AP1000 SSC Performance Verification Matrix

Purpose: The information in this matrix is draft and is only meant as a tool to help develop a framework to ensure key AP1000 Structures, Systems and Components (SSC) functions are adequately monitored and evaluated; ensure that potential causes and effects of challenges to these SSCs are well-understood so that – consistent with its stated mission - the ROP can:

- Collect information about licensee performance
- Assess the information for its safety significance
- Provide an appropriate licensee and NRC response

The staff will engage affected internal and external stakeholders during the development and validation (e.g., tabletops, pilots, etc.) of the methodology and approach. Furthermore, additional thought should be given to other plant challenges (e.g., seismic events) before finalizing the matrix. To further define and frame the baseline inspection program for the AP1000, the staff envisions developing a Risk Information Matrix similar to those developed for the original ROP as included in SECY-99-007, Attachment III.

Definitions:

SSC: A structure, system, or component that warrants regulatory oversight during operations. The three letter designators used match the plant system nomenclature specified in the AP1000 Design Control Document (DCD). SSCs that are classified as Regulatory Treatment of Non-Safety Systems (RTNSS) are identified. Reference: AP1000 DCD.

IMPORTANCE: The importance of each system is obtained from Inspection Manual Chapter (IMC) 2519 – Construction Significance Determination Process. The importance of each system is determined by the mean core damage frequency (CDF) when the SSC is assumed to be completely unavailable (Risk Achievement Worth). IMC 2519, Appendix A-10 categorizes plant systems into High (>1E-4), Intermediate (1E-4 to 1E-5), Low (1E-5 to 1E-6), and Very Low (<1E-6) Risk.

KEY SSC FUNCTIONS: Safety-related and/or risk-significant functions performed by the SSC.

IMPORTANT ATTRIBUTES: In plain English, features of the SSC and its support systems that provide assurance the system performance (including defense-in-depth, reliability, and availability) will be acceptable. Safety related Passive SSCs that require a TS Surveillance 10 year System Level Operability Test are identified. References: Risk-Insights for the Review of the AP1000 Design and AP1000 Technical Specifications.

VERIFY BY PI / VERIFY BY INSPECTION: Inspections, tests, analyses, and acceptance criteria (ITAAC) and pre-operational/start-up testing will provide reasonable assurance that initial SSC performance is acceptable. What tools (PIs, inspection, etc.) will be appropriate to ensure that SSC safety margins are not degraded during operations? RTNSS SSCs need special attention to ensure the required regulatory treatment is maintained.

TREATMENT BY SDP: Are there unique aspects to the SSC (e.g., passive cooling, digital I&C) that should be considered when evaluating inspection findings? Is the SSC of such low risk importance that we can consider using a simple screening criteria?

SSC *Not comprehensive	Location + Active or Passive	IMPORTANCE (magnitude of CDF if SSC unavailable)	KEY SSC FUNCTIONS	IMPORTANT ATTRIBUTES	VERIFY BY PI?	VERIFY BY INSPECTION ?	TREATMENT BY SDP
Accumulators (PXS)	Cont Bldg – Passive	LOW	safety injection to RCS to provide adequate core cooling for all LOCA sizes	2 accumulators; Requires 10 year System Level OPERABILITY Testing Program			
Chemical and Volume Control System (CVS)	Aux Bldg – Active	VERY LOW	Maintain reactor coolant system fluid purity and activity level within acceptable limits. Maintain the required coolant inventory in the reactor coolant system Maintain the reactor coolant chemistry conditions by controlling the concentration of boron and lithium hydroxide. Maintain the proper level of dissolved hydrogen in the reactor coolant during power operation Achieve the proper oxygen level prior to startup after each shutdown. Fill and pressure test the reactor coolant system (with connections for hydrostatic testing) Provide makeup water to the primary side systems that require borated reactor grade water Provide pressurizer auxiliary spray water for depressurization	2 trains with one pump and one letdown AOV isolation valve each; The chemical and volume control system (CVS) provides a safety-related means to terminate inadvertent RCS boron dilution and to preserve containment integrity by isolation of the CVS lines penetrating the containment.			
Component Cooling Water System (CCS) *****RTNSS*****	Turbine Bldg - Active	LOW	The component cooling water system is a non-safety-related, closed loop cooling system that transfers heat from various components needed for plant operation and removes core decay heat and sensible heat for normal reactor shutdown and cooldown.	2 trains with one pump each and backed up by the standby diesels			
Protection and Monitoring System (PMS)	Aux Bldg	HIGH	Digital I&C; likely to involve novel concepts	Functions with software, hardware and display panels			
Automatic	Cont Bldg -	HIGH	ADS valves open when	4 stages of 2			

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Depressurization System (ADS)	Passive		actuated and remain open for the duration of an automatic depressurization event	valves each; First 3 stages use MOVs; 4th stage uses MOV/squib valves; Valves are powered by Class 1E DC			
Core Makeup Tanks (PXS)	Cont Bldg – Passive	INTERMEDIATE	Provide core decay heat removal during transients, accidents or whenever the normal heat removal paths are lost	Requires 10 year System Level OPERABILITY Testing Program			
In-Containment RWST, Injection Mode (PXS)	Cont Bldg – Passive	HIGH	Provide core decay heat removal during transients, accidents or whenever the normal heat removal paths are lost Provide RCS makeup and boration during transients or accidents when the normal reactor coolant system makeup supply from the chemical and volume control system is unavailable or is insufficient Provide safety injection to the reactor coolant system to provide adequate core cooling for the complete range of loss of coolant accidents, up to and including the double-ended rupture of the largest primary loop reactor coolant system piping. Provide for chemical addition to the containment during post-accident conditions to establish flood-up chemistry conditions that support radionuclide retention with high radioactivity in containment and to prevent corrosion of containment equipment during long-term flood-up conditions.	2 separate injection lines with MOV/Squib valves; Requires 10 year System Level OPERABILITY Testing Program			
In-Containment RWST, Recirc Mode	Cont Bldg – Passive	HIGH	See above	2 separate recirc lines with			

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(PXS)				MOV/Squib valves; Requires 10 year System Level OPERABILITY Testing Program			
Main AC Power (ECS) ***RTNSS***	Annex Bldg - Active	LOW	Powers the reactor, turbine, and balance of plant auxiliary electrical loads On loss of normal and preferred sources, ancillary diesel generators supply selected loads Provides input ac power for the Class 1E dc battery Safety-related reactor coolant pump breakers open to allow CMT operation	Non-Class 1E system			
Normal RHR (RNS) ***RTNSS***	Aux Bldg - Active	LOW	Typical RHR system	Non safety system apart from containment & RCS isolation functions; long term post-accident containment inventory makeup			
Passive Containment Cooling System (PCS)	Shield Bldg – Passive	LOW	Reduce the containment temperature and pressure following a loss of coolant accident (LOCA) or main steam line break (MSLB) inside the containment	Requires 10 year System Level OPERABILITY Testing Program; Containment must be vented after 24 hours; PCS annulus drains inspected every 2 years			
Plant Control System (PLS)	Aux Bldg	MODERATE	Establish and maintain plant operating conditions within prescribed limits Minimize challenges to the protection systems Allow operator monitoring and manual control while relieving the operator from routine tasks	Non-safety related automatic and manual control of non-safety related equipment			
Reactor Coolant System (RCS)	Cont Bldg	LOW	Transfers heat to the steam and power				

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			conversion system (during power operation as well as the initial phase of plant cooldown) Transfers heat produced during the subsequent phase of plant cooldown and cold shutdown to the normal residual heat removal system				
Service Water System (SWS) ***RTNSS***	Turbine Bldg – Active	LOW	Supplies cooling water to remove heat from the non-safety-related component cooling water system heat exchangers in the turbine building, transferring it to the non-safety-related ultimate heat sink	2 trains; one running and the other in standby. Powered by onsite Diesels			
Startup Feedwater System (FWS) ***RTNSS***	Turbine Bldg – Active	VERY LOW	Supply feedwater to the steam generators during plant startup, hot standby and shutdown conditions, and during transients in the event of main feedwater system unavailability	This capability provides an alternate core cooling mechanism to the PRHR heat exchangers for non-LOCA or steam generator tube ruptures			
Steam Generator System (SGS)	Cont Bldg	VERY LOW	Remove heat from the reactor coolant system during power operation and anticipated transients as well as under natural circulation conditions				
DC-1E (IDS)	Aux Bldg – Passive	HIGH	Provides safety-related power for I&C and various valves needed for safe shutdown (both DC and AC, via inverters)	Four divisions; physical and electrical isolation important; two 24 hour and two 72 hour battery banks			
Passive RHR	Cont Bldg – Active	INTERMEDIATE	Long term decay heat removal; transfers heat from RCS into IRWST *Redundant to non-safety-related normal RHR (RNS)	Passive challenges to			

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				PRHR[1]: Cracked tubes; Hx Fouling; High initial IRWST temp; Non-condensable gasses; Degraded insulation (lower thermal head); Thermal stratification; Bypass flow caused by leaking valve			
				Capability exists in control room to detect 500 gpm crack; assumed limit to prevent rupture			
				Gutter system and corresponding valves return condensed water to IRWST, ensuring long-term availability of inventory			
				Actuated by redundant parallel AOVs that fail open on loss of air, PMS signal or 1E power Requires 10 year System Level OPERABILITY Testing Program			
DC POWER (EDS) *****RTNSS*****	Annex Bldg - Active	INTERMEDIATE	The non-Class 1E dc and UPS system (EDS) provides dc and uninterruptible ac power to non-safety-related loads	2 separate power supply trains; each will last 2 hours after loss of all AC			
DGs	Annex Bldg - Active	VERY LOW	Due to passive systems, DGs do not provide a	Same as existing DGs.			

[1] These are generic to passive cooling systems that rely on thermal head. A specific list for each passive system could be developed, possibly with support from RES.

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RTNSS			safety-related function but they are the preferred backup AC source, given LOOP.				
Offsite Power ***RTNSS***	Switchyard	VERY LOW	During plant startup, shutdown, and maintenance, the main ac power is provided from the high-voltage switchyard.	ac power source not required; Design includes connections to a preferred (offsite) power source and two non-safety-related onsite standby diesel generators.			
Diverse Actuation System (DAS) ***RTNSS***		LOW	Provide a non-safety-related system that serves as a diverse backup to the protection system for reactor trip and ESF actuation	Backup to PMS with diversity in signals used;			
Containment Hydrogen Control System (VLS)	Containment Bldg	LOW	The containment hydrogen control system is provided to limit the hydrogen concentration in the containment so that containment integrity is not endangered.	- Hydrogen concentration monitoring -Hydrogen control during and following a degraded core or core melt scenarios (provided by hydrogen igniters). In addition, two nonsafety-related passive autocatalytic recombiners (PARs) are provided for defense-in-depth protection against the buildup of hydrogen following a loss of coolant accident.			
In Vessel Retention of molten core (PXS - IVR)		LOW	The passive core cooling system (PXS) in-vessel retention (IVR) function provides the capability to cool the exterior of the reactor pressure vessel during severe accidents				

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			and to prevent the lower head from failing, thus retaining the molten debris within the vessel.				
Main control room and I&C rooms B/C ancillary fans Nuclear Island Nonradioactive Ventilation System (VBS - FANS)		LOW	Monitors the main control room supply air for radioactive particulate and iodine concentrations Isolates the HVAC penetrations in the main control room boundary on high-high particulate or iodine concentrations in the main control room supply air or on extended loss of ac power Deliver the required air flow to the main control room to meet the ventilation and pressurization requirements for 72 hours Provide passive heat sinks capable of limiting the temperature rise for the main control room, instrumentation and control rooms, and dc equipment rooms Serves the main control room, technical control support center area, Class 1E dc equipment rooms, Class 1E instrumentation and control (I&C) rooms, Class 1E electrical penetration rooms, Class 1E battery rooms, remote shutdown room, reactor coolant pump trip switchgear rooms, adjacent corridors, and the passive containment cooling system (PCS) valve room	For post-72 hour actions, VBS MCR and I&C rooms B/C ancillary fans (VBS-MA-10A/B, -11, -12) are available to provide cooling of the MCR and the two I&C rooms (B/C) that provide post-accident monitoring			