 s from initiation signal to a rated flow	Satisfied	Satisfied About 10 s
	Power source	-	DC	Not required (DC: kick down)
Lubricant oil pump		-	Required	Not required
Oil cooler		-	Required	Not required
Barometric condenser		-	Required	Not required
Vacuum pump		-	Required	Not required
Condensate pump		-	Required	Not required
Vacuum tank		-	Required	Not required
Separator		-	Required	Not required
Drain tank		-	Not required	Required
Drain pump		-	Not required	Required

9. STP-3&4 COLA Change Outline

The ABWR DCD identifies functional requirements for the RCIC system based on the types of turbines and pumps that were in use for RCIC designs in typical US nuclear power industry applications at the time of the DCD. However, the DCD did not specify the type of turbine and pump to be used.

The TWL pump design is simpler and more compact in comparison with the types of pump and turbine combinations contemplated at the time of the certified design. The performance of the TWL pump increases reliability over the current DCD design.

The proposed TWL pump design meets all safety-related system performance requirements per the commitments in the STP-3&4 COLA. Further, none of the safety analyses for the RCIC that were included in the DCD are adversely affected by the proposed design. In fact, the new design brings a higher level of reliability and simplicity of operation to the RCIC operations.

Key changes in RCIC system in STP-3&4 COLA are as follows.

<Bypass start system is deleted>

The RCIC design in the DCD specified the use of a bypass steam line with a DC motor-operated bypass valve connected to the steam supply line to the turbine to ensure that prompt turbine startup did not result in a pressure spike and a turbine overspeed trip prior to hydraulic pressure being sufficient to control the governor. The bypass valve and the bypass start system will be deleted from the RCIC system design since its function is not needed for the proposed turbine-pump which has superior high speed rating and speed regulation capability. The capability of the TWL pump has been proven in other nuclear plant applications. Furthermore, per COL action item 1.12, a start-up test of the RCIC system will confirm the proper operation of the RCIC turbine-pump during plant start-up testing.
This change relates to DCD Tier 1 2.4.

<Turbine safety and performance design is changed>

Conventional turbines used in US-ABWR turbine-pumps are not included in the scope of standard ASME Code. To assure that the turbine is fabricated to the standards commensurate with ASME safety and performance requirements, conventional US-ABWR turbine-pumps impose specific additional design requirements. In contrast, the TWL pump (monoblock casing with turbine-pump) can meet ASME Section III, Class 2 requirements for safety and performance requirements.

It is proposed that Tier 2 be changed to identify the turbine as an ASME Code Section III, Class 2 component.

<Barometric condenser is deleted>
The RCIC design in the DCD specified the use of a barometric condenser to which was directed the steam leakage past the rotating shaft seals in the prior turbine-driven RCIC pump concept. The proposed TWL pump monoblock casing design eliminates the need for shaft seals and the resulting steam leakage. Since there is no shaft seal leakage with the proposed pump design, there is no longer any need for the barometric condenser or it's associated piping and cooling water system. Changes are proposed to Tier 1 and Tier 2 of the DCD to delete references to the barometric condenser and its support system.

<Drain tank is added>
The proposed TWL pump design requires that a continuous flow of water be maintained through the encased shaft bearings. During standby conditions, this flow is provided by water from the condensate storage tank (CST) or the suppression pool (S/P) flowing by gravity head to the bearings and then to a leak-off line from the bearing to a separate drain tank. Water is transferred by a small pump from the drain tank to the main pump suction lines. The same drain tank is also used to capture steam condensate in the turbine exhaust line to the suppression pool.

9.1 Summary of Design Changes Related to DCD
The following is a summary of design simplifications based on changes from the DCD pump to the proposed TWL pump alternate design:

1) Monoblock Design
The monoblock design combines the turbine wheel and the pump impellers on a single shaft inside a single casing. This eliminates the risk of coupling misalignment of two shafts from two casings, eliminates the need for field alignments and reduces the installation space by about 50%. (See Figures 1 and 3)

Safety Impact: There are no adverse impacts on safety from using the proposed monoblock turbine/pump configuration.

2) No Shaft Seal
The proposed TWL pump monoblock design has both the turbine wheel and the pump impellers attached to a single shaft` within the single casing. There are no rotating shaft seals penetrating the

casing and therefore no leakage of shaft steam leakage has to be accounted for by piping system exhaust lines to a condenser.

COLA drawing: RCIC P&ID will be changed.
Safety Impact: There are no adverse impacts on safety from removal of the shaft seals. This also eliminates a potential radioactive leakage path from primary containment.

3) Bearings location
In the proposed TWL pump design, a central bearing supports a single shaft to which is attached the turbine wheel and pump impellers and the bearings are lubricated by water being moved by the pump. (See Figure 1) The proposed TWL pump design simplifies the bearing design for the RCIC turbine and pump in the DCD, which were based on two separate casings and separate shafts, with oil lubricated bearings located on either side of each shaft to support the pump impellers and turbine wheel, respectively.

COLA drawing: RCIC P&ID will be changed.
Safety Impact: There are no adverse impacts on safety from locating the shaft bearings inside the single turbine-pump casing.

4) Controls
In the proposed TWL pump design, control is completely internal to the pump and turbine with fewer control components. Pump discharge flow passes through an internal venturi and the differential pressure across the venturi acts on opposite sides of a balance piston which changes the position of a control valve to adjust the flow of steam. The steam flow to the turbine adjusts the turbine speed and thereby the water flow. No external electrical control devices or connections are required for flow control and operation is not dependent on AC electrical power. This greatly simplifies the RCIC turbine and pump flow controls described in the DCD for which the flow control was performed external to the pump and turbine. Control signals for the turbine and pump were measured in a flow element and evaluated in a flow controller that would send a signal to adjust the position of the control valve which adjusts the turbine speed and water flow.

COLA drawing: RCIC P&ID will be changed.
Safety Impact: There are no adverse impacts on safety from changing to the proposed flow control design. Per COL Action Item 1.12, the RCIC system will be operated during plant start-up testing to confirm that the design protects from turbine overspeed and excessive steam supply line pressure spikes.

5) Start Transients

The TWL pump is designed to achieve start-up very quickly with the operation of a single steam control valve. Once steam flow to the turbine commences, the control valve is self-adjusting and operates rapidly to produce rated flows within about 10 seconds (compared to design requirement of 29 seconds). A typical start transient is shown in Figure 6a. The TWL pump design provides turbine "overspeed" protection based on a primary, electronic overspeed trip which automatically shuts down the turbine upon receipt of any signal indicating turbine exceeds 110% of rated speed and a secondary mechanical design trip that limits turbine speed to 125 % (maximum) of rated speed.

The DCD design turbine-pump has a normally open governor valve which adjusts turbine speed through actuation of a shaft-driven hydraulic pump but it takes about 10 seconds of operation to achieve necessary pressure to control governor actuation. To avoid turbine overspeed trip while the hydraulic pump comes up to speed, a steam bypass line with a motor-operated steam bypass valve is attached to the steam supply and is open for 10 seconds prior to opening the main steam supply valve. Then the main steam supply valve is opened and turbine-pump speed is increased to achieve rated flow within a maximum time of approximately 30 seconds. A typical start transient for this system is shown in Figure 6b. The curve labeled "conventional start" is the idealized start transient without the steam bypass.

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

COLA safety analysis: No impact.

Safety Impact: There are no adverse impacts to safety for using the improved controls and resultant start transient.. The quicker response time (10 seconds) from TWL pump easily meets the RCIC system response time requirement (<29 seconds). There is no impact on safety analysis.

6) Lubrication

The TWL pump design uses process water to lubricate the bearings of the single shaft. Process water exits the first stage impeller and is routed through the pump cover and an external filter back to the central water chamber between the bearings. Bearing water flow that passes through the bearings is returned to the pump suction. During standby, flow of water to the bearing is maintained by water from the condensate storage tank (CST) or the suppression pool (S/P) flowing by gravity head to the bearings and then to a leak-off line from the bearing to a separate drain tank. Water is transferred by a small pump from the drain tank to the main pump suction lines. (See Figures 10 and 11).

The DCD design turbine-pump uses oil lubricated bearings for the pump and the turbine shafts. This requires an oil subsystem which would include 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 TWL pump design has eliminated the need for an oil cooling subsystem.

COLA drawing: RCIC P&ID will be changed.
Safety Impact: There are no adverse impacts on safety from elimination of the oil cooling subsystem. Elimination of the oil system lowers the combustible loading in the RCIC room which reduces the fire hazard risk.

7) Sealing System

The TWL pump design has the turbine wheel and the pump impellers all mounted on a single shaft in a single casing. There are no rotating shafts penetrating the casing and consequently no shaft seals for rotating shafts, whose leakage of potentially radioactive steam would have to be managed by additional components and piping. Some minor leakage past the double seals on non-rotating shafts (e.g., valve stems) is managed by routing drainage from these sources to the turbine exhaust and thence to the drain tank.
With the DCD turbine-pump design, rotating shafts exit from the pump and turbine casings. These shafts require seals to contain the water and steam and leakage from seals is piped to the barometric condenser
COLA drawing: RCIC P&ID will be changed.
Safety Impact: There are no adverse impacts on safety from the simplified sealing system design.

8) Barometric Condenser

The barometric condenser was required for the DCD turbine-pump (two-casing) design to collect the steam leakage by the seals of the rotating shafts and to receive cooling water for lubricating oil cooler.
The barometric condenser is not required for the TWL pump (monoblock casing) design since there are no rotating shafts penetrating the pump casing, and because the bearings are cooled by

water flowing through the turbine-pump so no lubrication oil needs to be cooled. Without the barometric condenser, the vacuum pump that maintains condenser hotwell vacuum is no longer needed as well. The significant reduction of equipment has the ancillary value of reducing some of the risks for later reliability breakdowns and the elimination of the condenser also lessens the potential of introducing oxygen to the inerted containment via in-leakage at the shaft seals.

COLA drawing: RCIC P&ID will be changed.

Safety Impact: There are no adverse impacts on safety from removal of the barometric condensers and associated auxiliary subsystems. Elimination of the barometric condenser and other auxiliary support equipment will make the RCIC system simpler and more reliable, and will prevent a potential dilution of the containment inert gas.

9) Intersystem LOCA (ISLOCA)

The proposed TWL pump design has been shown to satisfy the ISLOCA requirements identified in DCD Tier 2 Appendix 3M. The ISLOCA requirement for RCIC system in Appendix 3MA is revised to reflect deletion of some piping.

COLA Tier 2: Appendix 3MA will be changed.

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

9.2. Justification for Departure

The proposed changes from the DCD/COLA Rev.1 design are justified based on the following reasons:

1) All nuclear safety performance criteria for the RCIC system continue to be met.
2) All safety-related pressure boundary components are now ASME N-stamped since the new turbine-pump meets these requirements.
3) Combustible fire loading in the RCIC pump room has been reduced by the elimination of the turbine-pump lubricating oil system.
4) A potential source of radioactive bypass leakage from rotating shaft seals has been eliminated by the use of a single casing turbine-pump design.
5) The number of active safety-related components (steam bypass valve, electronic governor, etc.) has been reduced.
6) A potential dilution path for inerted primary containment atmosphere was eliminated by removal of the barometric condenser and its return line to the suppression pool.

7) Safety-related battery drain down has been reduced by reducing DC power demand during station blackout scenarios by eliminating the motor operated steam bypass valve and the electronic flow controls and instruments.

9.3. Qualification Information

The TWL pump design has been shown to satisfy the environmental requirements of IEEE Standard 323 for the environmental conditions inside the reactor building for normal and accident conditions. It has also been shown to satisfy the seismic requirements of IEEE Standard 344. Therefore the TWL pump design meets the environmental and seismic qualification requirements identified in the DCD Sections 3.10 and 3.11.
The TWL pump is functionally qualified to perform its required functions in compliance with ASME QME-1-2007, which is endorsed in RG 1.100, Rev.3.

9.4 Nuclear Safety Review

The change from the current RCIC turbine-pump (separate casings) design to the proposed TWL pump (monoblock casing) design will have no adverse impacts on safety compared to the approved ABWR design. In fact, the proposed change will increase plant safety and will improve plant operation and availability. Maintenance, inspection and surveillance requirements will be reduced because of simplified design, increased reliability and the reduced numbers of active components. The improvement in RCIC pump and turbine reliability will also reduce risk.

The RCIC system has been shown to comply with General Design Criteria 2, 17, 27, 35, 36 and 37 in Tier 2 Subsection 5.4.6.

FSER (NUREG-1503) describes conformance to GDC 4, 5, 29, 33, 34 and 54 based on SRP 5.4.6.

GDC 4: NUREG-1503, "FSER Related to the Certification of the ABWR Design" discussed how the original Terry-type turbine and pump is protected against pipe whip inside and outside of containment as required in GDC 4. The TWL pump system design meets the same criteria.

GDC 5: The RCIC system/equipment will not be shared between units and so GDC 5 requirements concerning shared systems do not apply to the RCIC system. Likewise, GDC 5 is not affected by the change to the TWL pump.

GDC 29 and 34: The RCIC system is designed to perform its function without the availability of any AC power and, in conjunction with the high-pressure core flooder system, is designed to ensure an extremely high probability of accomplishing its safety function.

This is not affected by the change to the TWL pump.

GDC 33: The RCIC System is designed to supply reactor coolant makeup for small leaks. Therefore, GDC 33 requirement for protection against small breaks is satisfied. NUREG-1503 discussed how the original Terry-Turbine met GDC 33. The TWL pump design meets the same criteria.

GDC 54: Compliance with the containment leakage requirements is discussed in Subsection 6.2.6 of NUREG-1503. Containment isolation criteria are discussed in Subsection 6.2.4 of NUREG-1503. The containment isolation system is described in Subsection 6.2.1 and Table 6.2-7 of the DCD/COLA Tier 2. Containment isolation valves in vacuum pump discharge lines were deleted by TWL pump design, and it does not adversely affect containment isolation; therefore, there is no impact on this criteria.

RCIC system performance specifications used in Tier 2 accident analyses are shown in Figure 6.3-5 of Tier 2. The RCIC system has been shown to perform satisfactorily in the accident analysis in Section 15.6.5 for a loss of coolant accident. The ATWS evaluation in Appendix 15E also showed that the RCIC performance resulted in satisfactory operation following a loss of feedwater with a failure to scram. The TWL pump design specifications comply completely with all of the RCIC performance specifications, so that use of the TWL pump has no adverse safety impact on the prior successful accident analyses.

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

9.5. Consistency with ABWR Design Control Document (DCD)

The design changes proposed in this Technical Report (TR) are to Tier 1 and Tier 2 sections in the DCD Revision 4 and COLA Revision 1 for the ABWR. This includes changes of the piping and instrumentation diagram (Figure 5.4-8) and the process flow diagram (Figure 5.4-9).
Further details of proposed changes from the DCD are described in the next section.

9.6. Descriptions of Changes from DCD

The changes are listed below and short explanations are provided to direct the reader to the detailed discussions located elsewhere in this Technical Report.

Tier 1

On page 2.4.4-3, the reference to the barometric condenser as subject to ISLOCA design pressure requirements is deleted. This component is not needed and will be deleted.

In Figure 2.4.4a, the steam bypass valve is deleted. This component is not needed and will be deleted.

In Figure 2.4.4a, Note 1 is modified 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 TWL pump is manufactured to the higher ASME Code requirements.

In the ITAAC in Section 2.4.4, the acceptance criteria pertaining to the steam bypass valve and "10s" timer in items 3.c, 3.e, and 3.f are deleted. The steam bypass valve will be deleted as unnecessary.

In ITAAC acceptance criteria 3.i (2), turbine torque is deleted. This parameter can not be directly measured in the TWL pump integrated turbine-pump design and is not needed since delivered flow rate against head is the critical system safety performance parameter in any case.

Tier 2

In Table 3.2-1, the reference to the barometric condenser is deleted; the turbine safety classification is upgraded to Quality Group B; and footnote "(m)" is deleted. The condenser is being deleted and the TWL pump is manufactured to higher ASME Code requirements.

In Section 3.9, the words under "Special Topics" that discuss qualification of the pump and turbine as separate components in several places are changed to reflect the integrated design of the turbine-pump.

In Section 3.9.3.1.8, the discussion about how a non-ASME turbine conforms to ASME requirements is deleted in its entirety. The TWL pump conforms to ASME requirements. In Table 3.9-8, components that are no longer required are removed from the listing of items subject to in-service testing (IST).

In Appendix 3MA, piping and components to be removed from the RCIC system 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.)

In Section 5.4, Figures 5.4-8 and 9, "bubbles" are drawn to indicate the equipment to be removed in the piping and instrumentation diagrams (P&IDs).

In Section 5.4.6, markups are included to incorporate details of construction and operations.

In Table 5.4-2, the listings for the barometric condenser, the vacuum pump, restricting orifices, and the steam bypass valve are deleted. These components will be deleted as unnecessary.

In Section 6.3.2.2.3, a reference to RCIC dependency on an external cooling water supply is deleted. The use of the TWL pump eliminates the need for this cooling water supply.

This change also affected and is reflected by changes in DCD/COLA sections as follows:

Tier 1 Section 2.4

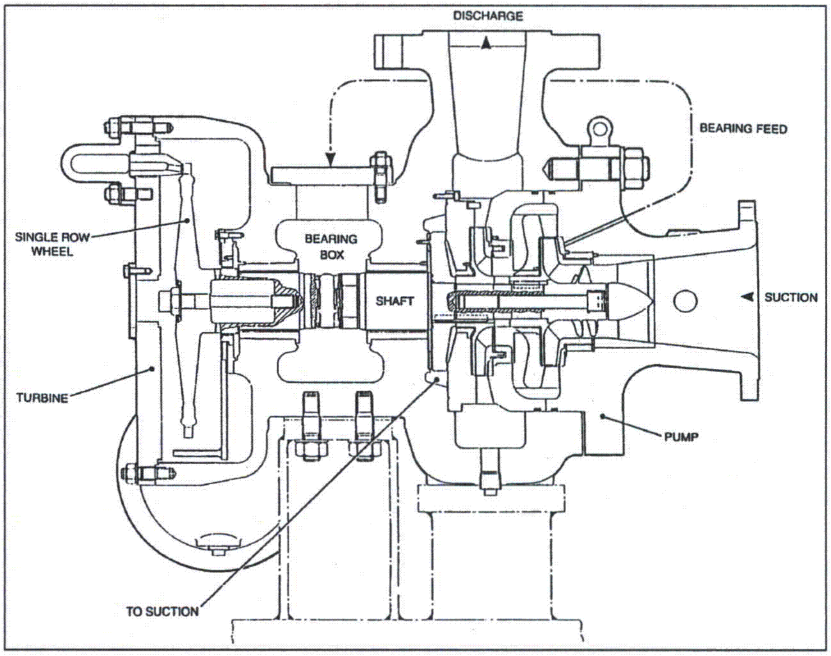
Tier 2 Sections 3.2, 3.9, 5.4, 6.2, 7.3, 14.2, 16.3, 16B.3, 19.3, 19.9, 19.11, 19.13

Tier 2 Appendix 1A, 3M, 3MA, 19K, 19M

10. Conclusion

The proposed use of the TWL pump integrated design will provide an overall improvement in plant safety and will fully meet the RCIC System design and performance requirements identified in the STP-3&4 COLA.

Table of Figures



. Figure 1 Cross-sectional View of the TWL Pump

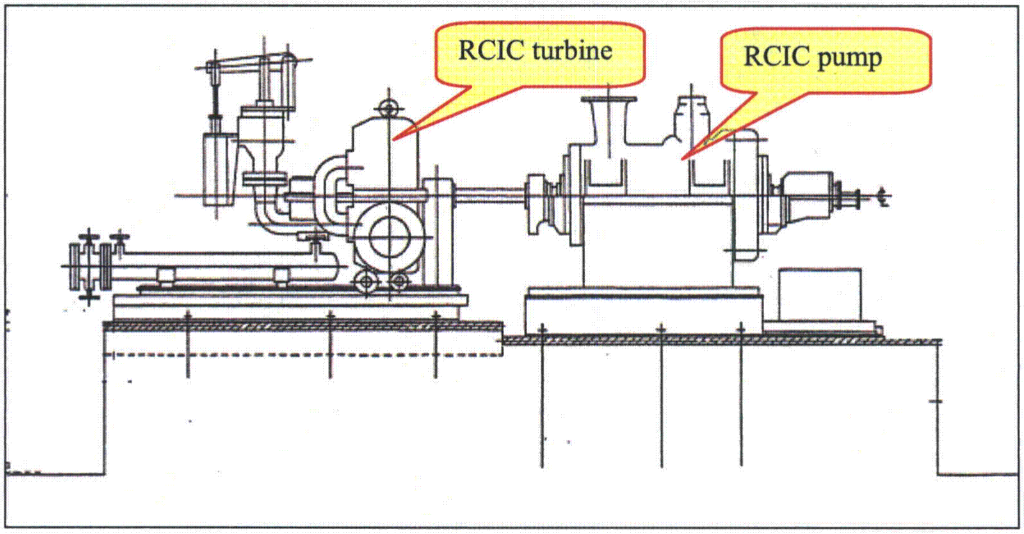


Figure 2 Sketch of the Conventional Pump/Turbine

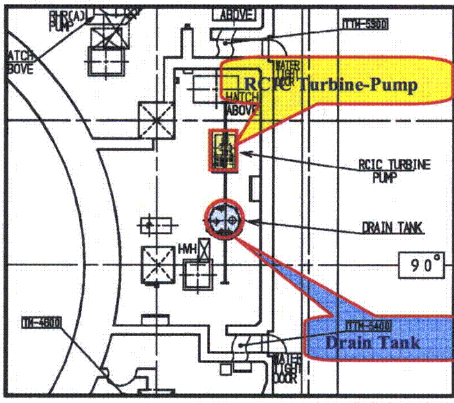
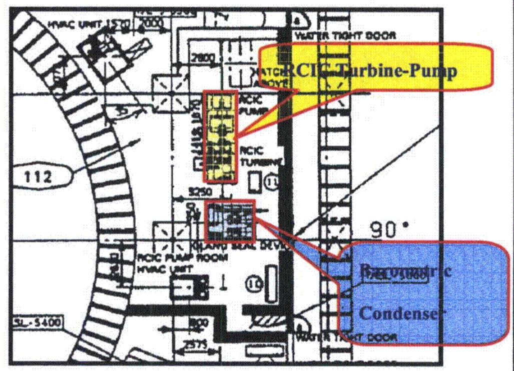
TWL Pump	Conventional Pump
	

Figure 3 Comparison of General Arrangement of Reactor Building

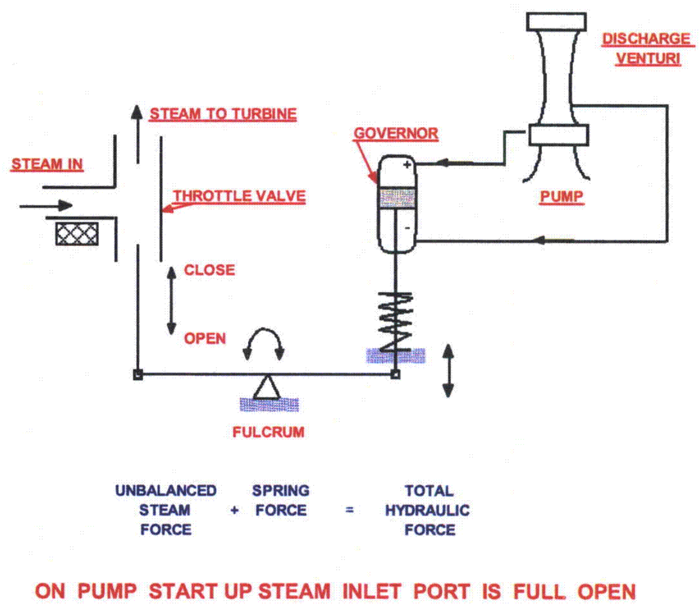


Figure 4a Sketch of TWL Pump Flow Control (Full Open)

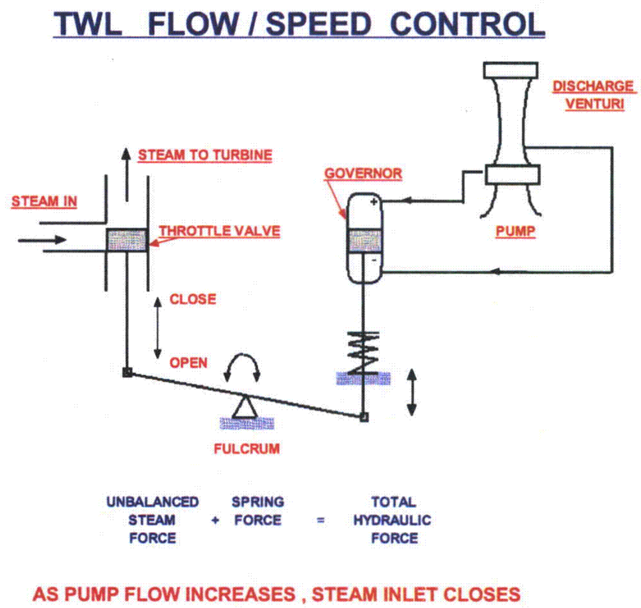


Figure 4b Sketch of TWL Pump Flow Control (Control)

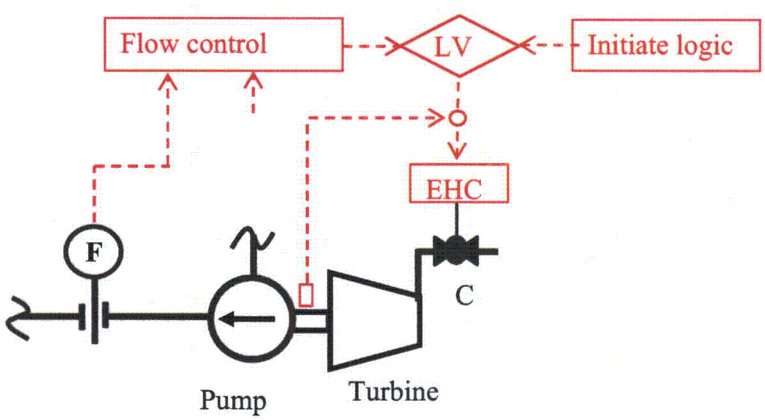


Figure 5 Sequence of Conventional Pump Flow Control

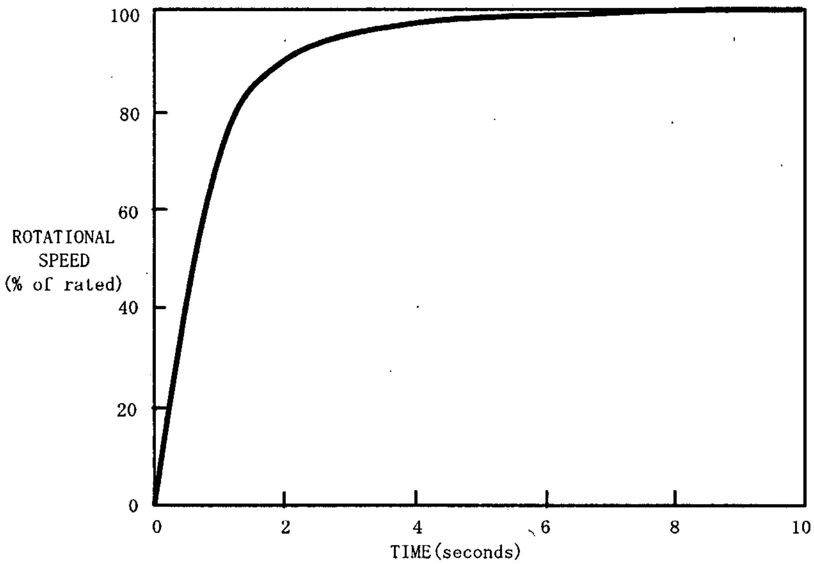


Figure 6a Typical Start Transient of TWL Pump

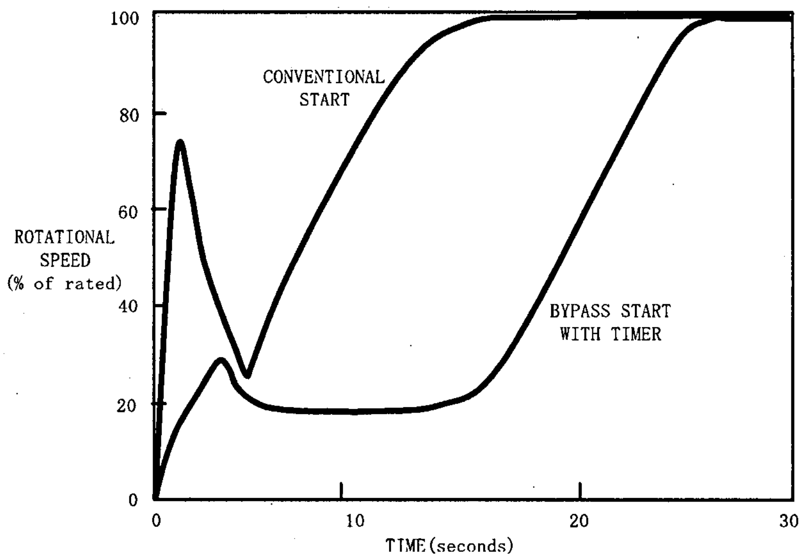


Figure 6b Typical Start Transient of Conventional Pump/Turbine

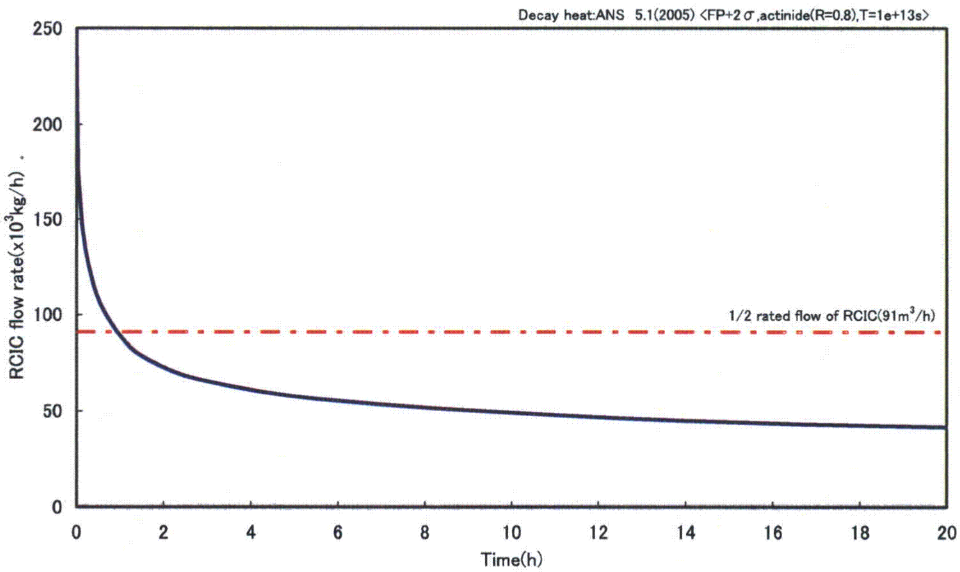


Figure 7 Flow Rate Based on Decay Heat

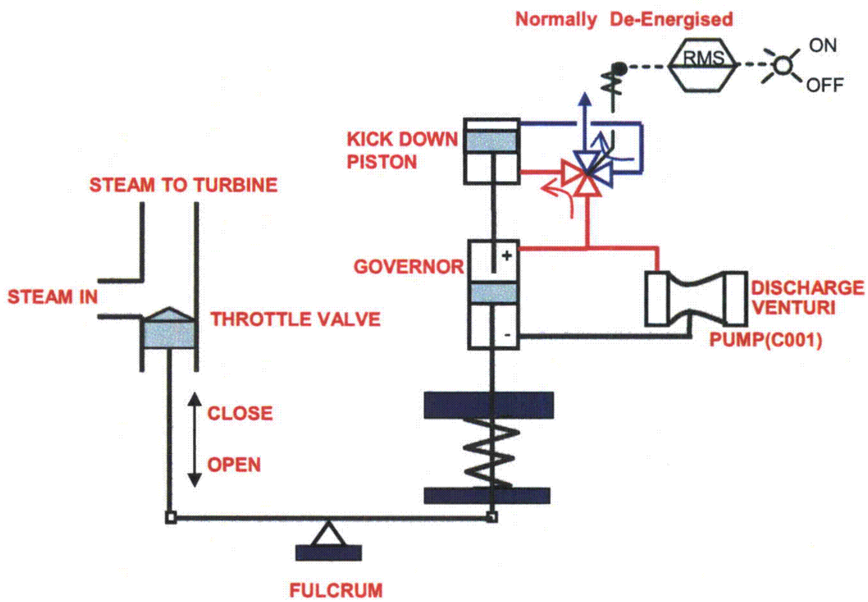
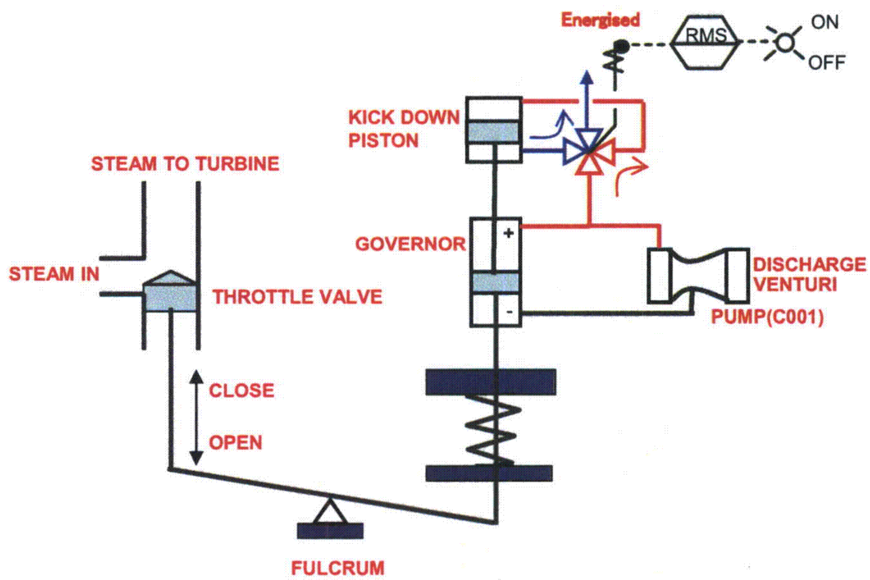
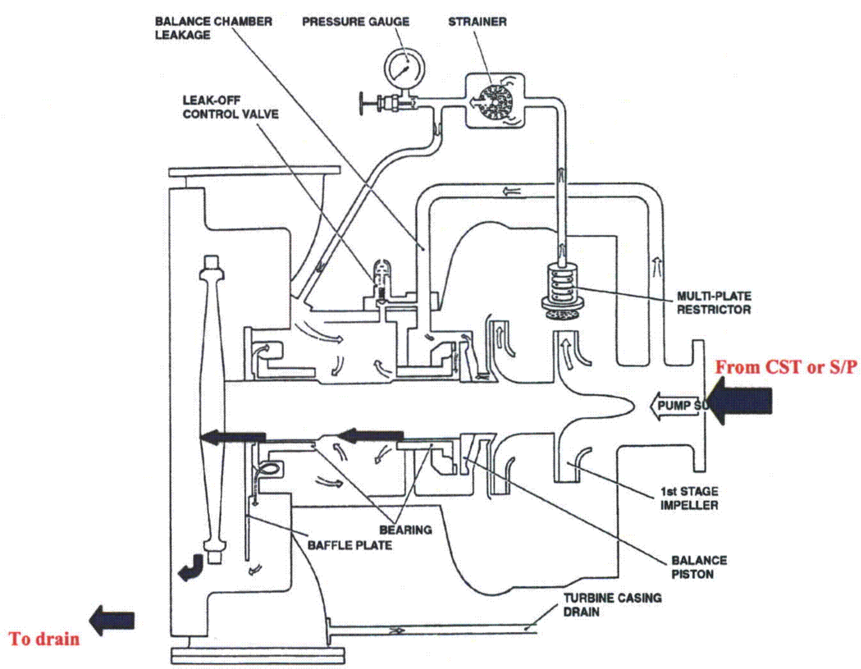


Figure 8a Flow Reduction Control (Rated Flow Control)



Reduced flow control (kick down)

Figure 8b Flow Reduction Control (Kick Down)



＊ : Standby leakage approx 2 gpm if no Stand Still seal fitted.

Figure 9a Sketch of Lubrication Flow (Standby)

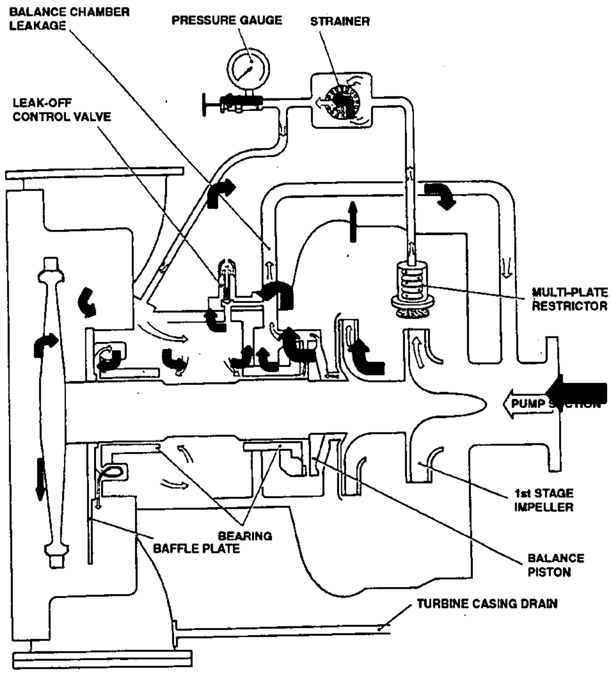


Figure 9b Sketch of Lubrication Flow (Operating)

Figure10 RCIC System P&ID (Rev.3) for STP-3

Figure 11 General Arrangement RCIC Drain Tank

Figure 12 General Arrangement RCIC Pump

Figure 13 Stop Gear & Pressure Governor RCIC Pump & Turbine

Appendix A Description of TWL Pump Design and Maintenance

B. Maintenance

Pumps are usually tested every month

/Record performance & vibrations

/Rotate the handle of the bearing lubrication water filter through one turn and check the differential pressure across the filter is satisfactory.

/Check governor linkage for anti scuff past or equivalent and check linkage strokes smoothly.

/Check hand trip and local and remote reset devices of overspeed trip gear.

Yearly Check

/Carry out an operational test of the overspeed trip gear.
(some perform every 2-5 years)

Recommended Five year Plan

Review of monthly test performance and vibration results will dictate the nature of the inspections.

/Inspect the wear rings and 'O' rings and seals and replace accordingly

/Check bearings for signs of wear (replace 10,000 – 12,000 hours)

/Replace bearing lubrication water filter element.

/Remove shaft trip bolt and clean external surfaces

/Inspect governor packing, stop valve & throttle valves as necessary

/Replace stand still seal – if fitted

Maintenance times

Once cleared and permitted to start

Rotating Element can be removed in 2 hours

Bearings replaced is 3 hours

Complete replacement of bearings and rotating element <12 hours

Areas where wear may take place

/Impeller and casing wear rings (5 year check)

/Shaft bearings (10,000 – 12,000 hours)

/Tip of trip bolt and associated trigger (only after excessive use) – regrind tip point

/Governor valve stem packing (5 year check)

/Seals within governor mechanism (5 year replacement)

/Pivot pins and bushes on mechanical governor (5 year replacement)

Recommended Spares holding

/1 set wear rings
/1 set bearings
/2 sets 'O' rings and seals
/1 set governor gland packing
/1 set pivot pins and bushes
/1 filter element

Service Capability

Houston Service Centre has Local Service Capability.

/Installation & Commissioning
/Repair, Maintenance & Overhaul
/Emergency Service
/Site testing
/Problem Solving & Technical Support
/Root Cause Analysis
/Condition Monitoring
/Upgrading – Hydraulic, Mechanical & Material for all Brands
/Re-rating of all Brands

Appendix B Operating Experience Information

CPL has many experiences in Auxiliary Feedwater and Emergency Core Cooling Pumps in Nuclear Power Stations.

TWL pumps constitute about 40% of them.

STP-3&4 duty is very close to Qinshan II Ext.

AUXILIARY FEEDWATER & EMERGENCY CORE COOLING PUMPS IN NUCLEAR POWER STATIONS			
INSTALLATION LIST			
LOCATION	DRIVER	Qty	STATUS C = Commissioned S = Supplied
Tomess	Motor	4	C
Heysham	Motor	4	C
Yonggwang 3 & 4	Diesel	4	C
Yonggwang 3 & 4	Motor	4	C
Yellow Creek	Motor	4	S
Yellow Creek	Turbine	4 (TWL)	S
Vandellos	Motor	2	2
Wolsong 2, 3 & 4	Motor	9	C
Ringhalls2, 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	Motor	4	C
Ulchin 3 & 4	Turbine	4 (TWL)	C
Yonggwang 5 & 6	Motor	4	C
Yonggwang 5 & 6	Turbine	4 (TWL)	C
Qinshan 2	Motor	4	C
Qinshan 2	Turbine	4 (TWL)	C
Dungeness'B'	Diesel	3	C
Lungmen 4	Turbine	2 (TWL)	S
Shin Kori	Motor	2	In manufacture
Shin Kori	Turbine	2 (TWL)	In manufacture
Qinshan 2 Ext	Motor	4	In manufacture
Qinshan 2 Ext	Turbine	4 (TWL)	In manufacture
Ling Ao II	Motor	4	In manufacture
Ling Ao II	Turbine	4 (TWL)	In manufacture
Hong Yan He 1 & 2	Motor	4	In manufacture
Hong Yan He 1 & 2	Turbine	4 (TWL)	In manufacture
Ningde 1 & 2	Motor	4	In manufacture
Ningde 1 & 2	Turbine	4 (TWL)	In manufacture
Total		**114(TWL) 42)**	

Appendix C TWL Pump Performance Curves for STP-3&4 RCIC

<High pressure condition>

Flow rate : $182m^3/h$

Developed head : 900m

<Low pressure condition>

Flow rate : $182m^3/h$

Developed head : 186m

Appendix D Subsection 5.4.6 of NUREG-1503

Reactor Coolant System and Connected Systems

This section is not applicable to the ABWR because a main steam isolation valve leakage control system is not used. This is discussed in Section 10.3 of this report.

5.4.6 Reactor Core Isolation Cooling System

The staff evaluated the reactor core isolation cooling (RCIC) system for conformance to SRP Section 5.4.6. The staff's review criteria are based on meeting the following:

(1) GDC 4 as related to dynamic effects associated with flow instabilities and loads.

(2) GDC 5 as related to structures, systems, and components important to safety not being shared among nuclear power units unless it can be demonstrated that sharing will not impair its ability to perform its safety function.

(3) GDC 29 as related to the system being designed to have an extremely high probability of performing its safety function in the event of anticipated operational occurrences.

(4) GDC 33 as related to the system capability to provide reactor coolant makeup for protection against small breaks in the reactor coolant pressure boundary so the fuel design limits are not exceeded.

(5) GDC 34 as related to the system design being capable of removing fission product decay heat and other residual heat from the reactor core to preclude fuel damage or reactor coolant pressure boundary overpressurization.

(6) GDC 54 as related to piping systems penetrating primary containment being provided with leak detection and isolation capabilities.

Unlike most current BWR designs, the RCIC system in the ABWR is a part of the emergency core cooling system (ECCS). The initiation logic is diversified by adding a high drywell pressure input as well as by maintaining the typical system initiation on RPV Level 2. ~~In the ABWR design, system reliability is improved by including a bypass line to the turbine steam inlet valve (F045 dc powered) to provide for a smoother turbine start and reduce the possibility of an overspeed trip~~. Since the RCIC system is a part of the ECCS, full-flow testing capability is provided using the safety-related suction source (i.e., suppression pool).

The RCIC system is designed as a high-pressure reactor coolant makeup system that will start independent of the ac power supply. All motor-operated valves will be dc operated, except the inboard steam isolation valves. Steam supply inboard isolation valve F035 and inboard bypass valve F048 will be powered from ac power sources; however, valve F035 will normally open and fail as is; therefore, loss of ac power will not prevent RCIC system operation. Inboard bypass valve F048 will be closed during the system operation; and hence, loss of ac power will not prevent RCIC system operation. The system will provide sufficient water to the reactor vessel to cool the core and to maintain the reactor in a standby condition if the vessel becomes isolated from the main condenser and experiences a loss of feedwater flow. The system also is designed to maintain reactor water inventory, in the event of a loss of normal feedwater flow, while the vessel is depressurized to the point at which the RHR system can function in the shutdown cooling mode.

In reviewing Amendment 32 to the SSAR, the staff noted that the previously described RCIC system capability, without ac power, of "8 hours" had been changed to "at least 2 hours." The staff raised a concern to GE that changing the capability from 8 hours to 2 hours would result in a measurable increase in the core damage frequency estimate as related to station blackout. To clarify the changed position, GE stated and the staff agreed that an RCIC system capability of up to 8 hours could only be adequately demonstrated during startup tests when plant steam is available after fuel loading. SSAR Section 5.4.6 stated that the RCIC system is designed to perform its function without ac power for at least 2 hours with a capability up to 8 hours. It further stated that the COL applicant will provide analyses for the as-built facility to demonstrate the 8-hour capability. This is acceptable and resolved the staff's concern.

The RCIC system consists of a steam-driven turbine-pump unit and associated valves and piping capable of delivering makeup water to the reactor vessel through the feedwater system. The steam supply to the RCIC turbine is taken from main steamline B at the upstream side of the inboard MSIV. The steam supply to the RCIC turbine will be ensured even if MSIVs are closed. Fluid removed from the reactor vessel following a shutdown from power operation will be normally made up by the feedwater system and supplemented by inleakage from the control rod drive system. If the feedwater system is inoperable, the RCIC system will start automatically when the water level in the reactor vessel reaches the Level 2 (L2) trip set point or will be started by the operator from the control room. The system is capable of delivering rated flow within 29 seconds of initiation. Primary water supply for the RCIC system comes from the condensate storage tank

TWL Pump has excellent quick start performance.

(CST), and a secondary supply comes from the suppression pool.

The RCIC system design operating parameters, as shown in SSAR Figure 5.4-9b, are consistent with expected operational modes.

Essential components of the RCIC system are designated seismic Category I (in accordance with RG 1.29, Revision 3) and QG B (in accordance with RG 1.26, Revision 3), as discussed in Section 3.2 of this report. The proposed initial test programs are discussed in Chapter 14 of this report.

The RCIC system is housed in the reactor building, which will provide protection against wind, tornados, floods, and other weather phenomena. Compliance with the requirements of GDC 2 is discussed in Section 3.8 of this report. In addition, the system is protected against pipe whip inside and outside the containment, as required by GDC 4 and as discussed in Section 3.6 of this report.

The HPCF and RCIC systems are located in different rooms of the reactor building for additional protection against common-mode failures. Different energy sources will be used for pump motivation (steam turbine for RCIC pump, electric power for HPCF pumps) and different power systems for control power. This diversity conforms to SRP Section 5.4.6.

To protect the RCIC pump from overheating, the RCIC system contains a miniflow line that will discharge into the suppression pool when the line to the reactor vessel is isolated. When sufficient flow to the vessel is achieved, a valve in the miniflow line will automatically close, thus directing all flow to the reactor.

The makeup water system connection to the RCIC system will maintain the pump discharge line in a filled condition up to the injection valve. The makeup water system operation eliminates the possibility of an RCIC pump discharging into a voided pipe and minimize waterhammer effects. A high point vent is provided, and the system will be vented periodically. The RCIC system includes a full-flow test line with water return to the suppression pool for periodic testing. The periodic tests will be performed according to ASME Code, Section XI, as required by the TSs. The staff requires, for any emergency core cooling system (ECCS), that the TSs include a system functional test at least every refueling outage, with simulated automatic actuation and verification of proper automatic valve position to verify that the RCIC pump will develop a minimum flow of 182 m^3/hr (800 gpm). This was DFSER TS Item 5.4.6-1. GE has submitted the ABWR TS which include the functional testing; this is acceptable. Therefore, DFSER TS Item 5.4.6-1 is resolved.

The suction piping of the RCIC system is designed for low pressure. A relief valve, therefore, is provided to protect against overpressurization of the line from the high-pressure piping. The suction pressure piping was upgraded from 1.37 MPa (200 psig) to 2.82 MPa (410 psig) for resolving the generic issue pertaining to interfacing systems loss-of-coolant-accident (ISLOCA) as discussed in Chapter 20 of this report.

Suitable provisions will be provided for isolation of the RCIC system from the RCS by one testable valve and a closed dc-powered valve in the RCIC system discharge line, and two normally open motor-operated valves with appropriate closure signals to terminate the leakage of the pipe as a result of a break outside containment. Inservice testing of pumps and valves is discussed in Section 3.9.6 of this report.

The RCIC system will have controls that will shut down the system if operating conditions exceed certain limits. A leak detection system is provided to detect leakage in the RCIC system.

The CST level transmitter will be supported and mounted in such a way that automatic suction transfer to the suppression pool from the non-seismic tank will take place without failure during a seismic event.

The RCIC system design meets RG 1.1, "Net Positive Suction Head for Emergency Core Cooling and Containment Heat Removal System Pumps," Revision 0.

In the DSER (SECY-91-153), the staff identified Outstanding Issue 24, which required an evaluation of the TMI-2 Action Items as related to the ECCS. The staff's evaluation of these items (NUREG-0737 requirements that are incorporated into 10 CFR 50.34(f)(1)(v) and (1)(ix)), as related to the RCIC system, is provided in Chapter 20 of this report. Therefore, DSER Outstanding Issue 24 is resolved.

During an earlier review, the staff found that the testing of steam isolation valves (F035 and F036) leading to the RCIC turbines in currently operating BWRs did not include actual operating conditions such as a differential pressure of about 7,000 kPa (1,000 psig) and a temperature of 286 °C (546 °F) expected during a steam pipe break downstream of the valves. Thus, there is no verification that the isolation valves will close during a break as a result of dynamic steam flow forces. Generic Issue (GI)-87, "Failure of HPCI Steamline Without Isolation," addresses this concern. Tests performed as part of the NRC effort to resolve GI-87 have reinforced concerns about the operability of motor-operated valves (MOVs) under these design-basis conditions. The staff concerns regarding operability of MOVs are given in Generic Letter 89-10 (June 1989) and its supplements. GE assumed closure of these valves in the steamline break analysis. Therefore, this functional requirement is incorporated into the ITAAC. In the DFSER the staff noted that the COL applicant referencing the ABWR design should verify test data showing the steam isolation valves (F035 and F036) will isolate under actual operating conditions of a differential pressure at about 7,000 kPa (1,000 psig) and a temperature of 286 °C (546 °F). This was DFSER COL Action Item 5.4.6-1. Since verification of the valves performance by the preoperational and power ascention testing is discussed in Chapter 14 of the SSAR, it need not be specified as a COL action item.

GE originally submitted the design description and the ITAAC for the RCIC system. At the time the DFSER was issued, the ITAAC review was in progress. Therefore, this was DFSER Open Item 5.4.6-1. GE has since provided a revised design description and ITAAC. The adequacy and acceptability of the ABWR design description and ITAAC are evaluated in Chapter 14.3 of this report. Therefore, this item is resolved.

The RCIC system meets GDC 4, 5, 29, 33, 34, and 54 as identified in SRP Section 5.4.6. Compliance with GDC 4 on protecting the system against dynamic effects associated with flow instabilities and loads is discussed in Section 3.6 of this report. Since the ABWR is a single-unit plant, GDC 5 are not applicable. The RCIC system meets GDC 29 and 34 because it is designed to performed its function without the availability of any ac power and, in conjunction with the high-pressure core flooder system, is designed to ensure an extremely high probability of accomplishing its safety function. The RCIC system is used to supply reactor coolant makeup for small leaks. Accordingly the system meets GDC 33. Compliance with GDC 54 is discussed in Section 6.2 of this report.

The staff concludes that the design of the RCIC system conforms to the Commission's regulations and is, therefore, acceptable.

5.4.7 Residual Heat Removal System

The staff evaluated the residual heat removal (RHR) system according to SRP Section 5.4.7. The staff's review criteria are based on meeting the following:

(1) GDC 2 with respect to the seismic design of systems, structures, and components whose failure could cause an unacceptable reduction in the capability of the residual heat removal system. Acceptability is based on meeting position C-2 of RG 1.29 or its equivalent.

(2) GDC 4 as related to dynamic effects associated with flow instabilities and loads (e.g., water hammer).

(3) GDC 5 which requires that any sharing among nuclear power units of structure, systems and components important to safety will not significantly impair their safety function.

(4) GDC 19 with respect to control room requirements for normal operations and shutdown.

(5) GDC 34 which specifies requirements for a residual heat removal system.

The RHR system consists of three independent loops - subsystems A, B, and C. Each loop contains a motor-driven pump, heat exchanger, piping, valves, instrumentation and controls. Each loop can take suction from either the RPV or the suppression pool and will be capable of discharging water to either the RPV or back to the suppression pool through a full-flow test line. Each shutdown cooling loop has its own heat exchanger, which will be cooled by the reactor building cooling water system. RHR subsystems B and C can be used for wetwell and drywell sprays. The RHR system will operate in the following modes:

(1) shutdown cooling

(2) suppression pool cooling

(3) wetwell and drywell spray cooling

(4) low-pressure flooder mode

(5) fuel pool cooling

(6) ac independent water addition

Affidavit for Withholding Confidential and Proprietary Information from Public Disclosure under 10 CFR § 2.390

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

In the Matter of

STP Nuclear Operating Company — Docket Nos.52-012, 52-013

South Texas Project
Units 3 and 4

AFFIDAVIT

I, Kenji Arai, being duly sworn, hereby depose and state that I am Senior Manager, System Design & Engineering Department, Nuclear Energy Systems & Services Division, Power Systems Company, Toshiba Corporation; that I am duly authorized by Toshiba Corporation to sign and file with the Nuclear Regulatory Commission the following application for withholding Toshiba Corporation's confidential and proprietary information from public disclosure; that I am familiar with the content thereof; and that the matters set forth therein are true and correct to the best of my knowledge and belief.

In accordance with 10 CFR § 2.390(b)(ii), I hereby state, depose, and apply as follows on behalf of Toshiba Corporation:

(A) Toshiba Corporation seeks to withhold from public disclosure the document entitled and identified as "Application of Turbine Water Lubricated (TWL) Pump to South Texas Project Units 3&4 RCIC Turbine-Pump", Revision 1, UTLR-0004-P (Proprietary), and all information identified as "Proprietary Class 2" therein (collectively, "Confidential Information").

(B) The Confidential Information is owned by Toshiba Corporation. In my position as Senior Manager, System Design & Engineering Department, Nuclear Energy Systems & Services Division, Power System Company, Toshiba Corporation, I have been specifically delegated the function of reviewing the Confidential Information and have been authorized to apply for its withholding on behalf of Toshiba Corporation.

(C) This document provides technical justification of application of the Turbine Water Lubricated (TWL) Pump to the RCIC turbine-pump for South Texas Project Units 3&4 Combined License Application to the Nuclear Regulatory Commission. The Confidential Information which is entirely confidential and proprietary to Toshiba Corporation is indicated in the document using brackets.

(D) Consistent with the provisions of 10 CFR § 2.390(a)(4), the basis for proposing that the Confidential Information be withheld is that it constitutes Toshiba Corporation's trade secrets and confidential and proprietary commercial information.

(E) Public disclosure of the Confidential Information is likely to cause substantial harm to Toshiba Corporation's competitive position and its business relations with the turbine-pump vendor by (1) disclosing confidential and proprietary commercial information about the design, manufacture and operation of the RCIC system for nuclear power reactors to other parties whose commercial interests may be adverse to those of Toshiba Corporation and the turbine-pump vendor, and (2) giving such parties access to and use of such information at little or no cost, in contrast to the significant costs incurred by Toshiba Corporation and the turbine-pump vendor to develop such information.

Toshiba Corporation has a rational basis for determining the types of information customarily held in confidence by it, and utilizes a system to determine when and whether to hold certain types of information in confidence.

The basis for claiming the information so designated as proprietary is as follows:

(a) The information reveals the distinguishing aspects of a process (or component, structure, tool, method, etc.) where prevention of its use by any of Toshiba Corporation's competitors without license from Toshiba Corporation constitutes a competitive economic advantage over other companies.

(b) It consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.), the application of which data secures a competitive economic advantage, e.g., by optimization or improved marketability.

(c) Its use by a competitor would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing a similar product.

(d) It reveals cost or price information, production capacities, budget levels, or commercial strategies of Toshiba Corporation, its customers or suppliers.

(e) It reveals aspects of past, present, or future Toshiba Corporation or customer funded development plans and programs of potential commercial value to Toshiba Corporation.

(f) It contains patentable ideas, for which patent protection may be desirable.

There are sound policy reasons behind the Toshiba Corporation system which include the following:

(a) The use of such information by Toshiba Corporation gives Toshiba Corporation a competitive advantage over its competitors. It is, therefore, withheld from disclosure to protect the Toshiba Corporation competitive position.

(b) It is information that is marketable in many ways. The extent to which such information is available to competitors diminishes the Toshiba Corporation ability to sell products and services involving the use of the information.

(c) Use by our competitor would put Toshiba Corporation at a competitive disadvantage by reducing his expenditure of resources at our expense.

(d) Each component of proprietary information pertinent to a particular competitive advantage is potentially as valuable as the total competitive advantage. If competitors acquire components of proprietary information, any one component may be the key to the entire puzzle, thereby depriving Toshiba Corporation of a competitive advantage.

(e) Unrestricted disclosure would jeopardize the position of prominence of Toshiba Corporation in the world market, and thereby give a market advantage to the competition of those countries.

(f) The Toshiba Corporation capacity to invest corporate assets in research and development depends upon the success in obtaining and maintaining a competitive advantage.

Further, on behalf of Toshiba Corporation, I affirm that:

(i) The Confidential Information is confidential and proprietary information of Toshiba Corporation.

(ii) The Confidential Information is information of a type customarily held in confidence by Toshiba Corporation, and there is a rational basis for doing so given the sensitive and valuable nature of the Confidential Information as discussed above in paragraphs (D) and (E).

(iii) The Confidential Information is being transmitted to the NRC in confidence.

(iv) The Confidential Information is not available in public sources.

(v) Public disclosure of the Confidential Document is likely to cause substantial harm to the competitive position of Toshiba Corporation, taking into account the value of the Confidential Information to Toshiba Corporation, the amount of money and effort expended by Toshiba Corporation in developing the Confidential Information, and the ease or difficulty with which the Confidential Information could be properly acquired or duplicated by others.

Mar. 16, 2010
Date

Kenji Arai
Senior Manager
System Design & Engineering Department
Nuclear Energy Systems & Services Division
POWER SYSTEMS COMPANY
TOSHIBA CORPORATIO

平成２２年登簿第　29　号

認　　証

嘱託人株式会社東芝部長新井健司は、公証人の面前で、添付書面に署名した。

よって、これを認証する。

平成２２年　3　月　16　日、本公証人役場において

横浜市中区羽衣町2丁目7番10号

横浜地方法務局所属

公　証　人

Notary

寺西賢一

KENJI　TERANISHI

証　　明

上記署名は、横浜地方法務局所属公証人の署名に相違ないものであり、かつ、その押印は、真実のものであることを証明する。

平成２２年　3　月　16　日

横浜地方法務局長　紺野清幸

APOSTILLE

(Convention de La Haye du 5 octobre 1961)

1. Country：JAPAN
   This public document
2. has been signed by　KENJI TERANISHI
3. acting in the capacity of Notary of the Yokohama District Legal Affairs Bureau
4. bears the seal/stamp of　KENJI TERANISHI　, Notary

Certified

5. at Tokyo　　6. MAR. 16. 2010
7. by the Ministry of Foreign Affairs
8. 10- №　300495
9. Seal/stamp：　　10. Signature：

MINISTRY OF FOREIGN AFFAIRS JAPAN

K. Oyabe

Kazutoyo OYABE

For the Minister for Foreign Affairs

Registered No. 2 9 of 2010.

Certificate of Acknowledgment of Notary

On this 16th day of March, 2010, before me, KENJI TERANISHI, a notary in and for YOKOHAMA District Legal Affairs Bureau, appeared Kenji ARAI, Senior Manager of TOSHIBA Corporation, who is personally known to me, affixed his signature to the attached document.

Witness, I set my hand and seal.

Notary — Notary's seal(Official)

Kenji Teranishi

KENJI TERANISHI

Kannai-odori Notary office

2-7-10, Hagoromocho, Naka-ku, Yokohama-city, Japan.

Attached to the Yokohama District Legal Affairs Bureau.