Enclosure 1

Changes to PSAR Sections 9.1.1 and 9.1.4

(Non-Proprietary)

Table 3.1-3: Principal Design Criteria

Principal Design Criteria	**SAR Section**
PDC 1, Quality Standards and Records	3.5, 4.3, 6.3, 7.3, 7.4, 7.5
PDC 2, Design bases for protection against natural phenomena	3.5, 4.2.2, 4.3, 4.7, 5.1, 6.3, 7.3, 7.4, 7.5, 8.2, 8.3, 9.1.1,- 9.1.2, 9.1.3, 9.1.4, 9.1.5, 9.2, 9.3, 9.4, 9.7, 9.8.2, 9.8.4, 9.8.5, 11.2
PDC 3, Fire Protection	6.3, 7.3, 7.5, 9.3, 9.4
PDC 4, Environmental and dynamic effects design bases	4.2.2, 4.3, 4.7, 6.3, 7.3, 9.1.1, 9.1.2, 9.1.4, 9.3, 9.7, 9.8.2 9.8.4
PDC 5, Sharing of structures, systems, and components	3.1
PDC 10, Reactor Design	4.2.1, 4.3, 4.5, 4.6, 5.1, 6.3, 7.3
PDC 11, Reactor Inherent Protection	4.5
PDC 12, Suppression of reactor power oscillations	4.5, 4.6, 5.1
PDC 13, Instrumentation and Control	7.2, 7.3, 7.5, 9.1.3
PDC 14, Reactor Coolant Boundary	4.3
PDC 15, Reactor coolant system design	7.3, 9.1.4
PDC 16, Containment design	4.2.1, 5.1
PDC 17, Electric Power systems	8.2, 8.3
PDC 18, Inspection and testing of electric power systems	8.2, 8.3
PDC 19, Control room	7.4
PDC 20, Protection system functions	7.3
PDC 21, Protection system reliability and testability	7.3, 7.5
PDC 22, Protection System Independence	7.5
PDC 23, Protection system failure modes	4.2.2, 7.3
PDC 24, Separation of protection and control systems	7.5
PDC 25, Protection system requirements for reactivity control malfunctions	7.3

Principal Design Criteria	**SAR Section**
PDC 26, Reactivity control systems	4.2.2 4.5
PDC 28, Reactivity limits	4.2.2, 7.3
PDC 29, Protection against anticipated operation occurrences	4.2.2, 7.3, 7.5
PDC 30, Quality of reactor coolant boundary	4.3
PDC 31, Fracture prevention of reactor coolant boundary	4.3
PDC 32, Inspection of reactor coolant boundary	4.3
PDC 33, Reactor coolant inventory maintenance	9.1.4
PDC 34, Residual heat removal	4.6, 6.3
PDC 35, Passive residual heat removal	4.3, 4.6, 6.3
PDC 36, Inspection of passive residual heat removal system	6.3
PDC 37, Testing of passive residual heat removal system	6.3
PDC 44, Structural and equipment cooling	9.1.5, 9.7
PDC 45, Inspection of structural and equipment cooling systems	9.1.5, 9.7
PDC 46, Testing of structural and equipment cooling systems	9.1.5, 9.7
PDC 60, Control of releases of radioactive materials to the environment	5.1, 5.2, 9.1.3, 9.2, 11.2
PDC 61, Fuel storage and handling and radioactivity control	9.3
PDC 62, Prevention of criticality in fuel storage and handling	9.3
PDC 63, Monitoring fuel and waste storage	9.3, 11.2
PDC 64, Monitoring radioactivity releases	9.1.2, 9.1.3, 9.2
PDC 70, Reactor coolant purity control	9.1.1, 9.1.4
PDC 71, Reactor coolant heating systems	9.1.5
PDC 73, Reactor coolant system interfaces	5.2

CHAPTER 9 AUXILIARY SYSTEMS

This chapter provides an overview description of the auxiliary systems at the reactor facility. Auxiliary systems are those systems not previously described elsewhere in this safety analysis report.

Additional details are provided for those auxiliary systems that are important to the safe operation and shutdown of the reactor or to the protection of the health and safety of the public, the facility staff, and the environment to support an understanding of those aspects of the design.

9.1 REACTOR COOLANT AUXILIARY SYSTEMS

The Reactor coolant auxiliary systems (RCAS) are a collection of systems that provide support for the functionality and performance of the reactor coolant (Flibe). The major functions of the system are as follows:

- Remove fission products, activation products, and other chemical impurities and particulates from the reactor coolant.
- Maintain the cover gas atmosphere (pressure and composition) in the head space above the core.
- Provide removal and storage of tritium.
- Control inventory, filling, and draining processes for systems containing reactor coolant, including transfer of coolant into the reactor.
- Provide active and passive thermal management to reactor system components.

The functions of the RCAS are implemented via the following subsystems:

- Chemistry control system (Section 9.1.1)
- Inert gas system (Section 9.1.2)
- Tritium management system (Section 9.1.3)
- Inventory management system (Section 9.1.4)
- Reactor thermal management system (Section 9.1.5)

These systems are further described in the subsections which follow.

9.1.1 Chemistry Control System

9.1.1.1 Description

The chemistry control system (CCS) is used during normal plant operations to monitor the coolant chemistry in the reactor vessel system and primary heat transport system (PHTS), through the interface with the Inventory Management System (IMS), for compliance with Flibe specifications described in Section 5.1. ~~Additionally, the CCS determines if the loading of graphite particulate in the PHTS is within acceptable levels.~~ The system extracts coolant samples for offline analysis of the Flibe chemistry, including the content of dissolved radionuclides in the Flibe and loading of insoluble materials~~ including graphite dust~~. A description of the offline sample analysis equipment will be provided with the application for an Operating License. ~~Should the analysis determine~~ If the Flibe is not within limits ~~only marginally meets the specification~~, the IMS may be used to remove and replace a sufficient amount of reactor coolant to restore conformance to the Flibe specification.

The CCS is not credited with performing any safety-related functions.

The CCS is shown in Figure 9.1.4-1.

9.1.1.2 Design Bases

The CCS does not perform any safety-related functions and is not credited for the mitigation of any postulated events. The system is also not credited for performing safe shutdown functions.

Consistent with principal design criteria (PDC) 2, safety-related structures systems and components (SSCs) located near the CCS ~~will be~~ are protected from the adverse effects of postulated CCS failures during a design basis earthquake.

Consistent with PDC 4, safety-related SSCs located near the CCS are protected from the adverse effects of postulated CCS failures during dynamic events.

Consistent with PDC 70, the CCS is designed to monitor the purity of reactor coolant within specified design limits in consideration of chemical attack, fouling and plugging of passages and radionuclide concentrations, and air or moisture ingress.

Consistent with 10 CFR 20.1406, the CCS is designed, to the extent practicable, to minimize contamination of the facility and the environment, and facilitate eventual decommissioning.

9.1.1.3 System Evaluation

Portions of the CCS may be located in proximity to SSCs that perform safety-related functions. Those safety-related SSCs will be protected from seismic induced failures of the CCS by either seismically mounting the applicable CCS components, confirming sufficient physical separation, or by the erection of barriers to preclude adverse interactions. The CCS is designed to preferentially fail in a way that does not impact the reactor vessel system. This satisfies the requirements of PDC 2.

The CCS is designed such that safety-related systems in proximity to the CCS are protected against the dynamic effects potentially created by the failure of CCS equipment by either confirming sufficient physical separation, the erection of barriers to preclude adverse interactions, or designing safety-related components to survive adverse interactions. This satisfies the requirements of PDC 4.

The CCS periodically monitors the reactor coolant chemistry using offline sample analysis to ascertain whether the coolant is within the Flibe specifications. The sample analysis examines materials dissolved within the salt (e.g. ~~i.e.~~ metal fluoride corrosion products) as well as entrained materials (e.g. ~~i.e. graphite dust,~~ fission products~~,~~ and activation products). If the Flibe is not within ~~only marginally meets~~ the specification in KP-TR-005, “Reactor Coolant topical report,” Revision 1 (Reference 1), or the circulating activity limits in the technical specifications, the IMS (see Section 9.1.4) may be used to remove and replace a sufficient amount of reactor coolant to restore conformance to the Flibe specification. This satisfies the requirements in PDC 70 for monitoring the purity of the reactor coolant.

The CCS interfaces with the IMS and supports containment of fission products and activation products from the reactor vessel system and PHTS. Therefore, the system is designed to minimize contamination and support eventual decommissioning, consistent with the requirements of 10 CFR 20.1406.

9.1.1.4 Testing and Inspection

The CCS sample analysis monitors will be periodically calibrated. The components of the CCS are located such that they are accessible for periodic inspection and testing.

9.1.1.5 References

1. Kairos Power, LLC, “Reactor Coolant Topical Report,” KP-TR-005-P-A.~~, Revision 1~~.

9.1.4.1.2 RV Fill/Drain Tank

The RV fill/drain tank provides a means of filling and draining the RV through a transfer line and a dip tube. The transfer into the RV is pump driven and the transfer out of the RV is gravity driven. The RV fill/drain tank transfer line is equipped with a passive RV isolation system to prevent unintentional draining, which is discussed in Section 9.1.4.3. The RV fill/drain tank is sized to hold the RV coolant inventory.

9.1.4.1.3 PHTS Fill/Drain Tank

The PHTS fill/drain tank provides a means of filling and draining the reactor coolant from the PHTS (see Section 5.1), including the primary heat exchanger (PHX), through a transfer line. The PHTS drain is gravity driven and the fill is pump driven between the PHTS fill/drain tank and the PHTS.

The PHTS fill/drain tank is sized to hold the PHTS and PHX reactor coolant inventory.

9.1.4.1.4 Solid IMS

New and used reactor coolant is stored in transfer canisters used to transport reactor coolant to and from the site in solid state at ambient temperature. Within the IMS, the reactor coolant is transferred – in liquid form – through transfer lines, driven by a cover gas pressure differential. The solid IMS function is to melt new reactor coolant in the canisters prior to a transfer into the IMS or to freeze the used reactor coolant in the canisters following a transfer from the IMS. The used reactor coolant presents a potential hazard due to radiological contamination.

The transfer canisters are constructed of stainless-steel and are designed per ASME BPVC, Section VIII. The transfer canisters are designed and fabricated to meet the pressure, mechanical loads, corrosion, and temperature requirements of the system.

9.1.4.2 Design Bases

Consistent with PDC 2, safety-related SSCs located near the IMS are protected from the adverse effects of IMS failures during a design basis earthquake.

Consistent with PDC 4, safety-related SSCs located near the IMS are protected from the adverse effects of IMS failures during dynamic events.

Consistent with PDC 15, the IMS is designed to ensure the design conditions of the reactor coolant boundary’s safety-related elements are maintained during normal and accident conditions.

Consistent with PDC 33, sufficient reactor coolant inventory is provided to protect against a loss of inventory in the safety-related portions of the reactor coolant boundary.

Consistent with PDC 70, the IMS is designed to maintain the purity of reactor coolant within specified design limits.

Consistent with 10 CFR 20.1406, the IMS is designed, to the extent practicable, to minimize contamination of the facility and the environment, and facilitate eventual decommissioning.

9.1.4.3 System Evaluation

The IMS does not perform safety-related functions and is not credited for the mitigation of postulated events. The system is also not credited for performing safe shutdown functions. The system is not credited to maintain the integrity of the reactor coolant pressure boundary.

Portions of the IMS may be located in proximity to SSCs with safety-related functions. Those safety-related SSCs are protected from failure of the IMS during a design basis earthquake by either seismically mounting the applicable IMS components, physical separation, or barriers to preclude adverse interactions. The IMS is designed to preferentially fail in a way that does not impact the RV system. This satisfies PDC 2 for the IMS.

The IMS is designed such that safety-related systems in proximity to the IMS are protected against the dynamic effects potentially created by the failure of IMS equipment. The IMS is a low pressure system, as the reactor coolant pressures are bounded by the reactor coolant static head pressures, thus precluding pipe whip. This satisfies PDC 4 for the IMS.

The IMS is designed to preclude the inadvertent draining of the RV. During operation, the RV fill/drain transfer line is equipped with a passive RV isolation system designed to preclude inadvertent reactor coolant draining from the RV. In the event of a leak in the RV fill/drain transfer line, the reactor coolant leak is detected by the control system, the PSP is tripped, and the RV cover gas pressure is limited to an upper bound thus precluding the ejection of reactor coolant through the transfer line dip-tube. During RV fill/drain operations, an isolation valve is used to interrupt the reactor coolant flow and a cover gas inlet is used to break the siphon in the transfer lines.

The RV coolant level management tank short dip tube and overflow weir designs preclude inadvertent reactor coolant draining from the RV into the RV level management tank. Additionally, the overflow line is designed in a way that precludes the uncovering of fuel due to thermal expansion of the reactor coolant. In the event of a leak in the RV level management tank or transfer line, the reactor coolant leak is detected by the control system, the pump for the reactor level management is tripped to minimize the overflow of reactor coolant from the RV through the overflow weir. The PHTS drain line is equipped with a PHTS drain valve. In the event of a leak in the PHTS fill/drain tank or drain line, the reactor coolant leak is detected by the control system, the PSP is tripped. While a PHTS leak cannot be precluded, the PHTS design contains an RV anti-siphon feature (see Section 4.3), thus precluding inadvertent reactor coolant drain from the RV. These design features satisfy the requirements of PDC 15.

The safety-related portions of the reactor coolant boundary are limited to the RV (see Section 4.3). Failures of other SSCs containing reactor coolant (e.g., salt spill), do not result in unacceptable consequences as described in Chapter 13. A failure of the RV is a prevented event. Thus, the makeup inventory of reactor coolant to the reactor vessel is not relied on to mitigate the consequences of a postulated event. Therefore, the requirements of PDC 33 have been addressed.

The CCS (see Section 9.1.1) periodically monitors the reactor coolant chemistry using offline sample analysis to ascertain whether the coolant is within the Flibe specifications in KP-TR-005, “Reactor Coolant topical report,” Revision 1 (Reference 3), or the circulating activity limits in the technical specifications. If the Flibe is not within limits, the IMS may be used to remove and replace a sufficient amount of reactor coolant to restore conformance to the Flibe specification. This satisfies the requirements in PDC 70 for maintaining the purity of the reactor coolant.

The system is expected to handle reactor coolant with fission as well as activation products; therefore, the system will be designed to minimize contamination and support eventual decommissioning, consistent with the requirements of 10 CFR 20.1406.

9.1.4.4 Testing and Inspection

The components of the IMS, including valves, tanks, pumps and other components, are located such that they are accessible for periodic inspection and testing.

9.1.4.5 References

1. American Society of Mechanical Engineers, “Process Piping,” ASME B31.3. 2016.
2. ASME, Boiler and Pressure Vessel Code, Section VIII, “Rules for Construction of Pressure Vessels,” New York, NY. 2015.
3. Kairos Power, LLC, “Reactor Coolant Topical Report,” KP-TR-005-P-A.