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Our ref: DCP_NRC_002948

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Subject: AP1000 Response to Request for Additional Information (SRP 3)

Westinghouse is submitting a response to the NRC request for additional information (RAI) on SRP Section 3. 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-SRP3.9.4-EMB1-01 R2

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. A. Lindgren /FOR

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/Enclosure

1. Response to Request for Additional Information on SRP Section 3

D063
NRO

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ENCLOSURE 1

Response to Request for Additional Information on SRP Section 3

RAI Response Number: RAI-SRP3.9.4-EMB1-01
Revision: 2

Question: (Revision 0)

It has come to the staff's attention that the adequacy of seismic qualification of the Control Rod Drive Mechanism (CRDM) for AP1000 standard design may not be adequate. GDC 2 of Appendix A to 10 CFR Part 50 states that structures, systems, and components important to safety shall be designed to withstand the effects of natural phenomena such as earthquakes, combined with appropriate effects of normal and accident conditions, without loss of capability to perform their safety functions. AP1000 CRDM pressure boundary components, such as CRDM pressure housing and CRDM rod travel housing are designed and qualified to meet the ASME Code requirements. However, the CRDM non-pressure boundary components, including the latch assembly and coil stack assembly are not explicitly qualified for seismic events. The potential for not working properly such as jamming of the latch mechanism or malfunction of the coils due to seismic events may prevent the control rods from dropping as designed. The applicant is requested to provide a justification to explain why the latch mechanism and coil stack assembly do not need to be seismically qualified to comply with GDC 2, or to revise the seismic classifications of the CRDM components to ensure adequate seismic qualification for the safety functions of the Control Rod Drive System.

Additional Question (Revision 1):

The staff does not accept Westinghouse's response to RAI-SRP3 9 4-EMB1-01 (Revision 0).

During a call with the NRC to discuss the Revision 0 response the staff clarified and emphasized that they needed to have a specific justification for why the latch assembly and coil stack assembly do not need to be seismically qualified and the absence of seismic qualification information.

They also asked that Table 3.2-3 and Section 3.9.4.2.3 of the DCD be revised to clarify which parts of the CRDM are safety-related and seismically qualified and which are not.

Additional Question (Revision 2):

The staff does not accept Westinghouse's response to RAI-SRP3 9 4-EMB1-01 (Revision 1) with regard to the latch assembly.

During a call with the NRC to discuss the Revision 1 response the staff clarified and emphasized that they needed to have further information about what safety measures are in place in case the latch assembly does jam as a result of an SSE such that there is no need for the latch assembly to be considered safety-related.

The NRC also requested additional discussion about why seismic testing of the driveline (to ensure RCCA trip ability) is unnecessary and impractical.

Westinghouse Response: (Revision 0)

The AP1000 Control Rod Drive Mechanism (CRDM) is designed to withstand the effects of a seismic event and function following a seismic event.

The CRDM performance assurance program is discussed in Section 3.9.4.4 of the DCD.

The pressure boundary integrity of the latch housing and rod travel housing, which are the only safety-related components of the CRDM, is qualified for an SSE by a structural analysis required to satisfy ASME Code, Section III criteria. The seismic analysis demonstrates that the rod travel housing is not subject to stresses exceeding yield stress during an SSE. Additionally its maximum relative deflection during an earthquake has been shown to be less than 2 inches (which is distributed over a length in excess of 20 feet). Maintaining the stresses below yield along with this minimal deflection per unit length assures that the drive rod will not bind inside the rod travel housing following an event subjecting the CRDM to earthquake loads.

However, the ability to insert control rods during a seismic event is not a design requirement for the AP1000. The Safety Analyses do not assume that the control rods will drop during a seismic event. The CRDM design requirement is that the mechanism is able to release the drive rod before and after a seismic event, but this function is not required during an SSE due to the incredibly low possibility of a Design Basis Accident (DBA) which requires the insertion of the control rods occurring at the same time as an SSE. SSEs are only considered to happen concurrently with conditions that occur more than 10% of the time (see Section 11 of Reference 1). The Safety Analyses for abnormal events documented in Chapter 15 do not combine these abnormal events with the effects of an SSE due to the low frequency of occurrence of an SSE.

The rod drop time assessment for AP1000 does not consider any seismic allowances since there are no Level B seismic events (Operating Basis Earthquake) per Reference 1. A safe shutdown earthquake (SSE) is a Level D faulted event, for which there are no rod drop time requirements. For the faulted event the criterion is that the rods must be able to insert into the core, but there is no insertion time requirement. Therefore, the design requirement is only that the deformation of the control rod guiding/supporting structures is minimized during an SSE event, such that the rods will still drop into the core.

Many tests are in place that ensure that the CRDM is able to step, hold, and release the drive rod (and coupled RCCA) as designed.

Each CRDM is production tested prior to shipment in accordance with Table 3.9-13 of the DCD to verify that the stepping requirements as well as the trip delay time requirements are met.

Additionally, the plant Technical Specifications SR 3.1.4.2 and 3.1.4.3 verify rod freedom of movement (trip ability) every 92 days and the ability of the entire drive line to meet the total rod drop time requirements prior to reactor criticality after each removal of the reactor head, respectively.

All of the above requirements guarantee that the CRDM is able to function as required before and during an SSE (keeping in mind that there is no requirement to drop the rod during the SSE). However, to verify that the CRDM is able to function as required *following* an SSE, Westinghouse proposes to add a requirement to perform SR 3.1.4.3 following an earthquake requiring plant shutdown prior to the plant achieving reactor criticality following the shutdown. This will ensure that not only the CRDM, but also the entire driveline (including the reactor vessel internal guide tubes, RCCAs, and fuel assemblies) was not damaged in a way that prevents the rods from being able to be inserted into the core within the 2.47 second Technical Specification required drop time. This will also verify whether the CRDMs are able to step properly.

In addition to this it is noted that the site Post-Earthquake Procedures that are required by DCD Section 3.7.5.2 are based on NP-6695 (as discussed in 3.7.5.2), which includes a thorough inspection of the CRDMs and entire driveline (see Section 5.3.2.2 of NP-6695 for details). Therefore the site will be required to perform many tests and inspections of the CRDM following an SSE before restarting the plant following the seismic event that would identify any functionality concerns.

The ASME Code qualification of the AP1000 CRDM pressure housings, along with the functionality testing and inspections described above adequately ensures that the CRDM for the AP1000 standard design will withstand the effects of natural phenomena such as earthquakes, or if functionality is hindered it will be identified and corrected prior to restarting of the reactor, and is therefore in compliance with GDC 2 of Appendix A to 10 CFR Part 50.

During the review of the Design Control Document for information that needs to be changed to address this request for additional information, changes to CRDM design information including the figure and materials was noted and is provided below.

Additional Westinghouse Response (Revision 1):

The following is provided as justification for the equipment classification for the latch assembly and coil stack assembly and why they do not need to be seismically qualified. The justification is based on 1) the design finality of the AP1000 Design Certification, 2) the precedence of operating plants, and 3) the function of the latch assembly and coil stack assembly in the AP1000 CRDM.

1. The design, function, equipment classification, and seismic requirements for the control rod drive mechanism were provided in the AP1000 Design Control Document (DCD) that supported the AP1000 design certification. The design, function, equipment classification, and seismic requirements for the control rod drive mechanism have not been altered in design certification amendment, nor does Westinghouse have any intent to modify the designs of any of these components. The CRDM is classified as AP1000 equipment Class D in the DCD (see Table 3.2-3) except that the pressure boundary portions are classified as equipment Class A because of their pressure boundary integrity function. Equipment Class D is not required to satisfy seismic Category I or seismic Category II requirements or to have seismic qualification requirements. Since the CRDM design has not changed (and no design changes are planned) and NRC has not changed the applicable regulations for

seismic qualification of structures, systems and components, the seismic qualification requirements in the certified design are applicable to the design certification amendment.

2. The AP1000 control rod drive mechanism is based on a proven Westinghouse design that has been used in many operating nuclear power plants designed by Westinghouse. The CRDMs in the operating plants do not have a safety related classification or seismic qualification requirement for the CRDM latch assembly or coil stack assembly. There have been no changes to NRC regulations that would require that the CRDM latch assemblies and coil stack assemblies in operating power plants be subject to seismic qualification. There also has not been operating experience that would indicate the need for a seismic qualification requirement for the latch assemblies and coil stack assemblies.

   The AP1000 CRDM latch assembly design is very similar to the design used in the operating fleet. For the AP1000 manufacturing process; however, additional quality standards have been invoked for the latch assembly to provide additional conservatism.

3. To assure functional capability of the CRDM following a seismic event or a pipe break, the bending moments on the CRDMs are limited to those that produce stress levels in the CRDM pressure housings less than ASME Code limits during anticipated transient conditions. This limit provides that the rod travel housing does not bend to the extent that the drive rod binds during insertion of the control rods.

   The latch assembly is designed to fail safe. When power to the operating coils is cut, the latch arms swing open due to the force of gravity. Any postulated failure of the latch assembly results in a dropped rod and a subsequent increase in negative reactivity.

   The latch assembly does not have a safety-related function. Its functions are to hold, move (insert or withdraw), or release the drive rod. The actual negative reactivity introduction that is required to mitigate certain DBAs is provided by the neutron absorber material of the RCCA, which is a safety-related component. The only function of the latch assembly during a DBA is to not fail in a way that would cause the RCCA to not be able to perform a safety-related function. The function of "not failing" is considered a non-safety related function. Therefore the latch assembly is not required to be seismically qualified.

   Postulated electrical or structural failures of the coil stack assembly do not result in a condition that would prevent control rod insertion. During a reactor trip all power is quickly cut from the coils. As a result, the CRDM operating coils are built using standard industrial quality assurance and are not required to be built to IEEE Class 1E standards.

   The coil stack assemblies and drive rods do not have a safety-related function. No credible failures of either of these items are postulated to inhibit rod drop or have any other safety related implications. This includes consideration for drive rod bending and breaking. The function of both of these items is a power generation function: to provide the function of holding or moving the core component to a designated vertical position within the core during plant operation under normal conditions to control and optimize the thermal output of the core. These items have no safety-related function during an accident condition or a seismic event. A failure of either of these items would result in a dropped rod and a subsequent increase in negative reactivity. Furthermore, the coil stack assembly is not physically within the reactor coolant pressure boundary and the safety-related reactor trip breaker ensures that power is quickly removed from the operating coils. Therefore the coil stack assembly and drive rod assembly are not required to be seismically qualified.

Additional Westinghouse Response (Revision 2):

Additional discussion is included in Section 4.6 of the DCD relating to the safety measures that are in place such that there is no need for the latch assembly or other active mechanical components of the CRDM to be considered safety-related in the event that the latch assembly or drive rod jams or the CRDM system fails in any other way that precludes RCCA insertion as a result of an SSE. Relevant excerpts from Section 4.6 of the DCD are included below:

"As indicated in Chapter 15, there are only three postulated events that assume credit for reactivity control systems, other than a reactor trip to render the plant subcritical. These events are the steam-line break, feedwater line break, and small break loss of coolant accident. The reactivity control systems in these accidents are the reactor trip system and the passive core cooling system (PXS).

The AP1000 instrumentation and control system includes a diverse actuation system (DAS). This system provides for automatic control rod insertion, turbine trip, passive residual heat removal heat exchanger start, core makeup tank start, isolation of critical containment penetrations, and start of the passive containment cooling system as appropriate upon conditions indicative of an anticipated transient without scram or other failure of the plant control and reactor protection system. This system is diverse and independent from the reactor trip system from the sensor through actuation devices.

In addition to the above, the AP1000 plant systems provide for operator response to an anticipated transient without scram (ATWS) event that includes core reactivity control followed by core decay heat removal. Core reactivity control is provided by a manual trip of the control rods, insertion of the control rods, the chemical and volume control system, or by the core makeup tank injection. The decay heat removal can be performed by the startup feedwater system or the passive residual heat removal system.

The evaluations of the steam-line break, the feedwater line break, and the small break loss of coolant accident, which presume the combined actuation of the reactor trip system and the control rod drive system and the passive safety injection, are presented in subsections 15.1.5 and 15.2.8 and Section 15.6. Reactor trip signals and signals to actuate passive safety features for these events are generated from functionally diverse sensors. These signals actuate diverse means of reactivity control; that is, control rod insertion and injection of soluble neutron absorber.

The probability of a common mode failure impairing the ability of the reactor trip system to perform its safety-related function is extremely low. However, analyses are performed to demonstrate compliance with the requirements of 10 CFR 50.62. These analyses demonstrate that safety criteria would not be exceeded even if the control rod drive system *were rendered incapable of functioning during anticipated transients for which its function would normally be expected. The evaluation demonstrates that borated water from the core makeup tank shuts down the reactor with no rods required, and the passive residual heat removal system provides sufficient core heat removal."*

Due to these additional safety measures, the latch assembly, and all other active mechanical components of the CRDM are not required to be classified as safety-related.

With regard to the impracticality of seismic testing of the AP1000 driveline, and Westinghouse's claim that it is not necessary, additional information is contained in the AP600 FSER, NUREG-1512, which is directly applicable to the AP1000 (page 3-231):

"Westinghouse also indicated that demonstration of CRDM operability during a seismic event is impractical and insertion of control rods is not required as long as operability of the CRDM is ensured immediately following the earthquake. The staff's subsequent evaluation concurs that demonstration of CRDM operability during a seismic event is not a regulatory requirement as long as its operability can be verified after the seismic event. However, Westinghouse should demonstrate adequacy of seismic qualification to ensure post-SSE operability of the control rod drive system in the AP600 design. In Revision 10 to Section 3.9.4.3 of the SSAR, Westinghouse indicates that functional capability of the CRDM following a seismic event or a pipe break is assured by analysis. The stresses in the CRDM and the rod travel housing are bounded by the ASME Code limits, and their deflections are within the limits specified in the SSAR Section 3.9.7 to ensure that control rods do not bind during insertion. The staff finds this acceptable, and therefore, DSER Open Item 3.9.2.4-1 and DSER Confirmatory Item 3.9.2.4-4 are closed."

Therefore it has previously been demonstrated by Westinghouse and accepted by the NRC that demonstration of CRDM operability during an SSE is not a regulatory requirement and that the CRDM has been adequately qualified to withstand a seismic event and operate following the SSE by way of the analysis of the pressure boundary and the related limits on deflection that ensure that the RCCA is able to insert following the SSE.

References:

1) APP-GW-G1-003, Revision 3, "AP1000 Seismic Design Criteria."

Design Control Document (DCD) Revision: ~~(Revision 0)~~

In Revision 0 of this response a revision to Section 3.7.5.2, -"Post-Earthquake Procedures" was included in the DCD mark-up. That mark-up up will not be included. Section 3.7.5.2 will remain in the DCD and not be changed by this response.

Modify DCD Tier 2 Section SR 3.1.4.3 (of the Chapter 16 Bases) as follows:

SR 3.1.4.3

Verification of rod drop times allows the operator to determine that the maximum rod drop time permitted is consistent with the assumed rod drop time used in the safety analysis. Measuring rod drop times prior to reactor criticality, after each reactor vessel head removal and each earthquake requiring plant shutdown, ensures that the reactor internals and rod drive mechanism will not interfere with rod motion or rod drop time, and that no degradation in these systems has occurred that would adversely affect control rod motion or drop time. This testing is performed with all RCPs operating and the average moderator temperature ≥500°F to simulate a reactor trip under conservative conditions. GRCA are excluded from this Surveillance because they are not considered in the calculation of SDM in MODES 1 and 2.

This Surveillance is performed during a plant outage due to the plant conditions needed to perform the SR and the potential for an unplanned plant transient if the Surveillance were performed with the reactor at power.

Modify DCD Tier 2 Section SR 3.1.4.3 (of the Chapter 16 Technical Specifications) as follows:

SR 3.1.4.3	-- **- NOTE -** Not applicable to GRCAs. -- Verify rod drop time of each rod, from the fully withdrawn position, is ≤ 2.47 seconds from the beginning of decay of stationary gripper coil voltage to dashpot entry, with: a. T_{avg} ≥500°F, and b. All reactor coolant pumps operating.	Prior to reactor criticality after each removal of the reactor head, and after each earthquake requiring plant shutdown

Modify DCD Tier 2 Table 3.2-3 as follows:

Table 3.2-3 (Sheet 34 of 65)

AP1000 CLASSIFICATION OF MECHANICAL AND FLUID SYSTEMS, COMPONENTS, AND EQUIPMENT

Tag Number	Description	AP1000 Class	Seismic Category	Principal Construction Code	Comments
Reactor System (Continued)					
~~RXS-MV-11B06~~	~~Control Rod Drive Mechanism Position B6~~	~~D~~	~~NS~~	~~Manufacturer Std.~~	
RXS-MV-11B06	CRDM Latch Assembly B6	D	NS	Manufacturer Std.	
RXS-MV-11B06	CRDM Drive Rod Assembly B6	D	NS	Manufacturer Std.	
RXS-MV-11B06	CRDM Coil Stack Assembly B6	D	NS	Manufacturer Std.	
RXS-MV-11B06L	CRDM Latch Housing B6	A	I	ASME III-1	
RXS-MV-11B06R	CRDM Rod Travel Housing B6	A	I	ASME III-1	

Note: Table 3.2-3 repeats the above entries (with the exception of the tag number) 69 times, because there are 69 CRDMs for the AP1000. This generic change shown above is typical and applies in all 69 locations. This text is not to be included in the DCD itself but is meant to clarify how the DCD is to be modified.

Modify DCD Tier 2 Section 3.9.4.2.3 as follows:

3.9.4.2.3 Internal Component Requirements

(2 paragraphs unchanged)

In addition to dead-weight and operational loads, the design of the driveline is evaluated for loads due to safe shutdown earthquake and flow induced vibration as described in Section 3.9.5.3, and the resulting deflections are limited such that the CRDM will function properly.

Modify DCD Tier 2 Section 4.5.1.1 as follows:

4.5.1.1 Materials Specifications

(3 paragraphs unchanged)

Internal latch assembly parts are fabricated of heat-treated martensitic and austenitic stainless steel. Heat treatment is such that stress-corrosion cracking is not initiated. Components and parts made of stainless steel do not have specified minimum yield strength greater than 90,000 psi. Magnetic pole pieces are immersed in the reactor coolant and are fabricated from Type 410 stainless steel. Nonmagnetic parts, except shims, pins, and springs, are fabricated from Type 304 stainless steel. A cobalt alloy or qualified substitute is used to fabricate the latch, link, and link pins. Springs and shims are made from nickel-chromium-iron alloy (Alloy X-750 and Alloy 625). Lock screws are fabricated on Type 316 stainless steel. Latch arm tips fabricated of stainless steel may be surfaced with a suitable hard facing material to provide improved resistance to wear. Hard chrome plate is used selectively for bearing and wear surfaces.

The drive rod assembly is also immersed in the reactor coolant and uses a Type 410 stainless steel drive rod. The drive rod coupling is machined from Type 403 or 410 stainless steel. The protective sleeve and disconnect button are also Type 410 stainless steel. The remaining ~~Other~~ parts are Type 304 or Type 304L stainless steel with the exception of the springs, button retainer, and the locking button which are fabricated of nickel-chromium-iron alloy, ~~and the locking button, which is fabricated of , cobalt alloy bar stock or a qualified substitute.~~

Replace Tier 2 Figure 3.9-4 with the figure shown below.

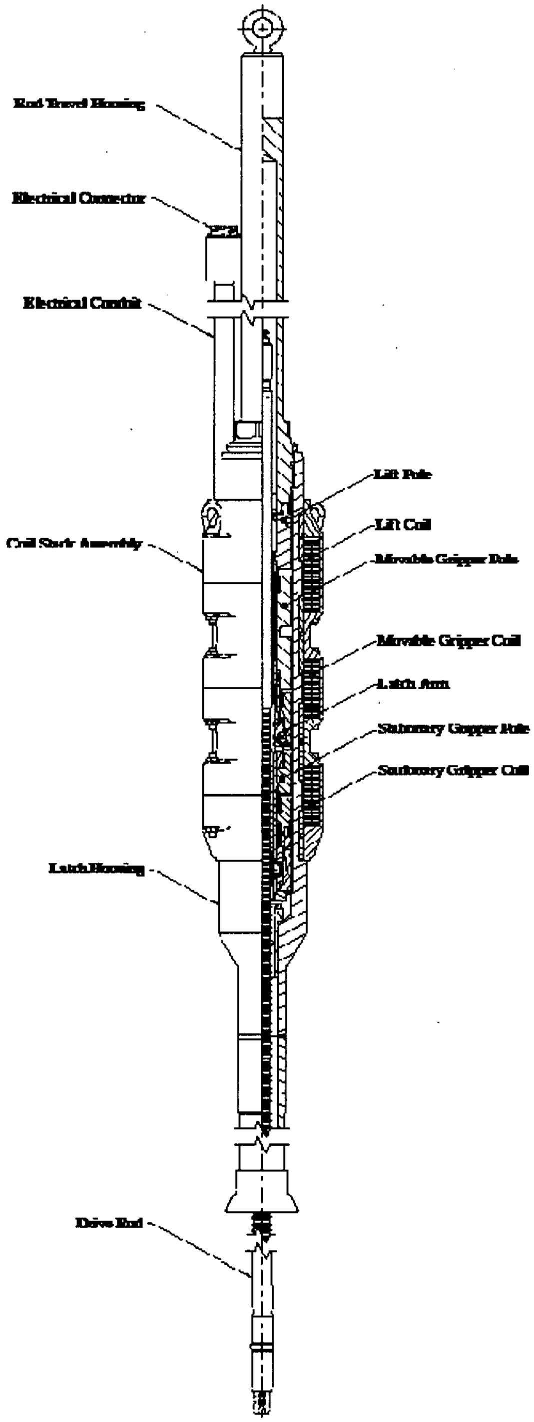

Figure 3.9-4
Control Rod Drive Mechanism

PRA Revision:
None

Technical Report (TR) Revision:
None