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Your ref: Project Number 740
Our ref: DCP/NRC1926

June 7, 2007

Subject: AP1000 COL Response to Request for Additional Information (TR #34)

In support of Combined License application pre-application activities, Westinghouse is submitting a response to the NRC request for additional information (RAI) on AP1000 Standard Combined License Technical Report 34, APP-GW-GLN-016, Rev. 0, AP1000 Licensing Design Change Document for Generic Reactor Coolant Pump. This RAI response is submitted as part of the NuStart Bellefonte COL Project (NRC Project Number 740). The information included in the responses is generic and is expected to apply to all COL applications referencing the AP1000 Design Certification.

The responses are provided for Requests for Additional Information TR34-1, TR34-2, TR34-3, TR34-4, TR34-5, TR34-6, and TR34-7, transmitted in NRC letter dated May 2, 2007 from Steven D. Bloom to Andrea Sterdis, Subject: Westinghouse AP1000 Combined License (COL) Pre-application Technical Report 34 – Request for Additional Information (TAC NO. MD3648).

Pursuant to 10 CFR 50.30(b), the responses to requests for additional information on Technical Report 34 are submitted as Enclosure 1 under the attached Oath of Affirmation.

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,

D. F. Hutchings for

A. Sterdis, Manager
Licensing and Customer Interface
Regulatory Affairs and Standardization

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NRO

/Attachment

1. "Oath of Affirmation," dated June 7, 2007

/Enclosure

1. Response to Requests for Additional Information on Technical Report No. 34

cc:	D. Jaffe	- U.S. NRC	1E	1A
	E. McKenna	- U.S. NRC	1E	1A
	G. Curtis	- TVA	1E	1A
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	C. Pierce	- Southern Company	1E	1A
	E. Schmiech	- Westinghouse	1E	1A
	G. Zinke	- NuStart/Entergy	1E	1A
	A. Preston	- Westinghouse	1E	1A

ATTACHMENT 1

"Oath of Affirmation"

ATTACHMENT 1

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

In the Matter of:)

NuStart Bellefonte COL Project)

NRC Project Number 740)

APPLICATION FOR REVIEW OF
"AP1000 GENERAL COMBINED LICENSE INFORMATION"
FOR COL APPLICATION PRE-APPLICATION REVIEW

W. E. Cummins, being duly sworn, states that he is Vice President, Regulatory Affairs & Standardization, for Westinghouse Electric Company; that he is authorized on the part of said company to sign and file with the Nuclear Regulatory Commission this document; that all statements made and matters set forth therein are true and correct to the best of his knowledge, information and belief.

W. E. Cummins
Vice President
Regulatory Affairs & Standardization

Subscribed and sworn to
before me this 7th day
of June 2007.

COMMONWEALTH OF PENNSYLVANIA
Notarial Seal
Debra McCarthy, Notary Public
Monroeville Boro, Allegheny County
My Commission Expires Aug. 31, 2009
Member, Pennsylvania Association of Notaries

Notary Public

ENCLOSURE 1

Response to Request for Additional Information on Technical Report No. 34

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR34-001
Revision: 0

Question:

TR34-1 The revised DCD Section 5.4.1.2.1, "Design Description," states that the reactor coolant pump is a single stage, high-inertia, centrifugal sealless pump of either canned motor or wet winding design. ... 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. ... Sealless reactor coolant pumps have a long history of safe, reliable performance in military and commercial nuclear plant service."

A. In addition to the differences described above, are there other differences between a canned-motor sealless pump and a wet winding motor sealless pump? Could these differences result in the wet winding sealless pump not meeting the design bases and the reactor coolant pressure boundary safety function of the reactor coolant pumps?

B. Describe physical arrangements to show how the rotor in the wet winding motor pump is isolated from the reactor coolant, and how the stator insulation protects the stator (windings and insulation) from the reactor coolant circulating inside the motor and bearing cavity.

C. Please provide a list of examples of both the canned motor and the wet winding sealless RCP operations in military and commercial plant service that demonstrate their long history of safe and reliable performance.

Westinghouse Response:

A. The reactor coolant pump design and licensing basis for the standard AP1000 plant is the canned motor reactor coolant pump. The reactor coolant pumps are integral to the reactor coolant system pressure boundary and are designed and fabricated to meet the requirements for Class 1 components, as defined in Section III of the ASME Boiler and Pressure Vessel Code. The acceptability of the reactor coolant pump pressure boundary is summarized in, APP-GW-GLR-052, Revision 0, AP1000 Reactor Coolant Pump Design Specification and Reports Summary. If required, any future alternative reactor coolant pump design will meet the same design basis requirements and safety functions as the standard AP1000 design.

B. Wet winding rotor isolation and stator insulation design.

Similar to the canned motor pump design, the rotor in the wet winding sealless motor pump is canned to isolate the rotor from the reactor coolant. Isolation of the stator windings from reactor coolant is achieved by encasing each individual stator winding in protective insulation.

C. Summary of past RCP experience.

Canned motor pumps using technology similar to the AP1000 have been utilized in military applications for over 53 years. Over 1500 canned motor pumps have been placed in service for commercial and military applications. Records indicate that in some applications, canned motor pumps have provided continuous maintenance free service for 40 years.

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
None

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR34-002
Revision: 0

Question:

TR34-2 One of the design changes in the AP1000 reactor coolant pumps is that the thermal barrier cooling coil and wraparound heat exchanger configuration has been replaced with an externally mounted, conventional shell and tube heat exchanger and a stator cooling jacket. The revised DCD Sections 5.4.1.2.1 and 5.4.1.2.2 describe the revised motor cooling arrangement. An auxiliary impeller at the lower part of the rotor shaft circulates a controlled volume of the reactor coolant through the motor cavity, where the rotor, bearing and stator are cooled, and through an external heat exchanger where the reactor coolant is cooled to about 150°F by the component cooling water (CCW) circulating on the shell side. The CCW also circulates through a cooling jacket on the outside of the motor housing to cool the stator.

A. Provide a summary the RCP cooling design, such as the overall heat generation rate of the pump operation, heat removal capacity of the stator cooling jacket located outside of the stator, heat removal capacity of the external heat exchanger, including design flow rates and velocities on the tube and shell sides, and overall heat transfer coefficient of the heat exchanger, as well as the CCW water temperature.

B. Describe how the auxiliary impeller controls the primary coolant flow rate through the motor cavity and the external heat exchanger.

Westinghouse Response:

A. Summary of the RCP Cooling Design

The AP1000 RCP motor is a significant heat source that requires both an external heat exchanger and a stator shell water jacket for cooling. The motor electrical losses account for approximately 1 MW and the fluid and friction losses account for approximately 1.4 MW. In addition to the motor losses, the hot primary system is an additional source of heat, with 20 to 30 kW crossing the thermal barrier into the motor.

The heat sink for the nearly 2.4 MW of motor and thermal barrier heat is the component cooling water (CCW). CCW is supplied to each motor at temperatures of 60 to 95°F (15.5 to 35°C) at a flow rate of 600 gpm (136 m^3/hr). The flow supply is split near the motor to supply 540 gpm (123 m^3/hr) to the external tube and shell heat exchanger and 60 gpm (13.6 m^3/hr) to the stator shell water jacket. The flow rate to the water jacket was chosen to minimize the stator winding temperature with a minimal increase in the water temperature inside the motor.

The heat flow to the water jacket is small, approximately 30 kW. Although the loss is a small fraction of the total motor loss, the winding temperature is design limiting and the water jacket is essential: without the water jacket the winding temperatures would increase by over 212°F (100°C).

The external heat exchanger removes nearly 99% of the motor heat loss (all except for the 30 kW to the water jacket and a few kW lost to the containment atmosphere). The heat exchanger is located high relative to the motor to maintain natural circulation through the motor when the motor is not running. The external heat exchanger is specified to remove 2.4 MW with 540 gpm (123 m^3/hr) of CCW at 95°F (35°C) and 600 gpm (136 m^3/hr) of primary flow at 157°F (69°C). At the specified flow rates, the CCW enters at a maximum temperature of 95°F (35°C) and exits at 125°F (51.7°C), while the hot primary fluid enters at 157°F (69°C) and exits at 129°F (53.9°C).

One or more heat exchanger vendors have submitted design proposals that meet the specification, but the designs are preliminary and proprietary. Consequently, design details are not available to provided responses concerning the external heat exchanger.

B. Auxiliary Impeller

The auxiliary impeller is a simple radial-hole design that provides the 600 gpm (136 m^3/hr) design value of motor internal circulation. The auxiliary impeller is an integral feature of the rotor shaft that operates when the rotor turns, regardless of direction. Similar to most pumps, the auxiliary impeller is a volumetric device in which the flow rate increases linearly with rotation speed. The internal cooling water, or bearing water, circulates upward in the rotor/stator annulus to the top of the motor, upward through a vertical riser, through the horizontally mounted external heat exchanger, down a long vertical down comer, then reenters the bottom of the motor. The suction for the auxiliary impeller is located at the bottom of the rotor shaft. The auxiliary impeller has an Euler head rise of 240 ft (73.2 m) at 1782 rpm. RCP testing will verify that the actual bearing water flow rate is sufficient to satisfy design requirements. If necessary, an annular ring that extends the diameter of the radial holes can be shrink-fitted to the rotor shaft to increase the auxiliary impeller flow capacity.

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
None

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR34-003
Revision: 0

Question:

TR34-3 It is stated that the RCP flywheel design is changed because of the need to increase the minimum pump assembly rotating inertia from the current value of 16,500 lb-ft^2 to meet the pump coastdown used in the safety analyses shown in Fig. 15.3.2-1. The revised Table 5.4-1 does not specify the new minimum rotating inertia.

What is the new required minimum rotating inertia that would meet the pump coastdown rate of Figure 15.3.2-1 used in the safety analyses?

Westinghouse Response:

The minimum rotating assembly inertia that is required to meet the AP1000 RCP coastdown requirement is 22,890 lb-ft2 (964 kg-m2).

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
None

RAI Response Number: RAI-TR34-004
Revision: 0

Question:

TR34-4 The revised DCD Section 5.4.1.2.1 states that "If required, the lower [flywheel] assembly is located below the motor." The revised Figure 5.4-1 includes a lower flywheel assembly. The report AP1000 RCP-06-009, "Structural Analysis Summary for the AP1000 Reactor Coolant Pump High Inertia Flywheel," dated October 19, 2006, is based on a canned motor reactor coolant pump with an upper flywheel assembly and a lower flywheel assembly of tungsten heavy alloy.

A. Clarify why it is necessary to include the qualifier "if required" and whether the AP1000 sealless pump design has a lower flywheel assembly that is incorporated into the thrust bearing assembly.

B. Clarify whether the report AP1000 RCP-06-009 is applicable to wet winding motor sealless pump designs or RCP designs without a lower flywheel. If applicable, describe the bases of this conclusion. If not applicable, describe what requirements should be specified for COL applicants using a wet winding motor sealless pump design or a RCP design without a lower flywheel.

Westinghouse Response:

A. The caveat "if required" is placed in Section 5.4.1.2.1 to encompass both design basis of the canned motor and wet winding reactor coolant pump design. The canned motor design utilizes two flywheel assemblies to achieve acceptable rotordynamic characteristics and the coastdown necessary for the AP1000 plant to meet its safety function. The wet winding design utilizes a larger single flywheel design to meet the same requirements.

B. The report AP1000 RCP-06-009 is only applicable to the canned motor reactor coolant pump design. If a COL applicant specifies the use of the wet winding motor sealless pump design, a similar report will be generated and submitted to the NRC to prove that high energy missile created by the failure of the flywheel do not have sufficient energy to penetrate the adjacent pressure boundary components.

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
None

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR34-005
Revision: 0

Question:

TR34-5 In Section II.1.0, "Introduction," of APP-GW-GLN-016, Revision 0, the applicant stated that, to provide primary coolant flow, the Westinghouse AP1000 nuclear plant design employs four single stage, high-inertia, centrifugal sealless pumps. The RCPs are mounted in pairs in the channel head at the bottom of the steam generators and are an integral part of the primary pressure boundary. The integration of the pump suction into the bottom of the SG channel head eliminates the cross-over leg of coolant loop piping; reduces the loop pressure drop; simplifies the foundation and support system for the SG, pumps, and piping; and reduces the potential for uncovering the core by eliminating the need to clear the loop seal during a small loss-of-coolant accident (LOCA).

The applicant is requested to provide the results of the design calculations for the simplified foundation and support system for the steam generator, pumps, and reactor coolant loop piping to demonstrate the adequacy of system and components under the seismic and dynamic (RCP-induced vibrations, etc.) loads as a result of licensing design changes for the RCP.

Westinghouse Response:

Work is currently in progress to update the reactor coolant system loop configuration and perform updated stress analysis using the most current reactor coolant pump, steam generator and loop piping models as well as seismic spectra. Based on the previously completed loop analysis (Note 1) Westinghouse is confident the AP1000 RCS design will meet the seismic and dynamic loads as specified in the AP1000 Design Control Document (Note 2). Final Acceptance of loop piping will be provided by the as-built ASME stress report per ITAAC 2.B of Table 2.1.2-4 of the AP1000 Design Control Document.

Pressure boundary components of the reactor coolant system are defined in Section III of the ASME Boiler and Pressure Vessel Code as Class 1 components and are analyzed to meet stress allowable requirements specified in Article NB per the requirements of The AP1000 Design Control Document and applicable design specifications. The applicable edition of the ASME Code is 1998 Edition, 2000 Addenda, except as follows: The 1989 Edition is used for Section III, Articles NB-3200, NB-3600, NC-3600, ND-3600 in lieu of later editions and addenda per US Code of Federal Regulations, 10CFR50.55a.

Note 1: A copy of the previously completed loop analysis is located at the Westinghouse Energy Center and is available for review by the NRC per APP-GW-GLR-013, Revision 1, AP1000 Standard Combined License Technical Report Safety Class Piping Design Specifications and Design Reports Summary.

Note 2: The seismic and dynamic loads considered for the analysis of Class 1 components are outlined in Tables 3.9-3 and 3.9-5 of the AP1000 Design Control Document.

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
None

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR34-006
Revision: 0

Question:

TR34-6 In Section 6.0, "Pump Casing Discharge Nozzle Changes," of APP-GW-GLN-016, Revision 0, the applicant stated that stress analysis results of the current casing discharge nozzle showed that the allowable stresses were exceeded. To reduce the stresses in the casing, the wall thickness near the discharge nozzle was increased, which results in an increase (2.25 inches) in the length of the discharge nozzle.

The applicant is requested to provide the detailed summary of the stress analysis by describing the loads considered, the analysis model constructed, and the Codes and Standards used for the allowable stresses, etc., including the demonstration that the pump casing discharge nozzle design changes are acceptable for 60 years operation from the metal fatigue standpoint.

Westinghouse Response:

Requirements in the AP1000 Reactor Coolant Pump Design Specification (Note 1) state that pressure boundary components of the RCP (casing) shall meet the stress allowables specified in Section III, Article NB of the ASME Boiler and Pressure Vessel Code (Note 2) for the plant's 60-year design life given the seismic and dynamic loading combinations and transient conditions provided in the AP1000 Design Control Document and the design specification.

For the analysis performed to date, the AP1000 Reactor Coolant Pump Casing and Main Closure Interim Report (Note 1) results indicate that the stress and fatigue assessments of the reactor coolant pump casing, meet the requirements of the AP1000 Reactor Coolant Pump Design Specification. Additionally, for the analysis performed to date, the pressure boundary components are found to satisfy the ASME Class 1 nuclear power plant stress limits given by Section III, Subsection NB of the 1989 Boiler and Pressure Vessel Code, using the material properties from the 1998 Edition, 2000 Addenda Code (Note 2).

Note 1: A detailed summary of the analysis for the canned motor reactor coolant pump casing is contained in:

Curtiss-Wright EMD, Engineering Memorandum 7201, Revision 0, "AP1000 Reactor Coolant Pump Casing and Main Closure Interim Report", R.M. Perlman, April 27, 2007. (Curtiss-Wright Electro-Mechanical Corporation Proprietary - Class 2)

Copies of this document as well as the AP1000 Reactor Coolant Pump Design Specification are located at the Westinghouse Energy Center and are available for review by the NRC per APP-GW-GLR-052, Revision 0, AP1000 Reactor Coolant Pump Design Specification and Reports Summary.

Note 2: Pressure boundary components of the reactor coolant system are defined in Section III of the ASME Boiler and Pressure Vessel Code as Class 1 components and are analyzed to meet stress allowable requirements specified in Article NB per the requirements of The AP1000 Design Control Document and applicable design specifications. The applicable edition of the ASME Code is 1998 Edition, 2000 Addenda, except as follows: The 1989 Edition is used for Section III, Articles NB-3200, NB-3600, NC-3600, ND-3600 in lieu of later editions and addenda per US Code of Federal Regulations, 10CFR50.55a.

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
None

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR34-007
Revision: 0

Question:

TR34-7 In Section 4.0, "Heat Exchanger Configuration," of APP-GW-GLN-016, Revision 0, the applicant stated that a conventional shell and tube heat exchanger mounted on the pump flange has been implemented to replace the current wraparound heat exchangers; and Class 1 piping is installed to connect the heat exchanger to the inlet and outlet of the pump internal flow path.

A. The applicant is requested to demonstrate the mounting adequacy of the external heat exchangers under the seismic and dynamic (RCP-induced vibrations, etc.) loads.

B. In Section 7.0, "Reactor Coolant Pump Parameter Changes," of APP-GW-GLN-016, Revision 0, the applicant stated that to remove the additional heat resulting from the increase in motor load, the component cooling water which circulates through the external heat exchanger and stator cooling jacket has been increased from 360 gpm to 600 gpm. The applicant is requested to demonstrate, by calculations, the adequacy of heat exchanger tubes under the flow-induced vibration loads for 60 years design life, including potential fluidelastic instability vibration of the heat exchanger tubes.

C. The applicant is requested to demonstrate, by calculations, the adequacy of the Class 1 primary water piping from the external heat exchanger to the RCP under the design basis loads for 60 years design life including the seismic and dynamic (RCP-induced vibrations, etc.) loads.

Westinghouse Response:

A. Work is currently in progress to analyze the reactor coolant pump external heat exchanger. Requirements in the AP1000 Reactor Coolant Pump Design Specification (Note 1) as shown in Response B, assure the mounting adequacy of the external heat exchanger. The design specification states that the external heat exchanger support shall meet the stress allowables specified in Section III, Article NF of the ASME Boiler and Pressure Vessel Code, 1998 Edition, 2000 Addenda, for the plant's 60-year design life given the seismic and dynamic loading combinations provided in the AP1000 Design Control Document (Note 2) and the design specification.

B. Work is currently in progress to analyze the reactor coolant pump external heat exchanger. The AP1000 Reactor Coolant Pump Design Specification (Note 1) requires that the heat exchanger design considers and accounts for flow induced vibration loads and fluidelastic instability vibration by invoking the requirements of Westinghouse Document APP-GW-M1-001, Mechanical

Design Criteria. The requirements invoked from APP-GW-M1-001 are as follows:

6.5 Heat Exchangers

6.5.1 Tubular heat exchangers shall be designed to avoid flow-induced tube vibration under maximum expected flows and design temperature conditions. Adequacy with respect to flow-induced vibration shall be demonstrated by either of the following:

- An identical heat exchanger has operated satisfactorily under flow and temperature conditions at least as severe as those expected for the AP1000 heat exchangers.
- Maximum expected secondary side velocities are calculated to be below the critical velocities for fluid-elastic excitation and the lowest calculated tube natural frequency exceeds by a factor of 1.5 the vortex shedding frequency calculated for the maximum expected secondary side velocity.

6.5.2 Heat exchanger fouling factors and additional margin for tube plugging shall be provided on an individual heat exchanger basis and shall be identified in the heat exchanger specifications. The specified parameters shall be based on experience, service requirements, and industry codes and standards.

6.5.3 Heat exchangers shall be designed to withstand the maximum system pressure, and relief valves shall be provided in accordance with ASME Code requirements, e.g., if the heat exchanger can be isolated; however, relief valves shall not be used to justify the use of a heat exchanger that is designed for less than system pressure.

6.5.4 The heat exchanger design shall ensure that the inlet flow does not result in local high velocities which could result in erosion of the tubes, tube sheets, and other internal parts of the heat exchanger.

C. Work is currently in progress to analyze the external Class 1 primary water piping from the external heat exchanger to the RCP. Requirements in the AP1000 Reactor Coolant Pump Design Specification (Note 1) state that pressure boundary components of the RCP shall meet the stress allowables specified in Section III, Article NB of the ASME Boiler and Pressure Vessel Code (Note 3) for the plant's 60-year design life given the seismic and dynamic loading combinations and transient conditions provided in the AP1000 Design Control Document and the design specification. Final Acceptance of the RCP stress analysis will be provided by the as-built ASME stress report per ITAAC 2.A of Table 2.1.2-4 of the AP1000 Design Control Document.

Note 1: The AP1000 Reactor Coolant Pump Design Specification is located at the Westinghouse Energy Center and is available for review by the NRC per APP-GW-GLR-052, Revision 0, AP1000 Reactor Coolant Pump Design Specification and Reports Summary.

Note 2: The seismic and dynamic loads considered for the analysis of Class 1 Supports are outlined in Tables 3.9-3 and 3.9-8 of the AP1000 Design Control Document.

Note 3: Pressure boundary components of the reactor coolant system are defined in Section III of the ASME Boiler and Pressure Vessel Code as Class 1 components and are analyzed to meet stress allowable requirements specified in Article NB per the requirements of The AP1000 Design Control Document and applicable design specifications. The applicable edition of the ASME Code is 1998 Edition, 2000 Addenda, except as follows: The 1989 Edition is used for Section III, Articles NB-3200, NB-3600, NC-3600, ND-3600 in lieu of later editions and addenda per US Code of Federal Regulations, 10CFR50.55a.

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
None