2.4.26 Rod Position Measurement System

Design Description

1.0 System Description

The rod position measurement system (RPMS) measures the position of a rod cluster control assembly (RCCA) located within the reactor vessel and provides the measurement to the distributed control systems.

The RPMS provides the following safety-related functions:

- Receives safety-related RCCA position signals and signals from the control rod drive mechanisms.
- Sends safety-related temperature compensated analog RCCA position signals to the signal conditioning and distribution system (SCDS).

2.0 Arrangement

2.1 Deleted.

2.2 Physical separation exists between the divisions of the RPMS as listed in Table 2.4.26-1.

2.3 Physical separation exists between Class 1E RPMS equipment and non-Class 1E equipment.

3.0 Mechanical Design Features

3.1 Equipment identified as Seismic Category I in Table 2.4.26-1 can withstand seismic design basis loads without a loss of safety function(s).

4.0 I&C Design Features, Displays, and Controls

4.1 The RPMS receives input signals from the sources listed in Table 2.4.26-2—Rod Position Measurement System Input Signals.

4.2 The RPMS provides output signals to the recipients listed in Table 2.4.26-3—Rod Position Measurement System Output Signals.

4.3 The RPMS design and application software are developed using a process composed of six lifecycle phases with each phase having outputs which must conform to the requirements of that phase. The six lifecycle phases are the following:

1. Basic Design Phase.
2. Detailed Design Phase.
3. Manufacturing Phase.

4. System Integration and Testing Phase.

5. Installation and Commissioning Phase.

6. Final Documentation Phase.

4.4 Class 1E RPMS equipment listed in Table 2.4.26-1 can perform its safety function when subjected to electromagnetic interference (EMI), radio-frequency interference (RFI), electrostatic discharges (ESD), and power surges.

4.5 Hardwired disconnects exist between the service unit (SU) and each divisional monitoring and service interface (MSI) of the RPMS. The hardwired disconnects prevent the connection of the SU to more than a single division of the RPMS.

4.6 CPU state switches are provided at the RPMS cabinets to restrict modifications to the RPMS software.

4.7 Communications independence is provided between the RPMS divisions.

4.8 Locking mechanisms are provided on the RPMS cabinet doors. RPMS cabinet doors that are not closed are indicated on the PICS operator workstations in the MCR.

4.9 The RPMS is designed so that safety-related functions required for an anticipated operational occurrence (AOO) or postulated accident (PA) are performed in the presence of the following:

- Single detectable failures within the RPMS concurrent with identifiable but non-detectable failures.
- Failures caused by the single failure.
- Failures and spurious system actions that cause or are caused by the AOO or PA requiring the safety function.

4.10 Electrical isolation is provided on connections between Class 1E RPMS equipment and non-Class 1E equipment to prevent the propagation of credible electrical faults.

4.11 The RPMS uses TXS system communication messages that are sent with a specific protocol.

4.12 During data communication, the RPMS function processors receive all messages, but only the pre-defined messages for that specific RPMS function processor are considered valid and used. Other messages are ignored.

4.13 Communications independence is provided between RPMS equipment and non-Class 1E equipment.

5.0 Electrical Power Design Features

5.1 Equipment designated as Class 1E in Table 2.4.26-1 are powered from the Class 1E division as listed in Table 2.4.26-1 in a normal or alternate feed condition.

6.0 Environmental Qualifications

6.1 Equipment designated as mild environment in Table 2.4.26-1 can perform their function under normal environmental conditions, anticipated operational occurrences, and accident and post-accident environmental conditions.

Inspections, Tests, Analyses, and Acceptance Criteria

Table 2.4.26-4 lists the RPMS ITAAC.

Table 2.4.26-1—Rod Position Measurement System Equipment

Description	Tag Number(1)	Location	Seismic Category	IEEE Class 1E(2)	Environment
RPMS Cabinets, Division 1	30CLE11	Safeguard Building 1	I	1^{N} 2^{A}	Mild
RPMS Cabinets, Division 2	30CLF11	Safeguard Building 2	I	2^{N} 1^{A}	Mild
RPMS Cabinets, Division 3	30CLG11	Safeguard Building 3	I	3^{N} 4^{A}	Mild
RPMS Cabinets, Division 4	30CLH11	Safeguard Building 4	I	4^{N} 3^{A}	Mild

1. Equipment Tag numbers are provided for information and are not part of the design certification.

2. ^{N} denotes the division the equipment is normally powered from. ^{A} denotes the division the equipment is powered from when alternate feed is implemented.

Table 2.4.26-2—Rod Position Measurement System Input Signals

Item #	Signal	Source	# Divisions
1	RCCA positions: Division 1 (22 RCCA positions) Division 2 (22 RCCA positions) Division 3 (22 RCCA positions) Division 4 (23 RCCA positions)	Control Rod Drive Mechanisms	4
2	Temperature measurement signal for compensation	Control Rod Drive Mechanisms	4

Table 2.4.26-3—Rod Position Measurement System Output Signals

Item #	Signal	Recipient	# Divisions
1	Temperature Compensated RCCA positions: Division 1 (22 RCCA positions) Division 2 (22 RCCA positions) Division 3 (22 RCCA positions) Division 4 (23 RCCA positions)	SCDS	4

Table 2.4.26-4—Rod Position Measurement System ITAAC
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Commitment Wording		Inspection, Tests, Analyses	Acceptance Criteria
2.1	Deleted.	Deleted.	Deleted.
2.2	Physical separation exists between the divisions of the RPMS as listed in Table 2.4.26-1.	An inspection will be performed to verify that the as-built divisions of the RPMS are located in separate Safeguard Buildings.	The divisions of the RPMS are located in separate Safeguard Buildings as listed in Table 2.4.26-1.
2.3	Physical separation exists between Class 1E RPMS equipment and non-Class 1E equipment.	a. An analysis will be performed to determine the required safety-related structures, separation distance, barriers, or any combination thereof to achieve physical separation between as-built Class 1E RPMS equipment and as-built non-Class 1E equipment.	a. A report defines the required safety-related structures, separation distance, barriers, or any combination thereof to achieve physical separation between Class 1E RPMS equipment and non-Class 1E equipment.
		b. An inspection will be performed to verify that the required safety-related structures, separation distance, barriers, or any combination thereof exist between as-built Class 1E RPMS equipment and as-built non-Class 1E equipment.	b. The required safety-related structures, separation distance, barriers, or any combination thereof exist between Class 1E RPMS equipment and non-Class 1E equipment.

Table 2.4.26-4—Rod Position Measurement System ITAAC
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Commitment Wording		Inspection, Tests, Analyses	Acceptance Criteria
3.1	Equipment identified as Seismic Category I in Table 2.4.26-1 can withstand seismic design basis loads without a loss of safety function(s).	a. Type tests, analyses, or a combination of type tests and analyses will be performed on the equipment identified as Seismic Category I in Table 2.4.26-1 using analytical assumptions, or under conditions, which bound the Seismic Category I design requirements.	a. Test/analysis reports conclude that the equipment identified as Seismic Category I in Table 2.4.26-1 can withstand seismic design basis loads without a loss of safety function(s).
		b. An inspection will be performed of the as-built equipment identified as Seismic Category I in Table 2.4.26-1 to verify that the equipment, including anchorage, are installed in a condition bounded by the tested or analyzed condition.	b. Inspection reports conclude that the equipment identified as Seismic Category I in Table 2.4.26-1, including anchorage, are installed in a condition bounded by the tested or analyzed condition.
4.1	The RPMS receives input signals from the sources listed in Table 2.4.26-2.	A test will be performed to verify that the RPMS receives input signals from the sources listed in Table 2.4.26-2 by the use of test input signals.	The RPMS receives the input signals from the sources listed in Table 2.4.26-2.
4.2	The RPMS provides output signals to the recipients listed in Table 2.4.26-3.	A test will be performed to verify that the RPMS provides output signals to the recipients listed in Table 2.4.26-3.	The RPMS provides output signals to the recipients listed in Table 2.4.26-3.

Table 2.4.26-4—Rod Position Measurement System ITAAC
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Commitment Wording		Inspection, Tests, Analyses	Acceptance Criteria
4.3	The RPMS design and application software are developed using a process composed of six lifecycle phases, with each phase having outputs which must conform to the requirements of that phase. The six lifecycle phases are the following: 1) Basic Design Phase. 2) Detailed Design Phase. 3) Manufacturing Phase. 4) System Integration and Testing Phase. 5) Installation and Commissioning Phase. 6) Final Documentation Phase.	a. Analyses will be performed to verify that the outputs for the RPMS Basic Design Phase conform to the requirements of that phase.	a. A report concludes that the outputs conform to the requirements of the Basic Design Phase of the RPMS.
		b. Analyses will be performed to verify that the outputs for the RPMS Detailed Design Phase conform to the requirements of that phase.	b. A report concludes that the outputs conform to the requirements of the Detailed Design Phase of the RPMS.
		c. Analyses will be performed to verify that the outputs for the RPMS Manufacturing Phase conform to the requirements of that phase.	c. A report concludes that the outputs conform to the requirements of the Manufacturing Phase of the RPMS.
		d. Analyses will be performed to verify that the outputs for the RPMS System Integration and Testing Phase conform to the requirements of that phase.	d. A report concludes that the outputs conform to the requirements of the System Integration and Testing Phase of the RPMS.
		e. Analyses will be performed to verify that the outputs for the RPMS Installation and Commissioning Phase conform to the requirements of that phase.	e. A report concludes that the outputs conform to the requirements of the Installation and Commissioning Phase of the RPMS.
		f. Analyses will be performed to verify that the outputs for the RPMS Final Documentation Phase conform to the requirements of that phase.	f. A report concludes that the outputs conform to the requirements of the Final Documentation Phase of the RPMS.

Table 2.4.26-4—Rod Position Measurement System ITAAC
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Commitment Wording		Inspection, Tests, Analyses	Acceptance Criteria
4.4	Class 1E RPMS equipment listed in Table 2.4.26-1 can perform its safety function when subjected to EMI, RFI, ESD, and power surges.	Type tests or type tests and analyses will be performed to demonstrate that the Class 1E RPMS equipment listed in Table 2.4.26-1 can perform its safety function when subjected to EMI, RFI, ESD, and power surges.	Equipment identified as Class 1E in Table 2.4.26-1 can perform its safety function when subjected to EMI, RFI, ESD, and power surges.
4.5	Hardwired disconnects exist between the SU and each divisional MSI of the RPMS. The hardwired disconnects prevent the connection of SU to more than a single division of the RPMS.	a. An inspection of the as-built hardwired disconnects between the SU and each divisional MSI of the RPMS will be performed. b. A test of the hardwired disconnects between the SU and each divisional MSI of the RPMS will be performed.	a. Hardwired disconnects exist between the SU and each divisional MSI of the RPMS. b. The hardwired disconnects prevent the connection of the SU to more than a single division of the RPMS.
4.6	CPU state switches are provided at the RPMS cabinets to restrict modifications to the RPMS software.	a. An inspection will be performed to verify the existence of CPU state switches at the as-built RPMS cabinets that restrict modifications to the RPMS software. b. Tests will be performed to verify that the CPU state switches restrict modifications to the RPMS software.	a. CPU state switches are provided at the RPMS cabinets. b. CPU state switches at the RPMS cabinets restrict modifications to the RPMS software.

Table 2.4.26-4—Rod Position Measurement System ITAAC
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Commitment Wording		Inspection, Tests, Analyses	Acceptance Criteria
4.7	Communications independence is provided between RPMS divisions.	Tests using test input signals, analyses, or a combination of tests using test input signals and analyses will be performed to verify that communications independence is provided between the RPMS divisions.	Communications independence between the RPMS divisions is provided by: • The RPMS function processors do not interface directly with a network. Separate communication modules interface directly with the network. • Separate send and receive data channels are used in both the communications module and the RPMS function processor. • The RPMS function processors operate in a strictly cyclic manner. • The RPMS function processors operate asynchronously from the RPMS communications module.
4.8	Locking mechanisms are provided on the RPMS cabinet doors. RPMS cabinet doors that are not closed are indicated on the PICS operator workstations in the MCR.	a. A test will be performed to verify that the locking mechanisms on the RPMS cabinet doors operate properly. b. A test will be performed to verify that RPMS cabinet doors that are not closed are indicated on the PICS operator workstations in the MCR.	a. The locking mechanisms on the RPMS cabinet doors operate properly. b. RPMS cabinet doors that are not closed are indicated on the PICS operator workstations in the MCR.

Table 2.4.26-4—Rod Position Measurement System ITAAC
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Commitment Wording		Inspection, Tests, Analyses	Acceptance Criteria
4.9	The RPMS is designed so that safety-related functions required for an AOO or PA are performed in the presence of the following: ● Single detectable failures within the RPMS concurrent with identifiable but non-detectable failures. ● Failures caused by the single failure. ● Failures and spurious system actions that cause or are caused by the AOO or PA requiring the safety function.	A failure modes and effects analysis will be performed on the RPMS at the level of replaceable modules and components.	A report concludes that the RPMS is designed so that safety-related functions required for an AOO or PA are performed in the presence of the following: ● Single detectable failures within the RPMS concurrent with identifiable but non-detectable failures. ● Failures caused by the single failure. ● Failures and spurious system actions that cause or are caused by the AOO or PA requiring the safety function.
4.10	Electrical isolation is provided on connections between Class 1E RPMS equipment and non-Class 1E equipment to prevent the propagation of credible electrical faults.	a. Type tests, analyses, or a combination of type tests and analyses will be performed on the electrical isolation devices between Class 1E RPMS equipment and non-Class 1E equipment. b. An inspection will be performed on connections between as-built Class 1E RPMS equipment and non-Class 1E equipment.	a. A report concludes that the Class 1E isolation devices used between Class 1E RPMS equipment and non-Class 1E equipment prevent the propagation of credible electrical faults. b. Class 1E electrical isolation devices exist on connections between Class 1E RPMS equipment and non-Class 1E equipment.

Table 2.4.26-4—Rod Position Measurement System ITAAC
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Commitment Wording		Inspection, Tests, Analyses	Acceptance Criteria
4.11	The RPMS uses TXS system communication messages that are sent with a specific protocol.	A test will be performed on RPMS equipment to verify that RPMS communication messages are sent with a specific protocol.	The TXS system communication messages use a specific protocol structure and message error determination. Messages are validated by the following series of checks: ● Message header check contains the following: – Protocol version – Sender ID – Receiver ID – Message ID – Message type – Message length ● Message age is monitored. ● Message cyclic redundancy check is performed so that if one of the checks fails, the affected data are marked with an error status.
4.12	During data communication, the RPMS function processors receive all messages, but only the pre-defined messages for that specific RPMS function processor are considered valid and used. Other messages are ignored.	a. An analysis will be performed to define the pre-defined messages for that specific RPMS function processor. b. A test will be performed to verify that the RPMS function processors receive all messages, but only the pre-defined messages for that specific function processor are considered valid and used. Other messages are ignored.	a. A report defines the pre-defined messages for that specific RPMS function processor. b. The RPMS function processors receive all messages, but only the pre-defined messages for that specific function processor are considered valid and used. Other messages are ignored.

Table 2.4.26-4—Rod Position Measurement System ITAAC
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Commitment Wording		Inspection, Tests, Analyses	Acceptance Criteria
4.13	Communications independence is provided between RPMS equipment and non-Class 1E equipment.	Tests, analyses, or a combination of tests and analyses will be performed on the RPMS equipment to verify that communications independence is provided between RPMS equipment and non-Class 1E equipment.	Communications independence between RPMS equipment and non-Class 1E equipment is provided by: ● Data communications between RPMS function processors and non-Class 1E equipment are through a Monitoring and Service Interface (MSI). ● The MSI does not interface directly with a network. Separate communication modules interface directly with the network. ● Separate send and receive data channels are used in both the communications module and the MSI. ● The MSI operates in a strictly cyclic manner. ● The MSI operates asynchronously from the communications module. ● The RPMS uses a hardware device to ensure that unidirectional signals are sent to non-safety-related I&C systems.
5.1	Equipment designated as Class 1E in Table 2.4.26-1 are powered from the Class 1E division as listed in Table 2.4.26-1 in a normal or alternate feed condition.	a. Testing will be performed by providing a test input signal in each normally aligned division. b. Testing will be performed by providing a test input signal in each division with the alternate feed aligned to the divisional pair.	a. The test input signal provided in the normally aligned division is present at the respective Class 1E equipment identified in Table 2.4.26-1. b. The test input signal provided in each division with the alternate feed aligned to the divisional pair is present at the respective Class 1E equipment identified in Table 2.4.26-1.

Table 2.4.26-4—Rod Position Measurement System ITAAC
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Commitment Wording		Inspection, Tests, Analyses	Acceptance Criteria
6.1	Equipment designated as mild environment in Table 2.4.26-1 can perform their function under normal environmental conditions, anticipated operational occurrences, and accident and post-accident environmental conditions.	a. Type tests or type tests and analysis will be performed to demonstrate the ability of the equipment designated as mild environment in Table 2.4.26-1 to perform their function under normal environmental conditions, anticipated operational occurrences, and accident and post-accident environmental conditions.	a. EQDPs conclude that the equipment designated as mild environment in Table 2.4.26-1 can perform their function under normal environmental conditions, anticipated operational occurrences, and accident and post-accident environmental conditions, including the time required to perform the listed function.
		b. An inspection will be performed of the as-built equipment designated as mild environment in Table 2.4.26-1 to verify that the equipment, including the associated cables, wiring, and terminations located in a mild environment, are bounded by the type test or combination of type tests and analyses.	b. Inspection reports conclude that the equipment designated as mild environment in Table 2.4.26-1, including the associated cables, wiring, and terminations located in a mild environment, are bounded by the type test or combination of type tests and analyses.

Next File