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Your ref: Docket No. 52-006
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May 26, 2009

Subject: AP1000 Response to Request for Additional Information (SRP 5)

Westinghouse is submitting a response to the NRC request for additional information (RAI) on SRP Section 5. This RAI response is submitted in support of the AP1000 Design Certification Amendment Application (Docket No. 52-006). The information included in this response is generic and is expected to apply to all COL applications referencing the AP1000 Design Certification and the AP1000 Design Certification Amendment Application.

Enclosure 1 provides the response for the following RAI(s):

RAI-SRP5.4.1-CIB1-01 R1

Questions or requests for additional information related to the content and preparation of this response should be directed to Westinghouse. Please send copies of such questions or requests to the prospective applicants for combined licenses referencing the AP1000 Design Certification. A representative for each applicant is included on the cc: list of this letter.

Very truly yours,

Robert Sisk, Manager
Licensing and Customer Interface
Regulatory Affairs and Standardization

/Enclosure

1. Response to Request for Additional Information on SRP Section 5

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NRO

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ENCLOSURE 1

Response to Request for Additional Information on SRP Section 5

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-SRP5.4.1-CIB1-01
Revision: 1

Question (Revision 0):

Westinghouse Electric Technical Report 34 (TR-34), "AP1000 Licensing Design Change Document for Generic Reactor Coolant Pump" summarizes the changes to the AP1000 DCD, Revision 16, Section 5.4.1.2.1 "Design Description" which proposes to state that the reactor coolant pump is a single stage, high-inertia, centrifugal sealless pump of either canned-motor design or wet winding design and that the flywheel assembly is of bi-metallic design consisting of a heavy metal alloy and stainless steel. TR-34 justifies the change from a canned motor design to a sealless pump design in order to "provide flexibility in specific pump design and vendor selection." In addition Section 5.4.1.3.6.3 of AP1000 DCD, Revision 16 states that the analysis to determine the capacity of the housing to contain the fragments of the flywheel is performed in the Curtis Wright Electro-Mechanical Corporation Report AP1000 RCP-06-009-P. This Curtis Wright report is only applicable for the canned-motor design.

10 CFR 52.63(a)(1)(vii) states that the Commission may not modify, rescind, or impose new requirements on the certification information, whether on its own motion, or in response to a petition from any person, unless the Commission determines in a rulemaking that the change contributes to increased standardization of the certification information. The staff finds the proposed change in Section 5.4.1.2.1 of AP1000 DCD, Revision 16 is not consistent with 10 CFR 52.63(a)(1)(vii) since it proposes the deletion of a standard pump design (canned motor) to a more generic "sealless" pump design (canned motor, wet-winding, etc.). Therefore, the AP 1000 DCD and TR-34 should be changed to provide the following:

- A specific reactor coolant pump/flywheel design (i.e. a single-stage, high-inertia, centrifugal, sealless reactor coolant pump of canned-motor design). Currently, this is the only reactor coolant pump design that has a supporting analysis for the flywheel integrity and missile generation.
- Provide the material specifications for the flywheel and the specific inspections to be performed on the flywheel.
- Provide the material type for the end plates and outershell since TR-106 (Westinghouse Report APP-GW-GLN-106, Revision 0) replaced the material type “Alloy 690” with “corrosion resistant” from AP1000 DCD, Revision 16, Section 5.4.1.3.6.3.

Westinghouse Response (Revision 0):

Westinghouse proposes changes to the AP1000 DCD, Revision 16, to identify the canned motor design as the reactor coolant pump design that is the standard design for the AP1000 plant. This includes providing a sentence in Tier 2, section 5.4.1.2.1 that identifies the applicable RCP design as information requiring NRC staff approval to change. Sentences pertaining only to the wet winding design are removed from the DCD. Information identifying the materials used in the flywheel is added, and the inspections that will be performed on the flywheel are identified.

Westinghouse Additional Response (Revision 1) based on NRC comments at 3/18/09 meeting and a change in flywheel retainer ring material:

The flywheel retainer ring material has recently been changed as a result of lessons learned from a flywheel manufacturing mockup assembly. The retainer ring material has been changed from 18 Ni maraging steel (AMS 6519, Vascomax® T250) to 18Mn-18Cr alloy steel (ASTM A 289, Grade 8). It was determined that the susceptibility of the 18 Ni maraging steel to corrosion and hydrogen embrittlement created a risk of flywheel failure that could be eliminated by changing the retainer ring material to 18Mn-18Cr alloy steel. The 18Mn-18Cr material was developed to replace retaining ring material used in generators which had proven to be susceptible to a form of stress corrosion cracking in water containing environments. Corrosion testing performed on 18Mn-18Cr material has shown that it is not susceptible to stress corrosion cracking and hydrogen embrittlement. Although, the 18Mn-18Cr material has a lower yield strength than 18 Ni maraging steel, the calculated retainer ring stresses are still less than the allowable stress (1/3 of S_y for normal speed, and 2/3 of S_y for overspeed as specified in NUREG-0800, Section 5.4.1.1). Although the overall conclusions of the structural evaluation of the flywheel will not change, the summary report will be revised to include the new flywheel material parameters.

The flywheel retainer ring material change will be incorporated in DCD sections 5.4.1.2.1, 5.4.1.3.6.3, and 5.4.16. As agreed in the March 18, 2009 meeting with the NRC, Westinghouse will also include the retainer ring material ASTM reference in DCD section 5.4.1.3.6.3.

These changes are shown in the Revision 1 DCD markup starting on page 12 of this RAI response.

Design Control Document (DCD) Revision (Revision 0):
Revise Table 1.3-1 as follows:

Table 1.3-1 (Sheet 2 of 6)

AP1000 PLANT COMPARISON WITH SIMILAR FACILITIES

Systems – Components	**DCD**	**AP1000**	**AP600**	**Reference 2 Loop**
Reactor Vessel	5.3			
Vessel ID		159 in	157 in	172 in
Construction		forged rings	forged rings	welded plate
Number hot leg nozzles		2	2	2
– ID		31.0 in	31.0 in	42 in

Table 1.3-1 (Sheet 2 of 6)

AP1000 PLANT COMPARISON WITH SIMILAR FACILITIES

Systems – Components	DCD	AP1000	AP600	Reference 2 Loop
Number cold leg nozzles		4	4	4
– ID		22.0 in	22.0 in	30 in
Number safety injection nozzles		2	2	0
Steam Generators	5.4.2			
Type		Vertical U-tube Recirc. design	Vertical U-tube Recirc. design	Vertical U-tube Recirc. design
Model		Delta-125	Delta-75	–
Number		2	2	2
Heat transfer area/SG		123,538 ft^2	75,180 ft^2	103,574 ft^2
Number tubes/SG		10,025	6,307	9,300
Tube material		I 690 TT	I 690 TT	I 600 TT
Separate startup feedwater nozzle		Yes	Yes	No
Reactor Coolant Pumps	5.4.1			
Type		canned~~sealless~~	canned	shaft seal
Number		4	4	4
Rated HP		7,300 hp/pump	≤3,500 hp/pump	9,700 hp/pump
Estimated flow/loop		150,000 gpm	102,000 gpm	198,000 gpm

Revise Appendix 1A, Reg. Guide 1.14, Rev. 1. 8/75 – Reactor Coolant Flywheel Integrity, as follows:

Reg. Guide 1.14, Rev. 1, 8/75 – Reactor Coolant Pump Flywheel Integrity

1.a	ASTM A.20	Exception	The flywheel is made of a bi-metallic design. Heavy alloy segments are fitted to a stainless steel hub and~~,~~ ~~if necessary,~~ held in place by a retaining ring. Therefore, the specific guidelines in this section are not directly applicable to the AP1000.
1.b		Exception	Fracture toughness and tensile properties are checked for components that are required for structural integrity of the bi-metallic flywheel.
1.c		N/A	This guideline is not applicable to the flywheel assembly. Therefore, the guideline is not applicable to the AP1000 reactor coolant pump.
1.d		Conforms	The components of the flywheel that are relied upon for structural integrity require no welding.
2.a-b		Conforms	
2.c-e	ASME Code, Section III	Exception	The limits and methods of ASME Code, Section III, Paragraph F-1331.1(b), (replacement for Paragraph F-1323.1) are not directly applicable to the flywheel assembly. The calculated stress levels in the flywheel are evaluated against the ASME Code, Section III, Subsection NG stress limits used as guidelines and the recommended stress limits in Positions 4.a and 4.c of the Standard Review Plan 5.4.1.1.
2.f		Exception	The calculated stress levels in the flywheel satisfy the ASME Code, Section III, Subsection NG stress limits used as guidelines and the recommended stress limits in Position 4.a of the Standard Review Plan 5.4.1.1.
2.g		Conforms	
3		Conforms	
4.a	ASME Code, Section III, NB-2545 or NB-2546, NB-2540, NB-2530	Exception	The inspections and guidelines referenced in the regulatory guide were developed for steel flywheels in shaft seal pumps. The paragraphs of Subsection NB referenced in the regulatory guide apply only to forged and plate steel components. The bi-metallic

			flywheel design will be manufactured using multiple processes and materials. In accordance with the regulatory guide, each structural component of the bi-metallic flywheel will be inspected prior to final assembly according to its fabrication and the procedures outlined in Section III, NB-2500 of the ASME Code. Inspection of the flywheel assembly inside the sealed enclosure following a spin test is not practical.
4.b	ASME Code, Section XI	Exception	Inservice inspection of the flywheel assembly is not required to support safe operation of the reactor coolant pump. Planned, routine inspections of the flywheel assembly requires considerable occupational radiation exposure and are not recommended. Inservice inspection of the flywheel assemblies requires extensive disassembly. Postulated missiles from the failure of the flywheel are contained within the stator shell and the pressure boundary is not breached. Vibration of the shaft due to a small flywheel fracture or leak in the enclosure does not result in stresses in the pressure boundary of sufficient magnitude to result in a break in the primary pressure boundary.

Revise Tier 2 Subsection 5.1.3.3 as follows:

5.1.3.3 Reactor Coolant Pumps

The AP1000 reactor coolant pumps are high-inertia, high-reliability, low-maintenance, sealless pumps of ~~either~~ canned motor ~~or wet winding motor~~ design that circulate the reactor coolant through the reactor vessel, loop piping, and steam generators. The pumps are integrated into the steam generator channel head.

The integration of the pump suction into the bottom of the steam generator channel head eliminates the cross-over leg of coolant loop piping; reduces the loop pressure drop; simplifies the foundation and support system for the steam generator, pumps, and piping; and reduces the potential for uncovering of the core by eliminating the need to clear the loop seal during a small loss of coolant accident.

The AP1000 design uses four pumps. Two pumps are coupled with each steam generator.

Each AP1000 reactor coolant pump is a vertical, single-stage centrifugal pump designed to pump large volumes of main coolant at high pressures and temperatures. Because of its sealless design, it is more tolerant of off-design conditions that could adversely affect shaft seal designs. The main impeller attaches to the rotor shaft of the driving motor, which is an electric induction motor. The stator and rotor of the motor are both encased in corrosion-resistant cans constructed and supported to withstand full system pressure.

Primary coolant circulates between the stator and rotor which obviates the need for a seal around the motor shaft. Additionally, the motor bearings are lubricated by primary coolant. The motor is thus an integral part of the pump. The basic pump design has been proven by many years of service in other applications.

The pump motor size is minimized through the use of a variable frequency drive to provide speed control in order to reduce motor power requirements during pump startup from cold conditions. The variable frequency drive is used only during heatup and cooldown when the reactor trip breakers are open. During power operations, the drive is isolated and the pump is run at constant speed.

To provide the rotating inertia needed for flow coast-down, bi-metallic flywheel assemblies are attached to the pump shaft.

Revise Tier2 Subsection 5.4.1.2.1 as follows:

5.4.1.2.1 Design Description

[The reactor coolant pump is a single stage, hermetically sealed, high-inertia, centrifugal sealless pump of ~~either~~ canned motor ~~or wet winding~~ design.][1] It pumps large volumes of reactor coolant at high pressures and temperature. Figure 5.4-1 shows a reactor coolant pump. Table 5.4-1 gives the design parameters.

A reactor coolant pump is directly connected to each of two outlet nozzles on the steam generator channel head. The two pumps on a steam generator turn in the same direction.

A sealless pump contains the motor and all rotating components inside a pressure vessel. The pressure vessel consists of the pump casing, stator closure, stator main flange, stator shell, stator lower flange, and stator cap, which are designed for full reactor coolant system pressure. In a canned motor pump, the stator and rotor are encased in corrosion-resistant cans that prevent contact of the rotor bars and stator windings by the reactor coolant. ~~In a wet winding motor pump, the rotor is isolated from the reactor coolant while the windings are individually encased in protective insulation.~~ Because the shaft for the impeller and rotor is contained within the pressure boundary, seals are not required to restrict leakage out of the pump into containment. The connection between the pump casing and the stator closure is ~~may be~~ provided with a

[1] NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

welded canopy type seal assembly, which provides definitive leak protection for the pump closure. If the canopy seal is used, aAccess to the internals of the pump and motor is by severing the canopy seal weld. When the pump is reassembled, a canopy seal is rewelded. SeallessCanned motor reactor coolant pumps have a long history of safe, reliable performance in military and commercial nuclear plant service.

The reactor coolant pump driving motor is a vertical, water-cooled, squirrel-cage induction motor with a canned rotor and stator. It is designed for removal from the casing for inspection, maintenance, and replacement, if required. The stator can or insulation protects the stator (windings and insulation) from the controlled portion of the reactor coolant circulating inside the motor and bearing cavity. The can on the rotor isolates the copper rotor bars are isolated from the system andto minimizes the potential for the copper to plate out in other areas.

The motor is cooled by primary reactor coolant system coolant circulating through the motor cavity and by component cooling water circulating through a cooling jacket on the outside of the motor housing. Primary coolant used to cool the motor enters the lower end of the rotor and passes axially through the motor cavity to remove heat from the rotor and stator. An auxiliary impeller provides the motive force for circulating the coolant. Heat from the primary coolant is transferred to component coolant water in an external heat exchanger.

Each pump motor is driven by a variable speed drive, which is used for pump startup and operation when the reactor trip breakers are open. When the reactor trip breakers are closed, the variable frequency drives are bypassed and the pumps run at constant speed.

Flywheel assemblies provide rotating inertia that increases the coastdown time for the pump. Each flywheel assembly is of bi-metallic design consisting of a tungsten heavy metal alloy for mass with Type 403and stainless steel and 18Ni maraging steel structural components. The upper flywheel assembly is located between the motor and pump impeller. If required, tThe lower assembly is located below the canned motor, with the thrust bearing. Surrounding the flywheel assemblies are the heavy walls of the stator closure, casing, thermal barrier, or stator lower flange.

The materials in contact with the reactor coolant and cooling water (with the exception of the bearing material) are austenitic stainless steel, nickel-chromium-iron alloy, or equivalent corrosion-resistant material.

There are two jJournal bearings, one at the bottom of the rotor shaft and the other between the upper flywheel assembly and the motor.are provided as necessary based on rotor dynamics analyses. The bearings are a hydrodynamic film-riding design. During rotor rotation, a thin film of water forms between the journal and pads, providing lubrication.

The thrust bearing assembly is at the bottom of the rotor shaft. The pivoted pad hydrodynamic bearing provides positive axial location of the rotating assembly regardless of operating conditions.

The reactor coolant pump is equipped with a vibration monitoring system that continuously monitors pump structure (frame) vibrations. Five vibration monitors provide pump vibration information. The readout equipment includes warning alarms and high-vibration level alarms, as well as output for analytical instruments.

Four resistance temperature detectors (RTDs) monitor motor cooling circuit water temperature. These detectors provide indication of anomalous bearing or motor operation. They also provide a system for automatic shutdown in the event of a prolonged loss of component cooling water.

A speed sensor monitors rotor rpm's. Additionally, voltage and current sensors provide information on motor load and electrical input.

Revise the second and third paragraphs of Subsection 5.4.1.3.3 as follows:

5.4.1.3.3 Pressure Boundary Integrity

~~For the canned motor design, t~~The motor terminals form part of the pressure boundary in the event of a stator-can failure. The ASME Code does not include criteria or methods for completely designing or analyzing such terminals. Motor terminals are designed, analyzed, and tested using criteria established and validated based on many years of service. Where applicable, ASME Code requirements and criteria are used. Individual terminals are hydrostatically tested to test the integrity prior to performance testing.

~~For the wet winding design, the cable penetrations are designed as part of the pressure boundary. These penetrations are designed to be self sealing and include redundant sealing features.~~

Revise the last paragraph of Subsection 5.4.1.3.4 as follows:

5.4.1.3.4 Coastdown Capability

If the stator can~~ or winding insulation~~ should leak during operation, the reactor coolant may cause a short in the stator windings. In such a case, the result would be the same as a loss of power to that pump. With either a rotor or a stator can~~ or stator insulation~~ failure, no fluid would be lost to the containment.

Revise the second paragraph of Subsection 5.4.1.3.6.1 as follows:

5.4.1.3.6.1 Natural Frequency and Critical Speeds

Determination of the damped natural frequency of the reactor coolant pump rotor bearing system model includes the effects of the bearing films, can ~~or winding~~ annular fluid interaction, motor magnetic phenomena, and pump structure. The damped natural frequencies for the AP1000 reactor coolant pump exhibit sufficient energy dissipation to be stable. The high degree of damping provides smooth pump operation.

Revise the Subsection 5.4.1.3.6.3 as follows:

5.4.1.3.6.3 Flywheel Integrity

The reactor coolant pump in the AP1000 complies with the requirement of General Design Criterion (GDC) Number 4. That Criterion states that components important to safety be protected against the effects of missiles.

The flywheel assemblies are located within and surrounded by the heavy walls of the stator closure, stator main flange, casing, thermal barrier, or lower stator flange. In the event of a postulated worst-case flywheel assembly failure, the surrounding structure can, by a large margin, contain the energy of the fragments without causing a rupture of the pressure boundary. The analysis in Reference 10 of the capacity of the housing to contain the fragments of the flywheel is done using the energy absorption equations of Hagg and Sankey (Reference 2).

Compliance with the requirement of GDC 4 related to missiles can be demonstrated without reference to flywheel integrity, nevertheless, the intent of the guidelines of Regulatory Guide 1.14 is followed in the design and fabrication of the flywheel. The guidelines in Regulatory Guide 1.14 apply to steel flywheels. Since the bi-metallic design of the AP1000 reactor coolant pump flywheel does not respond in the same manner as homogeneous steel, many of the guidelines in the Regulatory Guide are not directly applicable.

The reactor coolant pump flywheel assemblies are fabricated from a tungsten heavy ~~metal~~ alloy, Type 403 ~~and~~ stainless steel, and 18Ni maraging steel. Heavy alloy segments are fitted to a stainless steel hub; these segments are not relied upon structurally. The segments are~~may be~~ held into place by an interference fit retainer cylinder of 18Ni maraging steel placed over the outside of the assembly. The assembly is hermetically sealed from primary coolant by ~~corrosion resistant~~ endplates and an outer thin shell of Alloy 625. Ni/Fe/Cr Alloy 600 is not used for this application.

The bi-metallic flywheel design will be manufactured using multiple processes and materials. In accordance with Regulatory Guide 1.14, each structural component of the bi-metallic flywheel will be inspected prior to final assembly according to its fabrication and the procedures outlined in Section III, NB-2500 of the ASME Code. The Type 403 stainless steel inner hub material will be subject to impact testing using three Charpy V-notch tests per ASTM A370, magnetic particle examination per ASTM A788 Supplemental Requirement S18, and ultrasonic examination per ASTM A788 Supplemental Requirement S20, Acceptance Levels BR and S. The retainer ring will be subject to fracture toughness testing per ASTM E399, magnetic particle examination per ASTM A788 Supplemental Requirement S18, and ultrasonic examination per ASTM A788

Supplemental Requirement S20, Acceptance Levels BR and S. Following finishing operations on the flywheel assembly the outside surface of the retainer ring and the inside surfaces of the inner hub~~bore~~ are subject to liquid penetrant inspections in conformance with the requirements of ASTM-E-165 (Reference 4). In-process controls used during the construction of the flywheel assemblies also provide for the quality of the completed assemblies.

The design speed of the flywheel is defined as 125 percent of the synchronous speed of the motor. The design speed envelopes all expected overspeed conditions. At the normal speed the calculated maximum primary stress in the flywheel assemblies is less than one third of minimum yield strength. At the design speed the calculated maximum primary stress in the flywheel assemblies is less than two thirds of minimum yield strength.

An analysis of the flywheel failure modes of ductile failure, nonductile failure and excessive deformation of the flywheel is performed to evaluate the flywheel design. The analysis is performed to determine that the critical flywheel failure speeds, based on these failure modes, are greater than the design speed. The critical flywheel failure speeds are not the same as the critical speed identified for the rotor. The critical flywheel failure speeds are greater than the design speed. The overspeed condition for a postulated pipe rupture accident is less than the critical flywheel failure speeds.

The flywheel assemblies are sealed within a welded nickel-chromium-iron alloy enclosure to prevent contact with the reactor coolant or any other fluid. The enclosure minimizes the potential for corrosion of the flywheel and contamination of the reactor coolant. The enclosure material specifications are ASTM-B-443~~168~~ and ASTM-B-564. Even though the welds of the flywheel enclosure are not external pressure boundary welds, these welds are made using procedures and specifications that follow the rules of the ASME Code. A dye penetrant ~~and ultrasonic~~ test of the enclosure welds is performed in conformance with these requirements. The final assemblies are leak tested using a leak test hole located in the inner hub.

No credit is taken in the analysis of the flywheel missile generation for the retention of the fragments by the enclosure. A leak in the enclosure during operation could result in an out-of-balance flywheel assembly. An out-of-balance flywheel exhibits an increase in vibration, which is monitored by vibration instrumentation.

The flywheel enclosure contributes only a small portion of the energy in a rotating flywheel assembly.

The stress in the welds of the flywheel enclosure components for normal and design speeds are within the criteria in subsection NG of the ASME Code, which is used as a guideline.

Pipe rupture overspeed is based on a break of the largest branch line pipe connected to the reactor coolant system piping that is not qualified for leak-before-break criteria. The exclusion of the reactor coolant loop piping and branch line piping of 6 inches or larger size from the basis of the pump loss of coolant accident overspeed condition is based on the provision in GDC 4 to exclude dynamic effects of pipe rupture when a leak-before-break analysis demonstrates that appropriate criteria are satisfied. See subsection 3.6.3 for a discussion of leak-before-break analyses. The criteria of subsection 3.6.2 are used to determine pipe break size and location for those piping systems that do not satisfy the requirements for mechanistic pipe break criteria.

In addition to material specification and non destructive testing requirement, each flywheel is subject to a spin test at 125 percent overspeed, followed by a visual inspection, during manufacture. This demonstrates quality of the flywheel. Since the basis for the safety of the flywheel is retention of the fragments within the reactor coolant pump pressure boundary, periodic inservice inspections of the flywheel assemblies are not required to ensure that the basis for safe operation is maintained.

Because of the configuration of the flywheel assemblies, inservice inspection of the flywheel assemblies may not result in significant inspection results. Inspection of the flywheel assemblies would require removal of the assemblies from the shaft, removal of the enclosures, rewelding of the enclosure, reassembly, and balancing of the pump shaft. Opening of the pump assembly for a periodic inspection of the enclosure would result in an increased occupational radiation exposure and would not be consistent with goals relative to maintaining exposure as low as reasonably achievable. Also, opening the pump may increase the potential for entry of foreign objects into the motor area. For these reasons, routine, periodic inspection of the flywheel assemblies in the AP1000 reactor coolant pump is not recommended.

Additional Design Control Document (DCD) markup (Revision 1) resulting from NRC comments at 3/18/09 meeting and a change in flywheel retainer ring material:

Revise the seventh paragraph of Subsection 5.4.1.2.1 as follows:

5.4.1.2.1 Design Description

[*The reactor coolant pump is a single-stage, hermetically sealed, high-inertia, centrifugal sealless pump of canned motor design.*]* It pumps large volumes of reactor coolant at high pressures and temperature. Figure 5.4-1 shows a reactor coolant pump. Table 5.4-1 gives the design parameters.

A reactor coolant pump is directly connected to each of two outlet nozzles on the steam generator channel head. The two pumps on a steam generator turn in the same direction.

A sealless pump contains the motor and all rotating components inside a pressure vessel. The pressure vessel consists of the pump casing, stator closure, stator main flange, stator shell, stator lower flange, and stator cap, which are designed for full reactor coolant system pressure. In a canned motor pump, the stator and rotor are encased in corrosion-resistant cans that prevent contact of the rotor bars and stator windings by the reactor coolant. Because the shaft for the impeller and rotor is contained within the pressure boundary, seals are not required to restrict leakage out of the pump into containment. The connection between the pump casing and the stator closure is provided with a welded canopy type seal assembly, which provides definitive leak protection for the pump closure. Access to the internals of the pump and motor is by severing the canopy seal weld. When the pump is reassembled, a canopy seal is rewelded. Canned motor reactor coolant pumps have a long history of safe, reliable performance in military and commercial nuclear plant service.

The reactor coolant pump driving motor is a vertical, water-cooled, squirrel-cage induction motor with a canned rotor and stator. It is designed for removal from the casing for inspection, maintenance, and replacement, if required. The stator can protects the stator (windings and insulation) from the controlled portion of the reactor coolant circulating inside the motor and bearing cavity. The can on the rotor isolates the copper rotor bars from the system and minimizes the potential for the copper to plate out in other areas.

The motor is cooled by primary reactor coolant system coolant circulating through the motor cavity and by component cooling water circulating through a cooling jacket on the outside of the motor housing. Primary coolant used to cool the motor enters the lower end of the rotor and passes axially through the motor cavity to remove heat from the rotor and stator. An auxiliary impeller provides the motive force for circulating the coolant. Heat from the primary coolant is transferred to component coolant water in an external heat exchanger.

Each pump motor is driven by a variable speed drive, which is used for pump startup and operation when the reactor trip breakers are open. When the reactor trip breakers are closed, the variable frequency drives are bypassed and the pumps run at constant speed.

Flywheel assemblies provide rotating inertia that increases the coastdown time for the pump. Each flywheel assembly is of bi-metallic design consisting of a tungsten heavy metal alloy for mass with Type 403 stainless steel and ~~18Ni maraging steel~~18Mn-18Cr alloy steel structural components. The upper flywheel assembly is located between the motor and pump impeller. The lower assembly is located below the canned motor, with the thrust bearing. Surrounding the flywheel assemblies are the heavy walls of the stator closure, casing, thermal barrier, or stator lower flange.

Revise the fourth and fifth paragraphs of Subsection 5.4.1.3.6.3 as shown below.

5.4.1.3.6.3 Flywheel Integrity

The reactor coolant pump in the AP1000 complies with the requirement of General Design Criterion (GDC) Number 4. That Criterion states that components important to safety be protected against the effects of missiles.

The flywheel assemblies are located within and surrounded by the heavy walls of the stator closure, stator main flange, casing, thermal barrier, or lower stator flange. In the event of a postulated worst-case flywheel assembly failure, the surrounding structure can, by a large margin, contain the energy of the fragments without causing a rupture of the pressure boundary. The analysis in Reference 10 of the capacity of the housing to contain the fragments of the flywheel is done using the energy absorption equations of Hagg and Sankey (Reference 2).

Compliance with the requirement of GDC 4 related to missiles can be demonstrated without reference to flywheel integrity, nevertheless, the intent of the guidelines of Regulatory Guide 1.14 is followed in the design and fabrication of the flywheel. The guidelines in Regulatory Guide 1.14 apply to steel flywheels. Since the bi-metallic design of the AP1000 reactor coolant pump flywheel does not respond in the same manner as homogeneous steel, many of the guidelines in the Regulatory Guide are not directly applicable.

The reactor coolant pump flywheel assemblies are fabricated from a tungsten heavy alloy, Type 403 stainless steel, and ~~18Ni maraging steel~~18Mn-18Cr alloy steel (ASTM A 289, Grade 8). Heavy alloy segments are fitted to a stainless steel hub; these segments are not relied upon structurally. The segments are held into place by an interference fit retainer cylinder of 18Mn-18Cr alloy steel ~~18Ni maraging steel~~ placed over the outside of the assembly. The assembly is hermetically sealed from primary coolant by endplates and an outer thin shell of Alloy 625. Ni/Fe/Cr Alloy 600 is not used for this application.

The bi-metallic flywheel design will be manufactured using multiple processes and materials. In accordance with Regulatory Guide 1.14, each structural component of the bi-metallic flywheel will be inspected prior to final assembly according to its fabrication and the procedures outlined in Section III, NB-2500 of the ASME Code. The Type 403 stainless steel inner hub material will be subject to impact testing using three Charpy V-notch tests per ASTM A370, magnetic particle examination per ASTM A788 Supplemental Requirement S18, and ultrasonic examination per ASTM A788 Supplemental Requirement S20, Acceptance Levels BR and S. The retainer ring will be subject to impact testing using three Charpy V-notch tests per ASTM A370, liquid penetrant examination per ASTM A788, Supplementary Requirement S19, ~~fracture toughness testing per ASTM E399, magnetic particle examination per ASTM A788 Supplemental Requirement S18,~~ and ultrasonic examination per ASTM A788 Supplemental Requirement S20, Acceptance Levels ~~BR~~ DA and S. Following finishing operations on the flywheel assembly the outside surface of the retainer ring and the inside surfaces of the inner hub are subject to liquid penetrant inspections in conformance with the requirements of ASTM-E-165 (Reference 4). In-process controls used during the construction of the flywheel assemblies also provide for the quality of the completed assemblies.

Revise Reference 10 of Subsection 5.4.16 as shown below.

5.4.16 References

1. Not used.

2. Hagg, A. C. and Sankey, G. O., "The Containment of Disk Burst Fragments by Cylindrical Shells," ASME Journal of Engineering for Power, April 1974, pp. 114-123.

3. Not used.

4. ASTM-E-165-95, "Practice for Liquid Penetrant Inspection Method."

5. ANSI/ANS-5.1-1994, "Decay Heat Power in Light Water Reactors."

6. ANSI/ANS-51.1-1983, "Nuclear Safety Criteria for the Design of Stationary Pressurized Water Reactor Plants."

7. ANSI N278.1-1975, "Self-Operated and Power-Operated Safety-Relief Valves Functional Specification Standard."

8. ASME QME-1-2007 Edition, "Qualification of Active Mechanical Equipment Used in Nuclear Power Plants."

9. ANSI B16.34-1996, "Valves - Flanged and Buttwelding End."

10. Curtiss-Wright Electro-Mechanical Corporation Report AP1000RCP-06-009-P Revision 1 (Proprietary), and AP1000RCP-06-009-NP Revision 1 (Non-Proprietary), "Structural Analysis Summary for the AP1000 Reactor Coolant Pump High Inertia Flywheel," ~~October 2006~~May 2009.

Westinghouse

PRA Revision:
None

Technical Report (TR) Revision:
None