Response to SDAA Audit Question

Question Number: A-3.9.4-7

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Question:

Figure 4.6-2 depicts a "rod holdout mechanism" and a "remote disconnect mechanism," which are not extensively discussed in the FSAR. Please provide information on these features, with an emphasis on any potential impact they may have on the safety-related function of inserting rods (If none, please provide explanation).

Response:

The rod hold out (RHO) and the remote control rod assembly (CRA) disconnect mechanism (RDM) are nonsafety-related and non-risk-significant.

Neither the rod hold out (RHO), nor the remote control rod assembly (CRA) disconnect mechanism (RDM) are used during normal plant operations. The FSAR markups to Section 3.9.4 and Section 4.6.1 describe the RHO and RDM. The RHO and RDM have no impact on the safety-related function of inserting the control rods. The proposed scenario of the RDM coils becoming inadvertantly energized is inconsequential because the RDM is only able to function when the control rod drive shaft is fully inserted, which would have no impact to the safety-related function of inserting the control rods.

Markups of the affected changes, as described in the response, are provided below:

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Table 1.1-1: Acronyms and Abbreviations

Acronym or Abbreviation	Description
ABS	auxiliary boiler system
ABVS	Annex Building HVAC system
ABWR	advanced boiling water reactor
AC	alternating current
ACCS	air cooled condenser system
ACI	American Concrete Institute
ACM	Availability Controls Manual
ACRS	Advisory Committee on Reactor Safeguards
AEA	Atomic Energy Act
AFU	air filtration unit
AFWS	auxiliary feedwater system
AHJ	authority having jurisdiction
AHU	air handling unit
AIA	Authorized Inspection Agency
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
ALARA	as low as reasonably achievable
ALU	actuation logic unit
ALWR	advanced light water reactor
AMCA	Air Movement and Control Association International, Inc.
ANB	Annex Building
ANS	American Nuclear Society
ANSI	American National Standards Institute
AO	axial offset
AOA	axial offset anomaly
AOO	anticipated operational occurrence
AOV	air-operated valve
API	American Petroleum Institute
APL	actuation and priority logic
APWR	advanced pressurized water reactor
AQ	augmented quality
ARM	area radiation monitor
ARO	all rods out
ARS	acceleration response spectra
ASAI	application specific action item
ASCE	American Society of Civil Engineers
ASD	adjustable speed drive
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASM	American Society for Metals International
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATB	Administration and Training Building
ATJC	articulating traveling jib crane
ATWS	anticipated transient without scram
AVT	all-volatile treatment
AWH	auxiliary wet hoist
AWS	American Welding Society
AWWA	American Water Works Association
BAS	boron addition system

Table 1.1-1: Acronyms and Abbreviations (Continued)

Acronym or Abbreviation	Description
PLM	priority logic module
PLRS	programmable logic requirement specification
PLS	plant lighting system
PLVVP	Programmable Logic Verification and Validation Plan
PMF	probable maximum flood
PMP	probable maximum precipitation
PORV	power-operated relief valve
POS	plant operating state
POV	power-operated valve
PPE	personal protective equipment
PPS	plant protection system
PRA	Probabilistic Risk Assessment
PRHA	Pipe Rupture Hazards Analysis
PRV	pressure relief valve
PSCIV	primary system containment isolation valves
PSD	power spectra density
PSMS	power supply monitoring system
PSS	process sampling system
PST	phase separator tank
PSTN	public switched telephone network
PTAC	performance and test acceptance criteria band
PTS	pressurized thermal shock
PVC	polyvinyl chloride
PVMS	plant-wide video monitoring system
PWHT	post-weld heat treatment
PWR	pressurized water reactor
PWS	potable water system
PWSCC	primary water stress-corrosion cracking
PZR	pressurizer
QA	quality assurance
QAP	Quality Assurance Program
QAPD	Quality Assurance Program Description
QPD	quadrant power difference
QD	quick disconnect
QHO	quantitative health objective
QPF	quadrant power fractions
RAI	Request for Additional Information
RAP	Reliability Assurance Program
RAW	risk achievement worth
RBC	Reactor Building crane
RBCM	Reactor Building components
RBVS	Reactor Building HVAC system
RCA	radiologically controlled area
RCCA	rod control cluster assembly
RCCWS	reactor component cooling water system
RCP	reactor coolant pump
RCPB	reactor coolant pressure boundary
RCRA	Resource Conservation and Recovery Act
RCS	reactor coolant system
RDM	remote CRA disconnect mechanism

Table 1.1-1: Acronyms and Abbreviations (Continued)

Acronym or Abbreviation	Description
RDT	reactor drain tank
REA	rod ejection accident
RETS	Radiological Effluent Technical Specifications
RFI	radio frequency interference
RFP	refueling pool
RFT	reactor flange tool
RG	Regulatory Guide
RHO	rod hold out
RHR	residual heat removal
RHX	regenerative heat exchanger
RIS	Regulatory Issue Summary
RL	response level
RLE	review level earthquake
RM	radiation monitoring
RMS	fixed area radiation monitoring system
RMTS	risk-managed technical specifications
RO	reverse osmosis
ROP	Reactor Oversight Process
RPI	rod position indication
RPS	reactor protection system
RPV	reactor pressure vessel
RRS	required response spectrum
RRV	reactor recirculation valve
RSA	remote shutdown area
RSR	results summary report
RSS	remote shutdown station
RSV	reactor safety valve
RTB	reactor trip breaker
RTD	resistance temperature detector
RTM	requirements traceability matrix
RT_{NDT}	reference temperature for nil-ductility transition
RTNSS	Regulatory Treatment of Nonsafety Systems
RTP	rated thermal power
RTPTS	reference temperature, pressurized thermal shock
RTS	reactor trip system
RVI	reactor vessel internals
RVV	reactor vent valve
RWB	Radioactive Waste Building
RWBCR	Radioactive Waste Building control room
RWBVS	Radioactive Waste Building HVAC system
RWDS	radioactive waste drain system
RWMS	radioactive waste management system
RWSS	raw water supply system
RXB	Reactor Building
RXCS	reactor core system
RXF	reactor fuel assembly
S&Q	staffing and qualifications
SAFDL	specified acceptable fuel design limit
SAM	seismic anchor motion
SAMDA	severe accident mitigation design alternative

detail below. The rods are moved in a controlled manner to maintain control of the power level and power distribution in the core. The CRDM is connected to the CRA at the bottom end of the control rod drive shaft.

The CRDM is capable of a continuous full-height withdrawal and insertion and holding a position during normal operating conditions.

The CRDM components in contact with the primary coolant are designed to operate for a 60-year design life. The CRDMs are designed to be replaceable and freely interchangeable without limitations in function and connections.

Control Rod Drive Shaft

The control rod drive shaft is the link and the method of transferring force between the CRDM and the CRA. The control rod drive shaft passes through the upper region of the reactor vessel to allow the CRDM to raise, lower, or hold the CRA. The control rod drive shaft also interacts with the rod position indication sensor coils that communicate the elevation of the control rods. The control rod drive shaft allows for the remote release of the CRA for refueling purposes.

The control rod drive shaft is analyzed to the guidance of ASME, Section III, Nonmandatory Appendix F for linear type supports and is evaluated to not adversely affect the integrity of the core support structures in accordance with NG-1122(c).

Martensitic stainless steel materials used in the control rod drive shafts are Cv tested in accordance with NB-2331.

Drive Coil Assembly

The drive coil assembly has four main coils: the lift coil, the upper gripper coil, the lower gripper coil, and the load transfer coil. The drive coil assembly is a part of the external assembly that slides over the pressure housing and sits on a ledge at the base of the pressure housing. The drive coil assembly is depicted by Figure 4.6-3.The direct current generated by the control cabinets is sent through a coil that generates a magnetic field; this magnetic field engages the flat-face plunger magnet of the latch arm assembly, which moves the latch arm to engage the control rod drive shaft. The rate at which the upper gripper coil, the load transfer coil, the lower gripper coil, and the lift coil are energized determines the speed of the control rod drive shaft. The motive power supply from the alternating current distribution system to the CRDM control cabinet is interrupted when the reactor trip breakers open, causing the control rods to be inserted via gravity. The CRDS safety function of rapid insertion of the control rods is accomplished when power is removed from the CRDM. Rod movement logic tracks the speed of the control rods, which utilizes direct rod position indication.

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~~The remote disconnect mechanism coils together with the magnets and internal components of the control rod drive shaft are capable of remotely connecting and disconnecting the control rod drive shaft from the CRA, as the control rod drive shafts are not accessible during NPM disassembly.~~

Pressure Housing

The pressure housing includes components of the CRDM that form the pressure boundary for the reactor coolant. The pressure housing is an ASME BPVC, Section III, Subsection NB component. The pressure housing consists of the single-piece pressure housing (bolted to the reactor vessel head), and the top plug assembly. The removable top plug assembly is threaded onto the top of the pressure housing to complete the RCPB seal.

Latch Mechanism Assembly

The basic functions of the latch mechanism assembly are to grip, release, lift, and lower the CRA. The lifting and lowering functions are referred to as “stepping,” and these steps are in 0.375-inch increments. The latch mechanism assembly contains two sets of latches, the upper gripper and lower gripper latches, as shown in Figure 4.6-5. The latches grip the control rod drive shaft when the teeth of the latch arms are engaged within the grooves in the upper segment of the control rod drive shaft.

The latch assembly is secured into the bottom of the pressure housing.

Rod Position Indicator Assembly

The rod position indicator assembly contains the rod position indication coils and interfaces with the CRDM seismic support plates. The coil assembly is a part of the CRDM external assembly and slides over the pressure housing and sits on the rod disconnect mechanism coil housing. The sensor coil assembly is shown in Figure 4.6-4.

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Remote CRA Disconnect Mechanism

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The CRDM includes a remote CRA disconnect mechanism (RDM) that is used during startup and shutdown when the control rod drive shaft is fully inserted to remotely couple and uncouple the control rod drive shaft to and from the CRA hub, as the control rod drive shafts are not accessible during NPM disassembly. The RDM is composed of two major portions: magnetic and mechanical features that are part of the control rod drive shaft assembly and two electrical coils, which are outside of the RCPB. The RDM coil assemblies are in a fixed position and are operated by a direct current sent through the coils that generates a magnetic field. When the RDM portion on the top of the control rod drive shaft is in alignment with the external RDM coils, which only occurs when the control rod drive shaft is fully inserted, this magnetic field engages the flat-face plunger magnets on the RDM portion on the top of the control rod drive shaft. The upper RDM coil actuates locking and unlocking features and the lower RDM coil raises or lowers the control rod drive shaft internal operating rod to engage or disengage the control rod drive shaft coupling with the CRA hub. The RDM feature is only able to be effectively activated when the CRA is being connected or disconnected. When the RDM coils are de-energized or are non-effective, the internal operating rod and shaft coupling are mechanically locked in place to ensure the CRA cannot be disengaged.

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Rod Hold Out Device

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The CRDM includes a rod hold out (RHO) device used only during refueling operations to secure the control rod drive shaft fully withdrawn in the upper portion of the CRDM pressure housing, which allows the control rod drive shaft to be removed with the upper NPM assembly. The RHO is composed of two major portions: the ball grip assembly inside the top of the CRDM pressure housing and one electrical coil outside of the RCPB. The RHO is engaged only when the CRA is uncoupled from the control rod drive shaft by withdrawing the control rod drive shaft beyond the normal range of travel until the tip of the drive shaft is held by the RHO ball grip assembly. It is not physically possible for the control rod drive shaft to engage with the RHO ball grip assembly without the CRA first being decoupled from the control rod drive shaft because the RHO is positioned in the top of the pressure housing beyond the normal operating travel range of the control rod drive shaft. The CRDS alignment cone at the top of the RVI guide tubes physically limits the withdrawal of the CRA, preventing a control rod drive shaft with coupled CRA from reaching the RHO ball grip. The RHO coil is only utilized for RHO disengagement. RHO engagement and holding is performed by mechanical means. The RHO coil is operated by a direct current sent through the coil that generates a magnetic field. This magnetic field engages the flat-face plunger magnets on the RHO ball grip to allow the control rod drive shaft to be disengaged and returned to its normal range of travel.

3.9.4.1.2 Operation of the Control Rod Drive Mechanisms

The CRDM mechanical and operational requirements are discussed in Section 4.6. The following describes the different modes of CRDM operation. Reactor trip, consisting of full insertion of the CRAs into the core at design conditions, is achievable during the CRDM operating modes described below.

When a reactor trip signal occurs, the operating coils are de-energized. De-energizing causes the latch mechanism assembly magnets to separate, retracting the latches from the drive shaft grooves and allowing the drive shaft and the CRA to drop into the reactor core under gravity.

Control Rod Insertion

4.6 Functional Design of Control Rod Drive System

The control rod drive system (CRDS) performs the following safety-related functions:

- releases the control rod assemblies (CRAs) during a reactor trip
- maintains the pressure boundary of the reactor pressure vessel (RPV)

The CRDS performs the following non safety-related functions:

- latching, holding, and maneuvering the CRAs during reactor startup, power operation, and shutdown
- provides rod position indication

4.6.1 Description of the Control Rod Drive System

The CRDS includes the control rod drive mechanisms (CRDMs) and associated equipment used to operate the CRDMs. The CRDM includes the control rod drive shaft, which extends to the coupling interface with the CRAs in the RPV. The CRDS supports the CRAs by latching, holding, and maneuvering the CRAs during reactor startup, power operation, and shutdown in response to signals from the control rod drive power converter and controller assembly, and in releasing the CRAs during a reactor trip. The CRDS also includes the rod position indicator cabinets and cables, CRDM power cables, and cooling water supply and return piping inside containment. The mechanical design of the CRDM is described in Section 3.9.4 and the design of the CRA is described in Section 4.2.2. The instrumentation and controls for the CRDS are described in Chapter 7.

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Figure 4.6-1 through Figure 4.6-6 illustrate the principal features of the CRDS. Figure 4.6-1 is a simplified drawing showing an overview of the location of components of the CRDS relative to the RPV and the containment vessel (CNV). The CRDMs are mounted on top of the RPV and laterally constrained in order to limit relative lateral seismic motion, yet allow for unrestricted axial expansion. The control rod drive shafts are located inside the RPV and aligned laterally by CRDS support structures that are part of the reactor vessel internals. Further details are provided in Section 3.9.4. The electromagnetic load transfer across the primary pressure boundary is facilitated by electromagnetic coils on the outside (Figure 4.6-3) that engage a set of magnetic poles connected to latches on the inside (Figure 4.6-5), in order to move the control rod drive shaft in a predetermined stepping sequence (Section 3.9.4). Figure 4.6-2 provides an illustration of the CRDM electromagnetic coils and housings, including the pressure housing~~s~~. The power and cooling water connectors are located on top of the pressure housing and rod position indication coil stack assembly for ease of access through the removable cover on top of the CNV (Figure 4.6-1). The rod hold out device is composed of a ball grip assembly inside the top of the CRDM pressure housing and an electrical coil on the outside of the pressure housing. The remote CRA disconnect mechanism is located at the top of the control rod drive shaft assembly and is activated using two electrical coils on the outside of the CRDM pressure housing. Further details are provided in Section 3.9.4. Figure 4.6-3 illustrates the CRDM drive coil and cooling jacket assembly. Figure 4.6-4 shows the layout of the rod position indicator sensor coil assemblies, which are