WCAP-14075
REV. 0

WESTINGHOUSE CLASS 3 (Non-Proprietary)

AP600 Design Differences Document For Development Of Emergency Operating Guidelines Report

Westinghouse Energy Systems

WCAP-14075
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WESTINGHOUSE CLASS 3 (Non-Proprietary)

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WESTINGHOUSE PROPRIETARY CLASS 3

AP600 Design Differences Document
For Development Of Emergency
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AP600 RESPONSIBLE MANAGER	SIGNATURE*	APPROVAL DATE
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AP600 Design Differences Document For Development Of Emergency Operating Guidelines Report

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Development of AP600-Specific Emergency Response Guidelines

The first step in developing the AP600-specific emergency response guidelines (ERGs) is to compare the low-pressure (LP) reference plant design with the AP600 design. To identify the design differences with respect to emergency operations between the ERG low-pressure reference plant design and the AP600 design, a comparison of the systems of the two plants is made. This comparison is performed in a systematic and complete manner.

The low-pressure reference plant is chosen as the initial starting point in the development of AP600-specific ERG's because the charging pumps (make-up pumps for AP600) are not part of the emergency core cooling system, thus making the AP600 more similar to the ERG low-pressure reference plant. Because of the major functional similarities between the AP600 design and the low-pressure ERG reference plant, the ERG process can easily be applied to the AP600 design.

This document provides the AP600/ERG low-pressure reference plant design differences. A high level comparison of the LP reference plant and the AP600 for use in adapting the ERG high level action strategies to the AP600 is made. A summary of differences in system functions, major design features, components and instrumentation and controls available to the plant operators is provided. From this differences document, the high-level operator action strategies for emergency operations are developed.

Differences Between the Two-Loop Low-Pressure Reference Plant and the AP600 Plant

This represents the first subtask in establishing the high-level operator action strategies for emergency operations for the AP600 design. This section establishes the bases for the high-level operator action strategies for emergency operations for the AP600 design. Since the Westinghouse Owners Group ERGs are the industry-approved reference for Westinghouse-designed pressurized water reactors, they are used for and adapted to the AP600.

The objective of this section is to compare the ERG low-pressure reference plant system designs upon which the ERGs are based, to the AP600 system designs to determine design differences with respect to emergency operation high-level operator action strategies. The results of this comparison are used as the basis for determining the applicability of the transient and accident analyses basis of the ERGs to the AP600 and preparation of high-level operator action strategies for the AP600 based on the ERGs.

Background

The Westinghouse Owners Group ERGs are generic guidelines that have been developed in two versions: a high-pressure (HP) version and a low-pressure (LP) version. Each version is based on a reference plant design configuration. The high-pressure version of the ERGs is based on a plant configuration that incorporates a safety injection system that includes safety injection pumps with a shutoff pressure greater than the reactor coolant system pressurizer power-operated relief valve pressure setpoint. The high-pressure plants use the charging pumps as safety injection pumps. The low-pressure version of the ERGs is based on a plant configuration that incorporates a safety injection system that includes safety injection pumps with a shutoff pressure less than the reactor coolant system pressurizer power-operated relief valve pressure setpoint. Low-pressure plants do not use the charging pumps as safety injection pumps.

When comparing the AP600 to the ERG reference plant, it is important to note that the AP600 has been designed as a simplified plant that minimizes the number and complexity of operator actions required to control the safety-related systems in response to an accident. This has been done through the use of passive safety-related systems to mitigate accidents. These passive safety-related systems do not require support systems such as emergency ac power sources, component cooling water, or service water for accident mitigation.

Also, operator actions for the AP600 have been simplified by eliminating required operator actions rather than by automating operator actions. The design includes greater safety margins and passive safety-related systems that do not require operator action.

A design goal is to eliminate operator actions required to maintain core cooling following design basis accidents for an indefinite time. After three days, it may be necessary for the operator to perform limited support actions in order to continue plant monitoring or to maintain low containment pressure to minimize doses.

The ERGs do not restrict the operator to using only safety-related systems to mitigate accidents. Nor do they restrict the time in which the operator is allowed to act. Alternatively, the ERGs are structured to use available plant equipment to mitigate transients and accidents in an optimal manner while monitoring and maintaining the plant critical safety functions.

Comparison of System Functions

To identify the design differences with respect to emergency operations between the ERG reference plant system designs and the AP600 system designs, a comprehensive, systematic comparison of the systems for the AP600 and low-pressure reference plant is made.

The first step in comparing the AP600 systems to the ERG reference plant systems was to select the ERG reference plant most similar to the AP600. The major design difference between the high-pressure and the low-pressure reference plants is the shutoff pressure of the safety injection pumps with respect to the reactor coolant system pressurizer power-operated relief valve pressure setpoint.

The AP600 system that corresponds to the low-pressure reference plant safety injection system is the passive core cooling system (PXS). The passive core cooling system uses passive, high- and low-pressure tanks to deliver makeup flow to the core subsequent to the initiation of engineered safeguards features. The passive core cooling system use pumps. Consequently, the ERG reference plant most similar to the AP600 is the low-pressure reference plant. The low-pressure version of the ERGs is the most applicable to the AP600. This comparison document compares the AP600 system designs with the system designs of the low-pressure reference plant.

The second step is to identify the functions of the low-pressure reference plant systems and the AP600 systems. The principal source documents used for this review are the Westinghouse Owners Group Low-Pressure Reference Plant Description (Reference 1), the AP600 SSAR, and information collected from selected AP600 design documents.

The Low-Pressure Reference Plant Description provides a description of the reference plant design configuration upon which the Westinghouse Owners Group ERGs are based.

Based on the review of plant systems, the AP600 systems that perform the same (or similar) functions as the low-pressure reference plant systems are identified. These systems are itemized in Table 1. This table provides a system comparison and also identifies the AP600 system acronyms since they differ from the acronyms used for the low-pressure reference plant systems. The AP600 systems that are classified as safety-related for accident mitigation purposes are footnoted in the table.

Table 2 provides a complete listing of AP600 systems and also identifies the system acronyms. The AP600 systems that are included in the Table 1 comparison are footnoted in Table 2.

The comparison of system functions for each low-pressure reference plant system is presented in the following subsections. The high-level system function of the low-pressure reference plant system is defined and the AP600 system that performs the function is identified. System design differences that may affect emergency operations are identified.

Reactor Trip Actuation System – The low-pressure reference plant reactor trip actuation system monitors specified process parameters and equipment status and actuates a reactor trip if conditions exceed specified limits.

On the AP600, these functions are performed by the protection and safety monitoring system, which includes the integrated protection system that performs the reactor trip function.

The protection and safety monitoring system provides safety-related, automatically and manually actuated reactor trip capabilities. The protection and safety monitoring system also monitors plant parameters required to ascertain the state of the plant and provide guidance for manual operator actions.

The AP600 has several design differences from the low-pressure reference plant with respect to the process parameters and equipment status that are monitored (input signals) and initiate a reactor trip. The results (output signals) of the reactor trip are similar for the two plants. From the standpoint of emergency operating strategies that are primarily associated with operator actions after the reactor trip is initiated, the function of the AP600 systems are similar to the low-pressure reference plant system.

Engineered Safety Features Actuation System – The low-pressure reference plant engineered safeguards features actuation system monitors specified process parameters and actuates and sequences the various emergency safeguards features if conditions exceed specified limits.

On the AP600, these functions are performed by the protection and safety monitoring system. The protection and safety monitoring system includes the integrated protection system that performs the functions of the engineered safeguards features actuation subsystem, and the diverse actuation system.

The protection and monitoring system provides the safety-related capability for automatic and manual actuation of engineered safeguards features. The protection and safety monitoring system also monitors plant parameters required to ascertain the state of the plant and provide guidance for manual operator actions.

The AP600 has some design differences compared to the low-pressure reference plant with respect to the process parameters that are monitored (input signals) and the equipment that is automatically actuated (output signals). Despite these differences, the AP600 systems are functionally similar to the low-pressure reference plant system from the standpoint of emergency operating strategies.

Nuclear Instrumentation System – The low-pressure reference plant nuclear instrumentation system monitors and displays the reactivity state of the reactor core.

On the AP600, the instrumentation that performs this function is included in the protection and monitoring system. From the standpoint of emergency operating strategies, the AP600 system is functionally similar to the low-pressure reference plant system.

Control Rod Instrumentation System – The low-pressure reference plant control rod instrumentation system monitors and displays the position of the reactor core control rods.

On the AP600, these functions are performed by the plant control system, which includes the rod position indication function. From the standpoint of emergency operating strategies, the AP600 system is functionally similar to the low-pressure reference plant system.

Radiation Instrumentation System – The low-pressure reference plant radiation instrumentation system monitors the radiation levels in specified process systems and specified areas internal and external to the plant.

On the AP600, monitoring specified areas of the plant is performed by the radiation monitoring system, which is supported by radiation sensors located in specified AP600 process systems, such as the steam generator system. From the standpoint of emergency operating strategies, the AP600 systems are functionally similar to the low-pressure reference plant system.

Containment Instrumentation System – The low-pressure reference plant containment instrumentation system monitors the environment conditions and isolation status of containment.

On the AP600, this function is performed by the protection and safety monitoring system. The protection and safety monitoring system uses input signals from containment condition sensors in other AP600 systems. From the standpoint of emergency operating strategies, the AP600 system is functionally similar to the low-pressure reference plant system.

Reactor Coolant System – The low-pressure reference plant reactor coolant system transfers heat from the reactor core to the main steam system or residual heat removal system to provide a barrier against the release of reactor coolant or radioactive material to the containment environment.

On the AP600, this function is performed by the reactor coolant system. From the standpoint of emergency operating strategies, the AP600 system is similar to the low-pressure reference plant system for this function, although the operation of various components differ from that in the ERGs.

Safety Injection System – The low-pressure reference plant safety injection system provides makeup to the reactor coolant system and introduces negative reactivity or restricts the addition of positive reactivity for events that require engineered safeguards features operation.

On the AP600, these functions are performed by the passive core cooling system. The AP600 system is significantly different from the low-pressure reference plant system since it delivers cooling flow to the core via passive sources and does not include any safety injection pumps. The automatic depressurization system functions to reduce reactor coolant system pressure sufficiently to allow the intermediate and low pressure passive core cooling system tanks to provide injection flow. The capability for providing short-term and long-term makeup flow to the core still exists and is performed by the passive core cooling system. From a standpoint of emergency operating strategies, the AP600 system is functionally similar to the low-pressure reference plant system even through the system is significantly different and the operation of various components differ significantly from that in the ERGs.

Residual Heat Removal System – The low-pressure reference plant residual heat removal system provides low pressure safety injection during events that require safeguards features operation and removes residual heat from the reactor coolant system during plant shutdowns at low reactor coolant system pressures.

On the AP600, these functions are performed by the safety-related passive residual heat removal heat exchangers and the nonsafety-related normal residual heat removal system. The normal residual heat removal system can be manually aligned to provide low pressure injection from the in-containment refueling water storage tank and can also be aligned to provide closed-loop shutdown cooling. This system differs from the low-pressure reference plant system in that it does not share components with engineered safeguards systems and its components are not actuated by an engineered safety feature actuation signal.

The passive core cooling system is the safety-related system that provides low-pressure injection flow from several injection sources. The passive core cooling system also provides residual heat removal at any reactor coolant system pressure via the passive residual heat removal heat exchangers. The passive core cooling system equipment is automatically actuated by the protection and safety monitoring system using engineered safety feature actuation. The protection and safety monitoring system includes the capability to manually actuate the passive core cooling system. From the standpoint of emergency operating strategies, the AP600 system is functionally similar to the low-pressure reference plant system, although the operation of the various components differ from that in the ERGs.

Chemical and Volume Control System – The low-pressure reference plant chemical and volume control system provides makeup to the reactor coolant system and provides reactivity control for normal operations and for any event that does not require engineered safeguards features operation.

On the AP600, these functions are performed by the chemical and volume control system. The AP600 chemical and volume control system is different from the low-pressure reference plant system. Its functions are similar to those of the low-pressure reference plant. The operation of various components differ from that in the existing ERGs, but from the overall standpoint of emergency operating strategies, the AP600 system is similar.

Component Cooling Water System – The low-pressure reference plant component cooling water system provides heat removal from components containing radioactive fluids via an intermediate closed-loop system. This function is required for both normal operation and engineered safety features operation.

On the AP600, this function is performed by the component cooling water system for normal operation. However, it is not required for engineered safety features operation and is, therefore, nonsafety-related. The AP600 component cooling water system is not an engineered safeguards features system and is not automatically actuated by the protection and safety monitoring system. This functional difference does not significantly impact the ERG emergency operating strategies. However, operation of various components differ from that in the ERGs.

Service Water System – The low-pressure reference plant service water system provides heat removal from system processes and equipment to the ultimate heat sink via an open-loop system. This function is required for both normal operation and engineered safety features operation.

On the AP600, this function is performed by the service water system for normal operation. However, it is not required for engineered safety features operation and is, therefore, nonsafety-related. The AP600 service water system is not an engineered safeguards features system and is not automatically actuated by the protection and monitoring system. This functional difference does not significantly impact the ERG emergency operating strategies. However, operatior. of various components differ from that in the ERGs.

Containment Spray System – The low-pressure reference plant containment spray system provides containment pressure suppression and airborne fission product removal for events that require engineered safeguards features actuation.

On the AP600, the pressure suppression function is performed by the safety-related passive containment cooling system. The passive containment cooling system removes heat from containment and thus suppresses containment pressure for events that release mass and energy to the containment. It is designed to deliver cooling flow to the outside of the steel containment shell to remove energy from the reactor containment to prevent the containment from exceeding its design pressure and to reduce containment pressure following design basis events.

On the AP600, the airborne fission product removal function is performed by the combined operation of the passive containment cooling system and the containment sump pH control system, which is part of the passive core cooling system. The steam released in containment is condensed on the steel containment shell due to cooling from the passive containment cooling system and this process removes airborne fission products. The containment sump pH control system adds sodium hydroxide to the floodup inventory in containment to maintain the required recirculation sump pH to promote fission product retention.

From the standpoint of emergency operating strategies, these two AP600 systems are functionally similar to the low-pressure reference plant system, although the systems are significantly different from the low-pressure reference plant system and the operation of various components differ significantly from that in the ERGs.

Containment Atmosphere Control System – The low-pressure reference plant containment atmosphere control system provides containment heat removal and combustible gas mixture control. For this low-pressure reference plant system, the containment heat removal function is provided by containment fan coolers. Containment combustible gas mixture control is provided by hydrogen recombiners and containment fan coolers, which provide mixing of the containment atmosphere.

The AP600 design includes containment fan coolers, that provide containment heat removal during normal operations. However, the AP600 containment fan coolers are not engineered safety features equipment and are, therefore, nonsafety-related. The AP600 containment fan coolers are not automatically actuated by the protection and safety monitoring system on an engineered safety features actuation signal, and are not taken credit for in the mitigation of accidents. As described above, the passive containment cooling system provides for containment heat removal.

On the AP600, combustible gas mixture control is performed by the containment hydrogen control system. The system includes hydrogen sensors and hydrogen igniters, in addition to hydrogen recombiners.

From the standpoint of emergency operating strategies for combustible gas control, the AP600 system is functionally similar to the low-pressure reference plant system. The strategies are augmented to incorporate the hydrogen sensors and hydrogen igniters. These design differences do not significantly affect the emergency operating strategies of the ERGs. However, operation of various components differ from that in the ERGs.

Main Steam System - The low-pressure reference plant main steam system provides controlled heat removal from the reactor coolant system via the steam generators.

On the AP600, this function is performed by the steam generator system and the main steam system. The AP600 steam generator system corresponds to the safety-related portions (that is, upstream of the main steam isolation valves) of the low-pressure reference plant main steam system. The AP600 main steam system corresponds to the nonsafety-related portions (that is, downstream of the main steam isolation valve) of the low-pressure reference plant system.

From the standpoint of emergency operating strategies, the AP600 systems are similar to the low-pressure reference plant system and can be used in a similar manner for this function. However, the AP600 steam generator system provides no safety-related heat sink function as used in the low pressure reference plant. Design differences do not significantly affect the emergency operating strategies, although operation of various components differ from that in the ERGs.

Main Feedwater and Condensate System – The low-pressure reference plant main feedwater and condensate system provides water to the secondary side of the steam generators during plant power (normal) operations.

On the AP600, this function is performed by the steam generator system, the main feedwater system, and the condensate system. The AP600 steam generator system corresponds to the safety-related portions (that is, downstream of the main feedwater isolation valve) of the low-pressure reference plant system. The AP600 feedwater system and condensate system correspond to the nonsafety-related portions (that is, upstream of the main feedwater isolation valve) of the low-pressure reference plant system.

From the standpoint of emergency operating strategies, the AP600 systems are similar to the low-pressure reference plant system and can be used in a similar manner for this function. Design differences do not significantly affect the emergency operating strategies, although operation of various components differs from that assumed in the ERGs.

Auxiliary Feedwater System – The low-pressure reference plant auxiliary feedwater system provides coolant to the secondary side of the steam generators during plant shutdown operations and for events that require engineered safeguards features actuation.

On the AP600, providing coolant to the secondary side of the steam generators is a plant shutdown operations (normal operations) function only and not an engineered safeguards features function.

For normal AP600 plant shutdown operations, the function is performed by the steam generator system and the startup feedwater system. The AP600 steam generator system corresponds to the secondary pressure boundary portions (that is, downstream of the auxiliary feedwater flow control valve) of the low-pressure reference plant system. The AP600 startup feedwater system corresponds to the portions of the low-pressure reference plant system upstream of the auxiliary feedwater flow control valve.

For events requiring engineered safeguards features actuation, delivery of water to the secondary side of the steam generators is not required since the safety-related function of heat removal from the reactor coolant is provided by the passive residual heat removal system which is a subsystem of the passive core cooling system. The system is automatically actuated by the protection and safety monitoring system. The passive residual heat removal system circulates reactor coolant to a primary loop heat exchanger located in the in-containment refueling water storage tank to remove heat directly from the reactor coolant.

From the standpoint of emergency operating strategies, heat removal from the reactor coolant is provided for the AP600 by the passive residual heat removal system. Providing water to the secondary side of the steam generators is not required subsequent to engineered safety features actuation. Consequently, the overall emergency operating strategies of the ERGs continue to apply to the AP600 even though the systems and components that provide heat removal from the reactor coolant differ significantly.

Steam Generator Blowdown System - The low-pressure reference plant steam generator blowdown system provides letdown from the secondary side of the steam generators.

On the AP600, this function is performed by the steam generator system and the steam generator blowdown system. The AP600 steam generator system corresponds to the safety-related portions (that is, upstream of the blowdown isolation valve) of the low-pressure reference plant system. The AP600 steam generator blowdown system corresponds to the nonsafety-related portions (that is, downstream of the blowdown isolation valve) of the low-pressure reference plant system. Any design differences do not significantly affect the emergency operating strategies, and the AP600 system can be used in a similar manner as the low-pressure reference plant system for this function.

Sampling System - The low-pressure reference plant sampling system provides a means of obtaining representative fluid samples for laboratory or on-line analysis. The sampling system consists of equipment that can be used to sample the reactor coolant system, the steam generators, and the containment recirculation sump.

On the AP600, this function is performed by the primary sampling system and the secondary sampling system. Any design differences do not significantly affect the emergency operating strategies, and the AP600 systems can be used in a manner similar to the low-pressure reference plant system for this function.

Spent Fuel Storage and Cooling System - The low-pressure reference plant spent fuel storage and cooling system controls fuel storage positions to maintain a subcritical geometric configuration and to provide heat removal to maintain stored fuel within specified temperature limits.

On the AP600, this function is performed by the spent fuel pit cooling system. The AP600 spent fuel pit cooling system is nonsafety-related. Following loss of onsite and offsite ac power, the spent fuel is cooled by the heat capacity of the water in the pit. Safety-related connections are provided in the spent fuel pit cooling system so that makeup can be made to the pit if necessary. From the standpoint of emergency operating strategies, the AP600 system is similar to the low-pressure reference plant system and can be used in a similar manner for this function. Design differences do not significantly affect the emergency operating strategies, although operation of various components differ from that in the ERGs.

Control Rod Drive Mechanism Cooling System - The low-pressure reference plant control rod drive mechanism cooling system provides heat removal from the control rod drive mechanisms.

On the AP600, this function is performed by the reactor system, which includes the integrated head package. From the standpoint of emergency operating strategies, the AP600 system is functionally similar to the low-pressure reference plant system for this function.

Control Rod Control System - The low-pressure reference plant control rod control system controls the position of the control rods in the reactor core.

On the AP600, this function is performed by the plant control system, which includes the rod control subsystem. From the standpoint of emergency operating strategies, the AP600 system is functionally similar to the low-pressure reference plant system for this function.

Turbine Control System - The low-pressure reference plant turbine control system controls the turbine-generator.

On the AP600, this function is performed by the main turbine control and diagnostic system. From the standpoint of emergency operating strategies, the AP600 system is functionally similar to the low-pressure reference plant system for this function.

Electrical Power System (ac and dc) - The low-pressure reference plant electrical power system provides ac and dc electrical power to equipment that requires electrical power to accomplish its functions. In addition to the offsite ac power supply, the system includes the onsite emergency ac and dc power supplies, which are powered by separate safety-related emergency diesel-generators and battery banks, respectively.

On the AP600, providing ac power is a normal operations function and not an engineered safe-guards features function. It is provided by a number of nonsafety-related electrical systems and includes two nonsafety-related diesel-generators. Only the supply of dc power for safety-related dc loads, vital instrumentation (including monitoring), and control room emergency lighting is an engineered safeguards features function. The supply of safety-related dc power is provided by the Class 1E dc and UPS system.

From the standpoint of emergency operating strategies, the absence of a need for safety-related ac power following engineered safety features actuation does affect emergency operating strategies. This potentially eliminates the need for strategies to cope with and recover from the loss of ac power. As a minimum, it changes the priority associated with the restoration of ac power (either from the nonsafety-related onsite diesel-generator or the offsite power supply) for the AP600.

Pneumatic Power System - The low-pressure reference plant pneumatic power system provides a supply of pneumatic power (typically instrument air) for instruments and controls.

On the AP600, this function is performed by the compressed and instrument air system for normal operation. However, it is not required for engineered safety features operation and is, therefore, nonsafety-related. The AP600 compressed and instrument air system is not an engineered safeguards features system and is not automatically actuated by the protection and safety monitoring system. This function difference does not significantly impact the ERG emergency operating strategies. However, operation of various components differ from that in the ERGs.

From the standpoint of emergency operating strategies, the AP600 system is functionally similar to the low-pressure reference plant system for this function.

ATWS Mitigation System - The low-pressure reference plant ATWS mitigation system provides diverse automatic actuation of turbine trip and auxiliary feedwater.

The AP600 diverse actuation system provides nonsafety-related diverse actuation of turbine trip and passive residual heat removal in the event of an anticipated transient without scram. Diverse actuation of the passive residual heat removal system provides decay heat removal corresponding to the function of the auxiliary feedwater system in the low-pressure reference plant.

From the standpoint of emergency operating strategies for ATWS, the diverse actuation system is functionally similar to the low-pressure reference plant system for this function.

The AP600 diverse actuation system also includes nonsafety-related diverse capability for manual and automatic actuation of reactor trip and selected engineered safety features. The diverse actuation system also monitors the plant parameters required to ascertain the state of the plant and provide guidance for operator actions utilizing the diverse manual controls.

From the standpoint of emergency operating strategies for events other than ATWS, the additional capabilities provided by the AP600 diverse actuation system do affect emergency operating strategies. The emergency operating strategies will need to be expanded to include the diverse manual and automatic actuation capabilities.

Comparison of System Design Features

Following the system function review, system design features that may affect emergency operations were compared. The results of this comparison are summarized in Table 3. Table 3 presents a summary of the significant design feature differences between the low-pressure reference plant and the AP600. The term *same* is used in Table 3 to indicate that from the standpoint of emergency operations, the specific design for the AP600 system and the low-pressure reference plant system is basically the same. That is, when writing the AP600 high-level operator action strategies, no change to the structure or operational strategy of the ERGs is anticipated.

Table 1 (Sheet 1 of 2)

Comparison of Low-Pressure Reference Plant Systems and AP600 Systems

Low-Pressure Reference Plant Systems NAME	AP600 Systems NAME	ACRONYM
1. Reactor Trip Actuation System	1. Protection and Safety Monitoring System (Reactor Trip Subsystem)	PMS[1]
2. ESF Actuation System	2. Protection and Safety Monitoring System (ESF Actuation Subsystem)	PMS[1]
3. Nuclear Instrumentation System	3. Protection and Safety Monitoring System	PMS[1]
4. Control Rod Instrumentation System	4. Plant Control System (Rod Position Indication Subsystem)	PLS
5. Radiation Instrumentation System	5. Radiation Monitoring System	RMS
6. Containment Instrumentation System	6. Protection and Safety Monitoring System Passive Containment Cooling System Passive Core Cooling System	PMS[1] PCS[1] PXS[1]
7. Reactor Coolant System	7. Reactor Coolant System	RCS[2]
8. Safety Injection System	8. Passive Core Cooling System	PXS[1]
9. Residual Heat Removal System	9. Normal Residual Heat Removal System Passive Core Cooling System	RNS[2] PXS[1]
10. Chemical and Volume Control System	10. Chemical and Volume Control System	CVS[2]
11. Component Cooling Water System	11. Component Cooling Water System	CCS
12. Service Water System	12. Service Water System	SWS
13. Containment Spray System	13. Passive Containment Cooling System Passive Core Cooling System	PCS[1] PXS[1]
14. Containment Atmosphere Control System	14. Containment Hydrogen Control System	VLS[1]
15. Main Steam System	15. Steam Generator System[3] Main Steam System	SGS[2] MSS
16. Main Feedwater and Condensate System	16. Steam Generator System[3] Main Feedwater System Condensate System	SGS[2] FWS CDS

(1) These AP600 systems are safety-related systems for accident mitigation.

(2) These AP600 systems (or portions of these systems) are safety-related systems for pressure boundary integrity.

(3) The AP600 steam generator system contains the safety-related steam generator pressure boundary portions of the corresponding low-pressure reference plant systems.

Table 1 (Sheet 2 of 2)

Comparison of Low-Pressure Reference Plant Systems and AP600 Systems

Low-Pressure Reference Plant Systems NAME	AP600 Systems NAME	ACRONYM
17. Auxiliary Feedwater System	17. Steam Generator System[3] Startup Feedwater System Passive Core Cooling System	SGS[2] FWS PXS[1]
18. Steam Generator Blowdown System	18. Steam Generator System[3] Steam Generator Blowdown System	SGS[2] BDS
19. Sampling System	19. Primary Sampling System Secondary Sampling System	PSS SSS
20. Spent Fuel Storage and Cooling System	20. Spent Fuel Pit Cooling System	SFS
21. Control Rod Drive Mechanism Cooling System	21. Reactor System	RXS
22. Control Rod Control System	22. Plant Control System (Rod Control Subsystem)	PLS
23. Turbine Control System	23. Main Turbine Control and Diagnostic System	TOS
24. Electric Power System (ac and dc)	24. Electrical Power Systems (ac and dc)	[4]
25. Pneumatic Power System	25. Compressed and Instrument Air System	CAS

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(1) These AP600 systems are safety-related systems for accident mitigation.

(2) These AP600 systems are safety-related systems for pressure boundary integrity.

(3) The AP600 steam generator system corresponds to the steam generator pressure boundary portions of the corresponding low-pressure reference plant systems.

(4) The AP600 electrical power systems consist of a number of systems, including the Class 1E dc and UPS system (IDS), which provides safety-related dc power and ac instrumentation power, and the onsite standby power system (ZOS), which is a nonsafety-related system and includes the nonsafety-related diesel generators.

Table 2 (Sheet 1 of 5)

AP600 Systems and Acronyms

NSSS/Steam Generator Auxiliary Systems

Steam Generator Blowdown System	BDS[1]
Containment System	CNS
Chemical and Volume Control System	CVS[1]
Passive Containment Cooling System	PCS[1]
Passive Core Cooling System	PXS[1]
Reactor Coolant System	RCS[1]
Normal Residual Heat Removal System	RNS[1]
Reactor System	RXS[1]
Steam Generator System	SGS[1]

Main Power Cycle & Auxiliary Systems

Condensate System	CDS[1]
Turbine Island Chemical Feed System	GFS
Condensate Polishing System	CPS
Demineralized Water Treatment System	DTS
Demineralized Water Transfer and Storage System	DWS
Main and Startup Feedwater System	FWS[1]
Heater Drain System	HDS
Main Steam System	MSS[1]
Main Turbine System	MTS
Raw Water System	RWS
Turbine Island Vents, Drains and Relief System	TDS
Gland Seal System	GSS

Non-Class 1E Power Systems

Main ac Power System	ECS
Non-Class 1E dc and UPS System	EDS
Onsite Standby Power System	ZOS[1]

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(1) These AP600 systems are included in the Table 1 system comparison.

Table 2 (Sheet 2 of 5)

AP600 Systems and Acronyms

Non-Nuclear Controls and Monitoring Systems

Data Display and Processing System	DDS
Fire-Smoke Detection and Alarm System	FDS
Meteorological and Environmental Monitoring System	MES
Plant Control System	PLS[1]
Plant Security System	SES
Secondary Sampling System	SSS[1]
Closed Circuit TV System	TVS
Diverse Actuation System	DAS
Special Monitoring System	SMS

Nuclear Control and Monitoring Systems

Incore Instrumentation System	IIS
Operations and Control Centers System	OCS
Protection and Safety Monitoring System	PMS[1]
Primary Sampling System	PSS[1]
Radiation Monitoring System	RMS[1]
Seismic Instrumentation System	SJS

Material Handling Systems

Fuel Handling and Refueling System	FHS
Mechanical Handling Systems	MHS

Class 1E and Emergency Power System

Class 1E dc and UPS System	IDS[1]

(1) These AP600 systems are included in the Table 1 system comparison.

Table 2 (Sheet 3 of 5)

AP600 Systems and Acronyms

Cooling and Circulating Water Systems

Cooling Tower Makeup and Blowdown System	CBS
Component Cooling Water System	CCS(1)
Condenser Tube Cleaning System	CES
Circulating and Service Water Chemical Injection System	CLS
Cooling Tower System	CTS
Circulating Water System	CWS
Spent Fuel Pit Cooling System	SFS(1)
Service Water System	SWS(1)
Turbine Building Closed Cooling Water System	TCS

Piping Services Systems

Compressed and Instrument Air Systems	CAS(1)
Fire Protection Systems	FPS
Plant Gas Systems	PGS
Potable Water System	PWS

Miscellaneous Electrical Systems

Security Lighting System	DCS
Communication Systems	EFS
Grounding and Lightning Protection System	EGS
Special Process Heat Tracing System	EHS
Plant Lighting System	ELS
Cathodic Protection System	EQS

(1) These AP600 systems are included in the Table 1 system comparison.

Table 2 (Sheet 4 of 5)

AP600 Systems and Acronyms

Radwaste Systems	
Gaseous Radwaste System	WGS
Liquid Radwaste System	WLS
Radioactive Waste Drain System	WRX
Spent Resin Processing System	WSS
Turbine-Generator Controls and Auxiliary Systems	
Condenser Air Removal System	CMS
Generator Hydrogen and CO2 Systems	HCS
Hydrogen Seal Oil System	HSS
Main Turbine and Generator Lube Oil System	LOS
Stator Cooling System	SCS
Main Turbine Control and Diagnostics System	TOS[1]
HVAC Systems	
Radiologically Controller Area Ventilation System	VAS
Nuclear Island Non-Radioactive Ventilation System	VBS
Containment Recirculation Cooling System	VCS
Main Control Room Habitability System	VES
Containment Air Filtration System	VFS
Health Physics/Control Access Area HVAC System	VHS
Containment Hydrogen Control System	VLS[1]
Pump House Building Ventilation System	VPS
Solid Radwaste Building Ventilation System	VRS
Turbine Building Ventilation System	VTS
Containment Leak Rate Test System	VUS
Central Chilled Water System	VWS
Annex/Aux Non-Radioactive Ventilation System	VXS
Hot Water Heating System	VYS
Diesel Generator Building Ventilation System	VXS

(1) These AP600 systems are included in the Table 1 system comparison.

Table 2 (Sheet 5 of 5)

AP600 Systems and Acronyms

Auxiliary Steam System	
Auxiliary Steam Supply System	ASS
Non-Radioactive Drain Systems	
Storm Drain System	DRS
Gravity and Roof Drain Collection System	RDS
Sanitary Drainage System	SDS
Waste Water System	WWS
Fuel Systems	
Onsite Standby Diesel Generator Fuel Oil Storage and Transfer System	DOS
Generation and Transmission Systems	
Main Generation System	ZAS
Switchyard System	ZBS
Startup Transformer System	ZSS
Excitation and Voltage Regulation System	ZVS

Table 3 (Sheet 1 of 21)

Comparison of System Design Features

Low-Pressure Reference Plant Design	AP600 Design
1. Reactor Trip Actuation System	
Reactor trip signal, including generation of P-4 signal to: - Turbine trip logic - Feedwater isolation logic - SI block logic.	Similar, except that reactor trip is also generated by the diverse actuation signal.
2. Engineering Safeguards Features Actuation System	
Safety injection (SI) signal	
SI actuation from: - Manual - High-1 containment pressure - Low pressurizer pressure - Low steam line pressure.	SI actuation from: - Manual - High-1 containment pressure - Low pressurizer pressure - Low steam pressure (in any SG) - Low T_{cold} (in any loop).
	When pressurizer pressure exceeds the P-11 setpoint, the accumulators are automatically armed for use by opening of the isolation valves.
Actuated on SI signal: - Reactor trip - Feedwater isolation - Auxiliary feedwater start - Diesel-generator start - Emergency fan cooler start - Safety injection system start - Component cooling water system start - Service water system start - Containment isolation phase A - Containment ventilation isolation	Actuated on SI signal: - Reactor trip - Feedwater isolation - Passive core cooling system start core makeup tank (CMT) and in-containment refueling water storage tank (IRWST) actuation - Containment isolation - RCP trip (with time delay) - Turbine trip

Table 3 (Sheet 2 of 21)

Comparison of System Design Features

Low-Pressure Reference Plant Design	AP600 Design
SI reset/block features include: - Manual reset/block of SI signal - Manual reset/block of low pressurizer pressure signal (P-11) - Manual reset/block of low steam line pressure signal.	SI reset/block features include: - Manual reset/block of SI signal - Manual low pressurizer pressure safeguards reset/ block (for low pressurizer pressure signal) - Manual steam/feedwater isolation and safeguards reset/block (for low steam pressure signal and low T_{cold} signal).
Once SI signal is reset, SI signal cannot be automatically actuated until reactor trip breakers are closed (P-4 removed).	Same.
Reset/block of low pressurizer pressure signal and low steam line pressure signal are interlocked with pressurizer pressure (P-11) permissive. Reset/block automatically cleared with pressurizer pressure exceeds permissive setpoint.	Similar, except block also applies to low T_{cold} signal.
Containment Spray Signal	
Containment spray actuation signal actuated on: - Manual - High-3 containment pressure setpoint.	Containment cooling actuation signal on: - Manual - High-2 containment pressure setpoint.
Equipment actuated on containment spray signal: - Containment spray system start - Containment isolation phase B.	Equipment actuated on containment cooling actuation signal: - Passive containment cooling system start. A containment isolation phase B signal does not exist; there are no phase B isolation valves.
Separate manual resets are provided for: - Containment spray signal - Containment isolation phase B signal.	Separate manual reset is provided for: - Containment cooling actuation signal Containment cooling is also actuated by the diverse actuation system on: - Manual - High containment temperature

Table 3 (Sheet 3 of 21)

Comparison of System Design Features

Low-Pressure Reference Plant Design	AP600 Design
Auxiliary Feedwater (AFW) Start Signal	
Auxiliary feedwater start signal for the motor-driven AFW pumps is actuated on: - SI signal - Trip of all main feedwater pumps - Blackout signal from associated ac emergency bus - Low-low level in any SG. Auxiliary feedwater start signal for the turbine-driven AFW pump is actuated on: - Low-low level in two SGs - Loss of power signal. Equipment actuated on auxiliary feedwater start signal includes closure of: - SG blowdown isolation valves - SG sample valves.	Not included in the AP600, which does not have a safety-related auxiliary feedwater system. See Passive Residual Heat Removal (PRHR) actuation for equipment system function.
Passive Residual Heat Removal Actuation (PRHR)	
Not included in LP reference plant.	The PRHR is actuated on: - Manual - Low SG level (narrow range) in any SG (with signal delay) in combination with low startup feedwater flow - Low SG level (wide range) in any SG - Coincident with first stage ADS actuation signal - Core makeup tank actuation The PRHR is also actuated by the diverse actuation system on: - Manual - High hot leg temperature - Low SG level (wide range)

Table 3 (Sheet 4 of 21)

Comparison of System Design Features

Low-Pressure Reference Plant Design	AP600 Design
	Equipment actuated on a PRHR actuation signal: - PRHR discharge valves - Close SG blowdown valves.
	Manual reset is provided for: - Manual PRHR actuation signal.
<u>Containment Isolation Phase A Signal</u>	
Containment isolation phase A signal is actuated on: - Manual - SI actuation signal.	Containment isolation signal is actuated on: - Manual - SI actuation signal - Manual actuation of containment cooling signal.
	Containment isolation is also actuated by the diverse actuation signal on: - Manual - High containment temperature
Manual reset is provided for containment isolation signal.	Manual reset is provided for containment isolation signal.
<u>Containment Isolation Phase B Signal</u>	
High-3 containment pressure	Not included in the AP600. A containment isolation phase B signal does not exist, there are no phase B isolation valves.
<u>Main Steam Line Isolation Signal</u>	
Main steam line isolation signal for SGs is actuated on: - Manual - High-2 containment pressure.	Main steam line isolation signal for SGs is actuated on: - Manual - High-1 containment pressure - Low steam pressure (in any SG) - Low T_{cold} (in any loop) - High steam pressure negative rate (in any SG).*

* This signal only active when below P-11 and low steam pressure and low T_{cold} auto signals are blocked.

Table 3 (Sheet 5 of 21)

Comparison of System Design Features

Low-Pressure Reference Plant Design	AP600 Design
Main steam line isolation signal for only the affected SG is actuated on: - Low steam pressure - High steam pressure negative rate (below P-11)	Main steam line isolation for only the affected SG is actuated on: - Manual
Equipment isolated on main steam line isolation signal: - Main steam line isolation valves - Main steam line isolation bypass valves.	Same.
Reset/block features include: - Manual reset for main steam isolation signal - Manual reset/block for low steam pressure signal. - Manual reset/block for high steam pressure negative rate signal.	Reset/block features include: - Manual reset for main steam isolation signal - Manual steam/feedwater isolation and safeguards reset/block (for low steam pressure signal, high steam pressure negative rate signal, and low T_{cold} signal). Manual steam/feedwater isolation and safeguards reset/block is interlocked with pressurizer pressure (P-11) permissive setpoint.
Containment Ventilation Isolation Signal	
Included in LP reference plant.	Similar. The AP600 has a containment air filtration system isolation signal on High-1 containment radioactivity.
Main Feedwater Isolation Signal	
Main feedwater isolation signal for SGs is actuated on: - SI signal - High-high level (P-14) in any SG - Reactor trip (P-4) coincident with low RCS T_{avg}.	Main feedwater isolation signal (close main feedwater isolation valves, control valves and trip main feedwater pump) is actuated on: - SI signal - Manual. - High-2 SG level (in any SG)

Table 3 (Sheet 6 of 21)

Comparison of System Design Features

Low-Pressure Reference Plant Design	AP600 Design
	In addition, closure of main feedwater control valves occurs on: - Reactor Coolant System (RCS) T_{avg} low-1 setpoint coincident with reactor trip (P-4). In addition, closure of main feedwater isolation valves and trip of main feedwater pumps is actuated on: - RCS T_{avg} low-2 setpoint. Closure of startup feedwater control valves and trip of startup feedwater pump are actuated on: - RCS Low T_{cold} setpoint (in any loop) - High-2 SG level (in any SG) Block of steam dump valves to condenser is actuated on: - RCS T_{avg} low-2 setpoint.
Equipment isolated on main feedwater isolation signal: - Main feedwater isolation valves - Main feedwater flow control valves - Main feedwater bypass valves.	Equipment isolated on main feedwater isolation signal: - Main feedwater isolation valves - Main feedwater flow control valves - MFW pumps tripped.
Reset/block features include: - Manual reset/block for SI signal (same as for SI signal) - Manual reset for reactor trip signal (P-4) coincident with RCS low T_{avg}.	Reset/block features include: - Manual reset for manual feedwater isolation signal - Manual steam/feedwater and safeguards reset/block (for RCS low-1 T_{avg} signal and RCS low-2 T_{avg} signal). Manual steam/feedwater and safeguards reset/block is interlocked with pressurizer pressure (P-11) permissive setpoint. Manual steam dump interlock selector switch provided for cooldown steam dump valves to condenser.

Table 3 (Sheet 7 of 21)

Comparison of System Design Features

Low-Pressure Reference Plant Design	AP600 Design
Core Makeup Tank (CMT) Actuation	
Not included in LP reference plant.	CMTs are actuated on: - Manual - SI signal - Pressurizer level low-2 setpoint - Low wide range SG level coincident with high hot leg temperature CMTs are also actuated by the diverse actuation system on: - Manual - Low pressurizer water level Actuated on CMT signal: - Actuate CVS - Close demin water isolation valves to CVS makeup - Arms first stage ADS - Actuate passive residual heat removal heat exchanger - Blocks pressurizer heaters Manual reset is provided for the manual CMT actuation signal.
Automatic RCS Depressurization	
Not included in LP reference plant.	First stage of automatic RCS depressurization actuated on: - Manual ADS actuation. - Manual reset is provided for manual ADS actuation. - CMT low-1 setpoint coincident with CMT actuation signal. - Sustained 4kV bus undervoltage (with time delay).

Table 3 (Sheet 8 of 21)

Comparison of System Design Features

Low-Pressure Reference Plant Design	AP600 Design
	First stage of automatic RCS depressurization is also manually actuated by the diverse actuation system.
	Actuated on ADS first stage signal: - Reactor trip - RCP trip - Actuate PRHR heat exchangers
	Second stage of automatic RCS depressurization actuated on: - First-stage actuation with time delay.
	Second stage of automatic RCS depressurization is also manually actuated by the diverse actuation system.
	Third stage of automatic RCS depressurization actuated on: - First-stage actuation with time delay.
	Third stage of automatic RCS depressurization is also manually actuated by the diverse actuation system.
	Fourth stage of automatic RCS depressurization actuated on: - CMT low-4 setpoint coincident with third-stage actuation (with time delay).
	Fourth stage of automatic RCS depressurization is also manually actuated by the diverse actuation system.

Table 3 (Sheet 9 of 21)

Comparison of System Design Features

Low-Pressure Reference Plant Design	AP600 Design
RCP Trip	
Not included in LP reference plant.	Trip of RCPs is actuated on: - Pressurizer level low-2 setpoint - Manual CMT actuation - First stage ADS actuation signal - Low wide range SG level coincident with high hot leg temperature - SI signal. In addition, RCPs are tripped individually on high bearing water temperature. Trip of the RCPs is also actuated by the diverse actuation system on: - Manual - Low pressurizer water level
3. Nuclear Instrumentation System	
Separate ranges provided for source, intermediate and power ranges with interlocks and permissives to change range. Source range detectors automatically energize with flux decreases below source range flux trip (P-6) setpoint.	Same.
Startup rate provided for source and intermediate ranges.	Same.
Neutron flux recorder provided.	Same.
4. Control Rod Instrumentation System	
Control rod position indication and control rod bottom light indication provided (analog rod position indication system).	Similar except that a digital rod position indication system is provided.

Table 3 (Sheet 10 of 21)

Comparison of System Design Features

Low-Pressure Reference Plant Design	AP600 Design
5. Radiation Instrumentation System	
Radiation instrumentation provided for: - Inside the containment - In the main steam system and steam generator blowdown system - Inside the auxiliary building.	Same.
6. Containment Instrumentation System	
Containment instrumentation provided for: - Containment pressure - Containment temperature - Containment recirculation sump level - Containment isolation valves and dampers position indication.	Same.
7. Reactor Coolant System	
One steam generator, one reactor coolant pump (RCP), one hot leg and one cold leg per reactor coolant loop. RCP connection to the steam generator is by a crossover line similar to a loop seal arrangement.	One steam generator, one hot leg, two cold legs and two reactor coolant pumps per loop. SGs are vertical U-tube, similar to reference plant. Two RCPs are connected directly to the cold leg channel head for each SG, eliminating the need for the crossover line connection.
RCPs are shaft-seal type, with continuous seal injection or thermal barrier cooling required.	RCPs are canned-motor type with no shaft seal. The motor bearings are lubricated by primary coolant. Purified CVS purge water is provided to the motor to minimize radioactive crud deposition. Cooling water is used to provide motor and bearing cooling.
No automatic RCP trip.	Automatic RCP trip on CMT actuation signals including safety injection, pressurizer low-2 level setpoint, first stage automatic RCS depressurization signal, high hot leg temperature coincident with low wide range steam generator level, and manual CMT actuation.

Table 3 (Sheet 11 of 21)

Comparison of System Design Features

Low-Pressure Reference Plant Design	AP600 Design
	Individual RCPs tripped on high bearing water temperature.
Hot leg and cold leg RTD bypass lines.	No RTD bypass lines. RCS temperature measured directly in the hot legs and cold legs of each reactor coolant loop.
Two power operated relief valves (PORVs) (and associated block valves) provide normal operation overpressure protection and cold overpressure protection. PORVs discharge to pressurizer relief tank.	No pressurizer PORVs. The pressurizer is designed so that pressurizer spray flow controls pressure increases. The PORV overpressure control function during normal operation is not required.
	However, six sets of RCS depressurization valves (two isolation valves per set) are provided from the pressurizer steam space to initiate automatic RCS depressurization in sequential stages. These valves discharge steam through spargers to the IRWST.
Two pressurizer safety valves provide overpressure protection. Valves discharge to the pressurizer relief tank.	Similar, except discharge to containment atmosphere.
Reactor vessel head vent to PRT.	No remote control reactor vessel head vent provided for emergency operations. A one-inch head vent is provided (at the top of the head) for normal operations.
Reactor vessel level instrumentation system (RVLIS) capable for providing level trend indication over the following ranges: -- upper range -- vessel level above the hot leg pipe when no RCPs running -- Full range -- vessel level from the bottom of the core to the upper head when no RCPs running -- Dynamic head range -- vessel level from the bottom of the core to the upper head with any combination of RCPs running.	No RVLIS.

Table 3 (Sheet 12 of 21)

Comparison of System Design Features

Low-Pressure Reference Plant Design	AP600 Design
No automatic depressurization valves.	AP600 employs automatic depressurization valves connected to the pressurizer and the RCS hot legs. The valves connected to the pressurizer (stages 1, 2, and 3) consist of six parallel sets of two valves in series that discharge to the IRWST. The valves connected to the hot legs (stage 4) consist of four parallel sets of two valves in series, with two set connected to each hot leg and discharge directly to containment.
8. Safety Injection System	
Injection Mode (high-head and low-head SI subsystem: Two high-head SI pumps take suction from boric acid tank (BAT) (12 wt %) or refueling water storage tank (RWST) and delivers to RCS cold legs. Automatic transfer of high-head SI pump suction from BAT to RWST on low BAT level (prior to SI reset). High-head SI pump design flow rate is about 650 gpm. High-head SI pump shutoff head is less than the PORV set point.	No high-head SI pumps. Passive high-pressure SI provided by gravity-flow from the core makeup tanks. There are two basic operating processes for the CMTs, steam-compensated injection and water recirculation. CMTs are pressurized by lines from the pressurizer and the RCS cold legs and inject directly into the reactor vessel. Following a small LOCA, the CMTs provide borated makeup to the reactor vessel at a high pressure and a relatively high flow rate for approximately 20 minutes. Following a steam line break, the CMTs provide borated makeup to mitigate the core reactivity transient and to shut down the core. Following a steam generator tube rupture (SGTR), the CMTs provide borated makeup to the reactor vessel to compensate for the SGTR leak. The PRHR functions in combination with the CMTs to remove core decay heat, reduce RCS temperature and pressure, equalize RCS and ruptured SG pressure, and terminate the leak. This process terminates the event by stopping RCS leakage into the SG without operator action or ADS actuation.

Table 3 (Sheet 13 of 21)

Comparison of System Design Features

Low-Pressure Reference Plant Design	AP600 Design
Two low-head safety injection (LHSI) pumps (which also serve as RHR pumps). Low-head SI pumps take suction from RWST and deliver to RCS cold legs.	No low-head SI pumps. Automatic RCS depressurization occurs on low core makeup tank level (concurrent with CMT actuation signal), which permits the in-containment refueling water storage tank (IRWST) to gravity feed to the RCS at low pressure. IRWST injection is possible only after the RCS has been depressurized by the ADS or by a LOCA.
Injection Mode (SI Accumulator Subsystem):	
One accumulator tank connected to each RCS cold leg. Safety injection accumulators are tanks pressurized to a nominal 750 psig with nitrogen. As pressure in the RCS drops below the nitrogen pressure, the nitrogen forces the borated water into the RCS.	Similar, except two accumulators pressurized to a nominal 700 psig inject directly into the reactor vessel.
Recirculation Mode:	
Switchover initiation - semiautomatic on sump valve opening on low RWST level. Low-head safety injection (LHSI) pumps take suction from containment recirculation sump and are manually aligned to discharge to the suction of high-head SI pumps into either the RCS hot or cold legs. The LHSI pumps also directly inject into the RCS cold legs. The RHR heat exchangers are used to cool the LHSI recirculation flow from the recirculation sumps in containment.	No switchover to recirculation like the reference plant since there are no SI pumps. Passive injection of water from the low-pressure IRWST provides a lower flow rate, but for a longer time, ranging from a minimum of six hours, for a break in the reactor vessel direct injection line, to days for other line breaks. Following the injection of water from the IRWST, the water level in the containment building is increased above the elevation of the RCS loop piping. Long-term cooling is established by water draining back to the RCS from sumps located inside the containment as well as water that condenses on the inside of containment shell and returns to the IRWST via gutters above the operating deck that collect the condensate.

Table 3 (Sheet 14 of 21)

Comparison of System Design Features

Low-Pressure Reference Plant Design	AP600 Design
9. Residual Heat Removal (RHR) System	
Two RHR pumps (which also function as low-head SI pumps) and two RHR heat exchangers located outside containment.	Two RHR pumps and RHR heat exchangers located outside containment.
	The normal residual heat removal system (RNS) removes heat from the core and RCS during normal cooldown and refueling operations. It is designed to remove heat from the core and RCS following successful mitigation of an accident by the passive safety-related systems. The RNS is a nonsafety-related system, and the pumps and heat exchangers are not used as part of the passive safety-related systems. The RNS is capable of providing low pressure makeup from the IRWST to the RCS. The system is designed to be manually initiated by the operator following receipt of an ADS signal. If the system is available, it will provide RCS makeup once the pressure in the RCS falls below the shutoff head of the RHR pumps. The RNS also provides nonsafety-related low-pressure makeup to the RCS for recovery from inadvertent actuation of the automatic depressurization signal (ADS). The RNS also serves as a low temperature overpressure function during refueling and shutdown operations, and cools the IRWST.
RHR pumps take suction from one hot leg and return the flow to two cold legs.	Similar, except return flow enters reactor downcomer directly via the direct vessel injection lines.
RHR initiated at nominal RCS operating conditions of 400 psig and 350°F.	Similar.
10. Chemical and Volume Control System	
Three positive displacement charging pumps (located outside containment) deliver continuous flow through the charging and RCP seal injection lines to the RCS.	Two centrifugal makeup pumps (located outside containment) with normal makeup flow rate (dilution or boration) of 100 gpm and maximum makeup flow rate of 135 gpm. Makeup pumps are not normally running unless needed for RCS boron changes, chemical addition, makeup for RCS leakage or for RCS shrinkage due to cooldown.

Table 3 (Sheet 15 of 21)

Comparison of System Design Features

Low-Pressure Reference Plant Design	AP600 Design
At least one charging pump is normally running. Charging pumps automatically stop on a SI signal.	The makeup pumps automatically start on a low pressurizer level signal in order to provide ma[illegible]up. The makeup pump automatically stops when the pressurizer level increases to the correct programmed value. The letdown control valve is automatically opened by the pressurizer level control system if the pressurizer level reaches its high (relative to programmed level) setpoint. This valve automatically closes when the pressurizer level returns to normal, and also closes on a high-3 degasifier level or on a containment isolation signal. To protect against steam generator overfill, makeup is isolated by closing the makeup line containment isolation valves if a high steam generator level signal is generated. These valves will also close and isolate the system on a high pressurizer level signal.
Continuous charging and letdown for RCS purification and boron control.	RCS purification is provided via a CVS purification loop located inside containment, which uses the head of the RCPs to circulate reactor coolant through the purification loop. This eliminates the necessity for running CVS makeup pumps continuously. Flow is returned to the RCS via the charging line. The normal RHR system provides the motive force for CVS purification during plant shutdown when the RCPs are stopped. Charging and letdown outside containment are not normally in service unless additions or reductions in RCS inventory are necessary.
Letdown, charging, and RCP seal return lines are automatically isolated on a containment isolation phase A signal.	The charging and letdown lines from the inside containment purification loop to outside containment are normally closed. However, they also receive a containment isolation signal similar to the reference plant. Since the makeup pumps start on an SI signal, the makeup line will not be isolated on containment isolation signal unless a low charging header pressure permissive is present.
12 wt % boric acid system.	2.5 wt % boric acid system.

Table 3 (Sheet 16 of 21)

Comparison of System Design Features

Low-Pressure Reference Plant Design	AP600 Design
Boric acid is supplied to the suction of the charging pumps from the boric acid tanks through either the normal reactor makeup water system or a separate emergency boration line. Boric acid transfer pumps provide the motive force. Borated water can also be supplied to the suction of the charging pumps from the refueling water storage tank.	The makeup pumps receive flow from the boric acid tank by direct gravity-feed via a makeup system control valve that also controls the flow of demineralized water. For boron dilution protection, this valve fails with the makeup pump suction aligned to the boric acid tank and can be manually controlled from main control room. There are no boric acid transfer pumps, no separate emergency boration line from the boric acid tank and no suction line from the IRWST.
11. Component Cooling Water (CCW) System	
The CCW system is a safety-related system. It provides heat removal from potentially radioactive system equipment, including the following: - RHR heat exchangers - Seal water heat exchanger - Containment fan coolers - RCPs	Similar but nonsafety-related and provides cooling water to different components. RCP motor and thermal barrier/bearing cooling are potential sources for leakage of high pressure reactor coolant into the CCS similar to the LP reference plant. The CCS is automatically isolated by nonsafety-related components if excessive leakage occurs, which is similar to the LP reference plant. However, reactor coolant leakage cannot be isolated and would discharge to the drain header via the RCP cooling water line relief valve(s), resulting in a small LOCA inside containment. Safety-related isolation is provided by the cooling water containment isolation valves which maintains the cooling water inventory inside containment.
12. Service Water System	
Service water pumps and service water valves.	Similar but nonsafety-related.

Table 3 (Sheet 17 of 21)

Comparison of System Design Features

Low-Pressure Reference Plant Design	AP600 Design
13. Containment Spray System	
Two low-head containment spray pumps take suction from RWST. System can be manually realigned for recirculation by taking suction from containment sump. One shared spray additive tank. Two spray additive eductors, one for each pump. Actuated on high containment pressure.	No containment spray pumps. Passive safety-related containment cooling is provided by a water tank that provides a gravity-fed flow onto the outside of the containment dome surface for three days. After three days, heat can be removed by convective air flow to maintain containment pressure below design pressure. Heat removal by the passive containment cooling system is initiated automatically in response to a high-2 containment pressure signal or manual actuation. Separate system provided for containment sump pH control. This is a subsystem of the passive core cooling system and activates on a high-2 containment radiation signal.
14. Containment Atmosphere Control System	
Four emergency fan coolers (two speeds) receive start signal in slow speed on SI signal.	Two fan coolers provided for normal operation. The fan coolers are nonsafety-related and not actuated by an engineered safety feature signal.
Two hydrogen recombiners with manual actuation.	Similar, except the hydrogen recombiners are powered by nonsafety-related power supplies. The hydrogen recombiners can be manually actuated by the protection and safety monitoring system. Nonsafety-related hydrogen igniters are also provided. The igniters can be manually actuated by the plant control system and the diverse actuation system.

Table 3 (Sheet 18 of 21)

Comparison of System Design Features

Low-Pressure Reference Plant Design	AP600 Design
15. Main Steam System	
Air-operated steam generator PORVs that fail closed.	Similar except that motor-operated steam generator power operated relief valve block valves are also provided with automatic closure on steam line low pressure.
Main steam safety-related valves.	Same.
Steam dump valves to condenser.	Same.
The SGs can be isolated from the main steam header by main steam line isolation and bypass valves located in the individual main steamlines.	Same.
Steam supplied to turbine-driven auxiliary feedwater (AFW) pump from two SGs.	No steam supply line, since there are no AFW pumps.
16. Main Feedwater and Condensate Systems	
The main feedwater and condensate system consists of separate main feedwater lines to each SG that originate from a common main feedwater header. The SGs can be isolated from the main feedwater header by feedwater flow control valves, bypass valves, and isolation valves located in the individual main feedwater lines.	Similar except flow control bypass valves are not provided. The main feedwater system is designed to take suction from the deaerator storage tank and supply the SGs with feedwater during power operation and transient conditions. The startup feedwater system can take suction from the deaerator storage tank or condensate storage tank and supply the SGs with feedwater during shutdown conditions. The condensate system collects and condenses steam from the LP turbines and turbine steam bypass systems and transfers this condensate from the main condenser to the deaerator storage tank.
Feedwater isolation valves.	Same.
Feedwater isolation signal.	Same.

Table 3 (Sheet 19 of 21)

Comparison of System Design Features

Low-Pressure Reference Plant Design	AP600 Design
One motor-driven and two steam-driven feedwater pumps.	Two motor-driven feedwater pumps.
17. Auxiliary Feedwater System	
Two motor-driven pumps, one steam-driven pump, condensate storage tank and alternate water supply. System performs both an engineered safety features (ESF) accident mitigation function and a normal startup and shutdown function. System is safety-related because of its ESF accident mitigation function.	A nonsafety-related startup feedwater system with two motor-driven pumps that take suction from the deaerator tank and/or condensate storage tank is provided to supply feedwater to the steam generators during normal startup and shutdown operations. The startup feedwater system function is similar to the reference plant auxiliary feedwater system role for normal operations. The startup feedwater pumps start automatically following loss of main feedwater flow in conjunction with an intermediate low SG level setpoint that is between the narrow range low setpoint and the programmed SG level setpoint or low narrow range SG level. In situations where startup feedwater is actuated, the flow control valves automatically control flow to each SG. The startup feedwater system does not perform an ESF accident mitigation function and is therefore not safety-related. Instead, the passive residual heat removal heat exchanger serves as the safety-related means of heat removal to mitigate loss of secondary heat sink accidents.
18. Steam Generator Blowdown System	
SG blowdown isolation valves close on an SI signal, an AFW initiation signal, or a high SG blowdown radiation signal.	Similar, but valves also close on PRHR actuation signal (instead of AFW actuation) and blowdown system high temperature, high pressure, or high radiation signals. The blowdown system can be used to cool the SG (feed and bleed) when the pressure is less than 125 psig.

Table 3 (Sheet 20 of 21)

Comparison of System Design Features

Low-Pressure Reference Plant Design	AP600 Design
19. Sampling System	
Sampling system for use in sampling RCS, steam generators and containment recirculation sump.	Similar. Separate sampling systems are provided for the primary and the secondary systems. The primary sampling system performs sampling for normal operations and post-accident operations. It consists of both on-line monitoring and grab sampling capabilities. The heat of the primary sampling system (PSS) is a shielded grab sampling unit, which is common for normal and post-accident activities. The valves (except for containment isolation) are manual and are located inside the grab sampling unit. The secondary sampling system (SSS) performs sampling of the secondary systems, including the steam generators.
20. Spent Fuel Storage and Cooling System	
The system provides heat removal from the stored fuel and includes the spent fuel pit level instrumentation.	Similar, with the equipment arranged in two independent trains. The functions of the AP600 spent fuel pit cooling system include spent fuel pit cooling, spent fuel pit purification, refueling cavity purification, water transfers (transfer water between IRWST and refueling cavity during refueling), and IRWST purification. Following a station blackout, make-up water must be provided to the spent fuel cooling pit after 72 hours. However, 72 hours is the minimum worst case scenario. Typically, it will be at least several days before makeup water must be provided to the spent fuel cooling pit.
21. Control Rod Drive Mechanism Cooling System	
CRDM fans.	Similar.

Table 3 (Sheet 21 of 21)

Comparison of System Design Features

Low-Pressure Reference Plant Design	AP600 Design
22. Control Rod Control System	
Control rods.	Same.
23. Turbine Control System	
Turbine trip.	Same.
Turbine load control.	Same.
24. Electrical Power System (ac & dc)	
Safety-related ac power system with two diesel-generators. Automatic diesel-generator start on loss of offsite power or on SI signal.	Nonsafety-related ac power system with two nonsafety-related standby diesel-generators provided to power selected shutdown loads continuously, based on one of two redundant components powered at a time. Automatic diesel generator start on loss of offsite power. The ac power system and the diesel generators are nonsafety-related since the AP600 safeguard systems are passive and do not include pumps or valves that require ac power to operate.
Safety-related dc battery banks.	Same.
25. Instrument Air System	
Instrument air compressors.	Same.
Instrument air to valves located inside containment is isolated on containment isolation signal (CIS). It is necessary to re-establish instrument air following SI and CIS reset in order to provide the necessary air supply to the air-operated valves.	Similar, but the use of air-operated valves inside containment is minimized. (For example, accumulator nitrogen vent valves have electric solenoid operators). Therefore, the need to establish instrument air to containment to support emergency operations is reduced.

Comparison of System Instrumentation and Controls

The low-pressure reference plant contains the instrumentation and controls available to the operator to operate the reference plant systems in response to emergency transients. In this context, instrumentation includes component status indication. Instrumentation and controls are defined to the extent necessary to maximize technical guidance in the ERGs with respect to system operation while maximizing the generic applicability of the technical guidance.

Table 4 contains a comparison of the low-pressure reference plant instrumentation and controls and the AP600 instrumentation and controls. The left-hand column of Table 4 identifies the low-pressure reference plant systems and associated instrumentation and control items within the defined scope of the low-pressure reference plant and specifically used in the ERGs.

Based on past practices and the similarities between the AP600 systems and the low pressure reference plant systems, the assumption has been made that the AP600 will have instrumentation and control similar to that of the reference plant. This information will be used as input to the task analysis that will be performed as part of the man-machine interface design. AP600 systems are identified by the system acronym (see Table 2 for acronym to system reference).

The term *same* is used in the table to indicate that from the standpoint of emergency operations, the specific instrumentation or control requirements for the AP600 system and the low-pressure reference plant system are basically the same. That is, when writing the AP600 high-level operator action strategies, no change to the structure or operational strategy of the ERGs is anticipated.

The comparison of the AP600 instrumentation and controls and the reference plant instrumentation and controls identified a number of instrumentation and control items that are on the AP600, but are not explicitly identified for the low-pressure reference plant. These items are included in the left-hand column of Table 4, but are preceded with a double asterisk (**) to distinguish them from the low-pressure reference plant items.

The instrumentation and controls comparison provides a high level comparison summary of the instrumentation (including component status indicators) and controls available to the plant operators. This summary is used in adapting the ERG high level strategies to the AP600. It does not include automatic controls.

Table 4 (Sheet 1 of 12)

Comparison of Instrumentation and Control Requirements

System/Instrumentation and Control Items	Low-Pressure Reference Plant Requirements		AP600 Requirements		System
	I(1)	C(1)	I(1)	C(1)	
1. Reactor Trip Actuation System					
Reactor trip annunciator	X	–	Similar	Similar(2)	DDS
Reactor trip and bypass breakers	X	–	Similar	Similar	PMS
Reactor trip signal	X	X	Similar	Similar	PMS
Turbine trip signal	X	X	Similar	Similar	PMS
2. ESF Actuation System					
SI annunciator	X	–	Similar	Similar(2)	DDS
SI signal	X	X	Similar	–	PMS
SI signal reset/block	X	X	Similar	Similar(3)	PMS
Low steam line pressure SI actuation signal block	X	X	Similar	Similar(4)	PMS
Low PRZR pressure SI actuation signal block	X	X	Similar	Similar(5)	PMS
Containment isolation phase A signal	X	X	Similar	Similar(6)	PMS
Containment isolation phase A reset	X	X	Similar	Similar(6)	PMS
Containment isolation phase B reset	X	X	–	(6)	–
Feedwater isolation signal reset	X	X	Similar	Similar	PMS
Main steam line isolation signal	X	X	Similar	Similar	PMS
** Containment cooling actuation signal	–	–	X	X	PMS
** Containment cooling actuation signal reset	–	–	X	X	PMS

Table 4 (Sheet 2 of 12)

Comparison of Instrumentation and Control Requirements

System/Instrumentation and Control Items	Low-Pressure Reference Plant Requirements		AP600 Requirements		System
	I(1)	C(1)	I(1)	C(1)	
** PRHR actuation signal	–	–	X	X	PMS
** PRHR actuation signal reset	–	–	X	X	PMS
** Main steam line isolation signal reset	–	–	X	X (4)	PMS
** Feedwater isolation signal	–	–	X	X	PMS
** Automatic RCS depressurization signal	–	–	X	X	PMS
** RCP trip signal	–	–	X	X	PMS
** CMT actuation signal	–	–	X	X	PMS
** CMT actuation signal reset signal	–	–	X	X	PMS
3. Nuclear Instrumentation					
Power range neutron flux reset	X	X	Similar	Similar	PMS
Intermediate range neutron flux	X	–	Similar	–	PMS
Intermediate range startup rate	X	–	Similar	–	RXS
Source Range Neutron flux	X	–	Similar	–	RXS
Source range startup rate	X	–	Similar	–	RXS
Neutron flux recorder	X	X	Similar	–	DDS
Source range detectors (energize)	X	X	Similar	Similar	PMS
4. Control Rod Instrumentation System					
Control rod position	X	–	Similar	–	PLS
Control rod bottom lights	X	–	–	–	–
** Control rod status messages	–	–	X	–	PLS

Table 4 (Sheet 3 of 12)

Comparison of Instrumentation and Control Requirements

System/Instrumentation and Control Items	Low-Pressure Reference Plant Requirements		AP600 Requirements		System
	$I^{(1)}$	$C^{(1)}$	$I^{(1)}$	$C^{(1)}$	
5. Radiation Instrumentation System					
Containment radiation	X	–	Similar	–	RMS
SG blowdown radiation	X	–	Similar	–	BDS
Condenser air ejector radiation (condenser exhaust radiation)	X	–	Similar	–	RMS
Auxiliary building radiation	X	–	Similar	–	RMS
SG steam line radiation	X	–	Similar	–	SGS
6. Containment Instrumentation System					
Containment pressure	X	–	Similar	–	PCS
Containment temperature	X	–	Similar	–	VCS
Containment recirculation sump level	X	–	Similar	(7)	PXS
Containment hydrogen concentration	X	–	Similar	–	VLS
Phase A containment isolation valves	X	X	Similar	Similar	(8)
Phase B containment isolation valves	X	X	–	(6)	–
Containment ventilation isolation dampers	X	X	Similar	Similar	(8)
** Passive containment cooling system storage tank to containment valve status	–	–	X	X	PMS
** Passive containment cooling system storage tank level	–	–	X	X	PMS
** Passive containment cooling system water flow	–	–	X	X	PMS
** Gutter to containment sump valve status	–	–	X	X	PMS

Table 4 (Sheet 4 of 12)

Comparison of Instrumentation and Control Requirements

System/Instrumentation and Control Items	Low-Pressure Reference Plant Requirements		AP600 Requirements		System
	I[1]	C[1]	I[1]	C[1]	
7. Reactor Coolant System					
RCS pressure	X	–	Similar	–	RCS
PRZR pressure	X	–	Similar	–	RCS
RCS hot leg wide range temperature	X	–	Similar	–	RCS
RCS cold leg wide range temperature	X	–	Similar	–	RCS
RCS average temperature	X	–	Similar	–	RCS
Core exit TC temperature	X	–	Similar	–	RCS
PRZR water temperature	X	–	Similar	–	RCS
PRZR steam temperature	X	–	Similar	–	RCS
PRZR level	X	–	Similar	–	RCS
Reactor vessel liquid inventory system (RVLIS)	X	–	(9)	–	–
Reactor coolant pumps	X	X	Similar	Similar	RCS
PRZR PORVs	X	X	–	–	
PRZR PORV block valves	X	X	–	–	
PRZR spray valves	X	X	Similar	Similar	RCS
Reactor vessel vent valves	X	X	Similar	Similar	RCS
PRZR heaters	X	X	Similar	Similar	RCS
** Automatic depressurization valves	–	–	X	X	RCS
** RCP speed	–	–	X	–	RCS
** RCP bearing water temperature	–	–	X	–	RCS

Table 4 (Sheet 5 of 12)

Comparison of Instrumentation and Control Requirements

System/Instrumentation and Control Items	Low-Pressure Reference Plant Requirements		AP600 Requirements		System
	I(1)	C(1)	I(1)	C(1)	
8. Safety Injection System					
Refueling water storage tank (RWST) level	X	–	(10)	–	PXS
High-head SI flow	X	–	–	–	–
High-head SI pumps	X	X	–	–	–
Accumulator isolation valves	X	X	Similar	Similar	PXS
Accumulator vent valves	X	X	Similar	Similar	PXS
Low-head SI pump suction valves from containment recirculation sump	X	X	–	–	–
Low-head SI pump suction valves from RWST	X	X	–	–	–
High-head SI pump suction valves from BAT	X	X	–	–	–
High-head SI pump suction valves from RWST	X	X	–	–	–
Low-head SI pump discharge valves to RCS cold legs	X	X	–	–	–
SI valves	X	X	Similar	Similar	PXS
** Core makeup tank level	–	–	X	–	PXS
** Core makeup tank inlet temperature	–	–	X	–	PXS
** Core makeup tank outlet temperature	–	–	X	–	PXS
** Core makeup tank inlet/outlet valves	–	–	X	X	PXS
** Accumulator level	–	–	X	–	PXS
** Accumulator pressure	–	–	X	–	PXS
** IRWST temperature	–	–	X	–	PXS
** IRWST outlet valves	–	–	X	X	PXS

Table 4 (Sheet 6 of 12)

Comparison of Instrumentation and Control Requirements

System/Instrumentation and Control Items	Low-Pressure Reference Plant Requirements		AP600 Requirements		System
	I(1)	C(1)	I(1)	C(1)	
** Passive RHR inlet/outlet temperature	–	–	X	–	PXS
** Passive RHR flow	–	–	X	–	PXS
** Passive RHR valves	–	–	X	X	PXS
** Containment floodup water level	–	–	X	–	PXS
9. Residual Heat Removal System					
Low-head SI (RHR) flow	X	–	(11)	–	RNS
Low-head SI (RHR) pumps	X	X	(11)	(11)	RNS
Low-head SI (RHR) pump suction valves from RCS	X	X	(11)	(11)	RNS
10. Chemical and Volume Control System					
Boric acid tank temperature	X	–	–	–	–
Boric tank level	X	–	Similar	–	CVS
Charging flow	X	–	Similar	(12)	CVS
RCP seal injection flow	X	–	–	–	–
Letdown flow	X	–	Similar	–	CVS
RCP number 1 seal leakoff flow	X	–	–	–	–
RCP number 1 seal differential pressure	X	–	–	–	–
Charging pumps	X	X	Similar(12)	Similar(12)	CVS
Charging pump suction valve from RWST	X	X	–	–	–
Charging pump suction valve from VCT	X	X	–	–	–

Table 4 (Sheet 7 of 12)

Comparison of Instrumentation and Control Requirements

System/Instrumentation and Control Items	Low-Pressure Reference Plant Requirements		AP600 Requirements		System
	I(1)	C(1)	I(1)	C(1)	
RCP seal return outside containment isolation valve	X	X	–	–	–
Letdown isolation valves	X	X	Similar	Similar	CVS
Letdown orifice isolation valves	X	X	(13)	(13)	CVS
Low-pressure letdown control valve	X	X	–	–	–
Excess letdown isolation valves	X	X	–	–	–
VCT makeup control system	X	X	(14)	(14)	CVS
VCT makeup control system (mode selector)	X	X	(14)	(14)	CVS
11. Component Cooling Water System					
CCW pumps	X	X	(11)	(11)	CCS
RCP thermal barrier CCW return inside containment isolation valve	X	X	(11)	(11)	CCS
RCP thermal barrier CCW return outside containment isolation valve	X	X	(11)	(11)	CCS
CCW valves	X	X	(11)	(11)	CCS
12. Service Water System					
Service water pumps	X	X	(11)	(11)	SWS
Service water valves	X	X	(11)	(11)	SWS
13. Containment Spray System					
Containment spray pumps	X	X	–	–	–
Containment spray valves	X	X	–	–	–
14. Containment Atmosphere Control System					
Containment ventilation isolation dampers	X	X	(15)	(15)	VCS

Table 4 (Sheet 8 of 12)

Comparison of Instrumentation and Control Requirements

System/Instrumentation and Control Items	Low-Pressure Reference Plant Requirements		AP600 Requirements		System
	I(1)	C(1)	I(1)	C(1)	
Containment fan coolers	X	X	(15)	(15)	VCS
Hydrogen recombiners	X	X	(15)	(15)	VLS
Containment air circulation equipment	X	X	(15)	(15)	VCS
Containment filtration equipment	X	X	(15)	(15)	VFS
** Hydrogen sensors	–	–	X	–	VLS
** Hydrogen igniters	–	–	X	X	VLS
15. Main Steam System					
SG pressure	X	–	Similar	–	SGS
SG narrow range level	X	–	Similar	–	SGS
SG wide range level	X	–	Similar	–	SGS
SG PORVs	X	X	Similar	–	SGS
Condenser steam dump valves	X	X	Similar	–	MSS
Main steam line isolation valves	X	X	Similar	–	SGS
Main steam line isolation bypass valves	X	X	Similar	–	SGS
Steam supply valves to turbine-driven AFW pump	X	X	–	–	–
Turbine stop valves	X	–	Similar	–	MSS
** SG steam line radiation	–	–	X	–	SGS
** SG PORV block valves	–	–	X	X	SGS
16. Main Feedwater and Condensate					
FW flow control valves	X	X	Similar	–	SGS
FW flow control bypass valves	X	X	–	–	SGS

Table 4 (Sheet 9 of 12)

Comparison of Instrumentation and Control Requirements

System/Instrumentation and Control Items	Low-Pressure Reference Plant Requirements		AP600 Requirements		System
	I(1)	C(1)	I(1)	C(1)	
FW isolation valves	X	X	Similar	–	SGS
** Feedwater pressure	–	–	X	–	SGS
** Feedwater temperature	–	–	X	–	SCS
** Feedwater flow	–	–	X	–	SGS
17. Auxiliary Feedwater System					
Auxiliary feedwater flow	X	–	Similar	(16)	SGS
Condensate storage tank level	X	–	Similar	(16)	FWS
MD AFW pumps	X	X	Similar	(16)	FWS
Condensate storage tank to hotwell isolation valves	X	X	Similar	(16)	FWS
AFW valves	X	X	Similar	(16)	SGS
** Startup feedwater flow control valves	–	–	X	X(16)	SGS
18. Steam Generator Blowdown System					
SG blowdown isolation valves	X	X	Similar	(8)	SGS
19. Sampling System					
SG blowdown sample isolation valves	X	X	Similar		BDS
20. Spent Fuel Storage and Cooling System					
Spent fuel pit level	X	–	Similar		SFS
21. Control Rod Drive Mechanism Cooling System					
Control rod drive mechanism fans	X	X	Similar		RXS

Table 4 (Sheet 10 of 12)

Comparison of Instrumentation and Control Requirements

System/Instrumentation and Control Items	Low-Pressure Reference Plant Requirements		AP600 Requirements		System
	I(1)	C(1)	I(1)	C(1)	
22. Control Rod Control System					
Control rods	X	X	Similar		PLS
23. Turbine Control					
Turbine runback	X	X	Similar		TOS
24. Electric Power System					
Diesel-generators	X	X	Similar	(17)	ZOS
25. Pneumatic Power System					
Instrument air compressor	X	X	Similar		CAS
Instrument air valves	X	X	Similar		CAS
26. Anticipated Transient Without Scram (ATWS)					
** ATWS mitigation system	X	–	X	X	DAS

Table 4 (Sheet 11 of 12)

Comparison of Instrumentation and Control Requirements

NOTES:

(1) I – Instrumentation requirements column

C – Control requirements column

An "X" entry indicates an instrumentation or control requirement within the scope of the reference plant or an instrumentation/control for the AP600.

A "–" entry indicates no requirement for the reference plant or no instrumentation/control for the AP600.

The term *similar* indicates that from the standpoint of emergency operations, the specific instrumentation (including component status indication) or component control requirements for the AP600 system and the low-pressure reference plant system are the same on a functional level. When writing the AP600 high-level operator action strategies, no change to the structure or operation strategy of the ERGs is anticipated.

(2) The AP600 data display and processing system (DDS) includes a plant alarm system, which is the functional equivalent of the low-pressure reference plant annunciator.

(3) Manual reset/block for SI signal concurrent with expiration of the SI signal reset time delay and P-4 reactor trip input signal.

(4) The AP600 Manual Steam/Feedwater Isolation and Safeguards Reset/Block is for main steam line isolation (low steam pressure, high steam pressure negative rate and Low T_{cold} signals) main feedwater isolation (low-1 T_{avg} and low-2 T_{avg} signals) and SI actuation signal (low steam pressure and Low T_{cold} signals).

(5) The AP600 Low Pressurizer Pressure Safeguards Reset/Block is for SI actuation signal (low pressurizer pressure).

(6) The AP600 has a single containment isolation signal, not separate phase A isolation, phase B isolation, and containment ventilation isolation signals as does the low-pressure reference plant.

(7) The AP600 containment sump does not have forced recirculation capabilities.

Table 4 (Sheet 12 of 12)

Comparison of Instrumentation and Control Requirements

NOTES:

(8) The AP600 containment isolation valves and ventilation dampers are located in the systems that penetrate containment.

(9) The AP600 hot leg level indication is used to monitor reactor coolant inventory.

(10) The AP600 In-containment Refueling Water Storage Tank (located inside containment) corresponds to the low-pressure reference plant Refueling Water Storage Tank (located outside containment).

(11) The AP600 normal residual heat removal system components, component cooling water components, and service water system components do not perform an engineered safety features function.

(12) The AP600 makeup pumps correspond to the low-pressure reference plant charging pumps. The makeup pump injection flow passes through a discharge flow control valve.

(13) Note that containment isolation valves also serve as letdown isolation valves and only one orifice exists.

(14) The AP600 makeup system provides makeup directly to the suction of the makeup pumps. The CVS does not include a volume control tank (VCT).

(15) The AP600 containment air recirculation cooling system (VCS), which includes the fan coolers, and the containment air filtration system (VFS) are for normal operation and are not actuated by an engineered safety features actuation signal.

(16) The AP600 startup feedwater system corresponds to the low-pressure reference plant auxiliary feedwater system. However, the AP600 system is used for normal shutdown operations and is not actuated by an ESF actuation signal.

(17) The AP600 diesel generators start on loss of offsite power only, and are not actuated by an engineered safety features actuation signal.

** The comparison of the AP600 instrumentation and controls and the reference plant instrumentation and controls identified a number of instrumentation and control items that are on the AP600, but are not explicitly identified for the low-pressure reference plant. These items are preceded with a double asterisk to distinguish them from the low-pressure reference plant items.

Comparison of Containment Structures

The low-pressure reference plant consists of a containment structure that has the functions to prevent the inadvertent release of radioactive fission products to the atmosphere and to provide biological shielding. The reference plant containment is a dry atmospheric containment and includes associated containment features that can vary widely from plant to plant. The low-pressure reference plant description also discusses other containment types and features, including the ice condenser containment, the sub-atmospheric containment, and the dual containment.

The AP600 containment is similar to the dual containment as described in the low-pressure reference plant description. The dual containment consists of a steel containment structure surrounded by a controlled volume annulus with upper annulus open to atmosphere, made possible by the use of a separate biological shield concrete structure. The AP600 containment is similar to the dual containment except that its associated containment systems differ from the low-pressure reference plant because of the passive nature of the AP600 systems.

Conclusions

Based on the comparison of the low-pressure reference plant systems and the AP600 systems, the plants have similar system functions. In several cases the functions are performed by different systems.

The most predominant system design differences between the low-pressure reference plant and the AP600 systems are in the engineered safeguards features systems. Specifically, the AP600 engineered safety features systems are passive, safety-related systems that rely on natural circulation and convection to remove and transfer heat from the core and the containment. They do not contain pumps that deliver fluid to the core or to the containment atmosphere and they do not rely on support systems for ac power sources and cooling water.

The AP600 passive systems that contain the majority of differences that will affect emergency operations are the passive core cooling system (which also provides passive residual heat removal) and the passive containment cooling system. However, the functions performed by each of these systems are similar to the functions performed by the low-pressure reference plant systems. The major difference is related to how the systems are controlled by the operator to accomplish the system function as part of an overall recovery strategy.

For example, the safety injection termination criteria in the ERGs do not directly apply to the AP600 since it does not have safety injection pumps. However, following initiation of the passive core cooling system, there is a need to determine when passive safety injection can be stopped. Thus criteria for termination of passive safety injection is necessary. The criteria may be different from the ERGs, but will serve the same basic intent as the ERG criteria.

Since the low-pressure reference plant and AP600 have similar basic system functions, the basic framework and recovery strategies contained in the low-pressure ERGS apply in general to the AP600.

Selected changes to the basic framework and to recovery strategies may be appropriate since the passive safety-related systems do not require support systems such as emergency ac power sources, thus impacting the ERG rules of usage with respect to loss of all ac power sources. However, the changes to the basic framework and recovery strategies should not be major.

More significant changes will occur in the AP600 decision criteria for operator actions and the detailed operator actions, since there are differences in which systems provide specific functions and since there are differences in system design features and system instrumentation and control requirements.

References

Westinghouse Owners Group Emergency Response Guidelines, Low-Pressure Reference Plant Description.

AP600 Plant Description Document, GW GO 001.

AP600 Plant Passive Containment Cooling System, System Specification Document, PCS-M3-001.

AP600 Plant Reactor Coolant System, System Specification Document, RCS-M3-001.

AP600 Plant Passive Core Cooling System, System Specification Document, PXS-M3-001.

AP600 Plant Primary Sampling System, System Specification Document, PSS-M3-001.

AP600 Plant Chemical and Volume Control System, System Specification Document, CVS-M3-001.

AP600 Plant Protection and Safety Monitoring, System Specification Document, PMS J7 001.

AP600 Plant Main Steam System, System Specification Document, MSS-M3-001.

AP600 Plant Component Cooling Water System, System Specification Document, CCS-M3-001.

AP600 Plant Spent Fuel Pit Cooling System, System Specification Document, SFS-M3-001.

AP600 Plant Normal Residual Heat Removal System, System Specification Document RNS-M3-001.

AP600 Plant Steam Generator System, System Specification Document, SGC-M3-001.

AP600 Plant Containment System, System Specification Document, CNS-M3-001.

AP600 Plant Condensate System, System Specification Document, CDS-M3-001.

AP600 Plant Functional Diagrams, Revision 0, Sheets 1-29 (SSAR Fig. 7.2-1).

AP600 Plant Reactor Coolant System Piping and Instrumentation Diagram, RCS-M6-001/002/003, Drawing No. 1874E74.

AP600 Plant Normal Residual Heat Removal System Piping and Instrumentation Diagram, RNS-M6-001.

AP600 Plant Spent Fuel Pit Cooling System Piping and Instrumentation Diagram, SFS-M6-001.

AP600 Main Control Room Emergency Habitability Piping and Instrumentation Diagram, VES-M6-001.

AP600 Plant Primary Sampling System Piping and Instrumentation Diagram, PSS-M6-001.

AP600 Plant Component Cooling Water System Piping and Instrumentation Diagram, CCS-M6-001/002/003/004.

AP600 Plant Chemical and Volume Control System Piping and Instrumentation Diagram, CVS-M6-001/002.

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AP600 Main and Startup Feedwater System Specification Document, FWS-M3-001.

AP600 Containment Hydrogen Control System Specification Document, VLS-M3-001.

AP600 Plant Control System Specification Document, PLS-J7-001.