US-EPR Technology Manual

Chapter 1.0

<u>US-EPR PLANT OVERVIEW</u>

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1.0 US-EPR PLANT OVERVIEW

1.1 Introduction

US-EPR (United States – Evolutionary Power Reactor) is the designation for an evolutionary nuclear electric generating plant designed by AREVA, a French industrial conglomerate. The US-EPR design is similar to that of a European version, the first two units of which are being constructed as the Olkiluoto-3 (Finland) and Flamanville-3 (France) plants. Additional units are planned for China and France.

The Design Control Document (similar to a final safety analysis report) for the US-EPR design was submitted to the USNRC for certification review in December of 2007. The first combined operating license application (COLA) for a US-EPR unit in the U.S. was submitted in 2007 and 2008 by UniStar Nuclear Operating Services for a third unit at the Calvert Cliffs site. UniStar was then jointly owned by Constellation Energy and Électricité de France (EdF), but in late 2010 EdF bought out Constellation's stake in the joint venture. Under the U.S. Atomic Energy Act, EdF would need a U.S.-based partner to obtain a license for Calvert Cliffs 3. Several subsequent COLAs have been submitted for more US-EPR plants in the U.S.

The US-EPR design is "evolutionary" in that it incorporates several thousand reactor-years of light water reactor design and operating experience worldwide. The EPR incorporates experience from the most recent currently operating designs: the N4 reactor in France and the KONVOI reactor in Germany. These designs evolved from the development of pressurized water reactors (PWRs) since their introduction in the mid-1950s.

The EPR design accounts for the expectations of utilities as stated in the European Utility Requirements (EUR) and the Utility Requirements Document (URD) issued by the Electric Power Research Institute (EPRI) in the U.S. The EPR complies with the recommendations and positions on major issues established by the French and German safety authorities. In 2004, the French safety authority certified that the EPR safety options comply with the safety-enhancement objectives established for the development of new nuclear reactors.

The US-EPR design is adapted to meet applicable U.S. regulatory and commercial requirements. In order to obtain design certification for the U.S. in accordance with 10 CFR 52, the US-EPR design has been modified to incorporate:

- U.S. quality assurance programs,
- U.S. codes and standards, and
- USNRC guidelines and approved methodologies.

1.2 Plant Design Overview

The US-EPR is an evolutionary four-loop PWR plant with a rated core thermal power of 4,590 MWth and a net electrical power output of approximately 1600 MWe. Those and other key plant parameters are listed in Table 1-1. The primary system design, loop configuration, and main components are similar to those of currently operating PWRs, thus forming a proven foundation for the design. Additionally, the US-EPR design incorporates several unique features, such as four redundant trains of emergency core cooling, containment and shield buildings, and a core melt retention system for severe accident mitigation.

The US-EPR design philosophy is based on the following objectives:

- Reduce the core damage frequency (CDF) and the large release frequency (LRF).

- Mitigate severe accidents.

- Protect critical systems from external events.

- Improve the human-machine interface (HMI).

- Extend response times for operator actions.

- Produce favorable transient plant behavior.

- Eliminate common-mode failures by physical separation and by incorporating diverse backup safety functions.

- Achieve a plant design life of 60 years. The design provides the ability to replace major components, including the steam generators.

- Increase redundancy and arrange redundant trains into separate divisions. The divisional separation is extended to supporting features such as cooling water, power supplies, and instrumentation and control (I&C). In the event of a loss of one division to an internal hazard, the remaining divisions provide at least one full-capacity system, taking into account a single failure.

- Produce low sensitivity to failures, including human errors, by incorporation of adequate design margins, automation and extended times for operator actions, high reliability of devices in their expected environments, and protection against common-mode failures.

- Reduce sensitivity to human errors by optimized digital I&C systems and information supplied by state-of-the-art operator-information systems.

- Consider operating experience in the design phase to simplify and optimize operation.

Consistent with international and U.S. probabilistic safety objectives, the CDF is less than 10^{-5}/reactor-year, including all events and all reactor states. Additionally, the overall mean LRF of radioactive materials to the environment from a core-damaging event is less than 10^{-6}/reactor-year. Innovative features result in the low probability of energetic scenarios that could lead to early containment failure. Design provisions for the reduction of the residual risk, core melt mitigation, and the prevention of large releases are as follows:

- Prevention of high pressure core melt by highly reliable decay heat removal systems, complemented by primary system overpressure protection,

- Primary system discharge into the containment in the event of a total loss of secondary side cooling,

- Features for corium spreading and cooling,

- Prevention of hydrogen detonation by reducing the hydrogen concentration in the containment at an early stage with catalytic hydrogen recombiners, and

- Reduction of containment pressure by a dedicated severe accident heat removal system (SAHRS), which has the capabilities to spray the containment atmosphere and to recirculate coolant through the cooling structure of the core melt stabilization system (CMSS).

External hazards (e.g., explosion pressure wave [EPW], seismic events, tornado-generated missiles, wind, fire) and aircraft hazards have been considered in the design of the safeguard buildings and in the hardening of the shield building.

1.3 Site Layout

The US-EPR plant is comprised of the following buildings:

- Reactor building,
- Safeguard buildings (4),
- Fuel building,
- Nuclear auxiliary building,
- Radioactive waste processing building,
- Access building,
- Emergency power generating buildings (2),
- Essential service water buildings (4),
- Turbine building, and
- Switchgear building.

The Nuclear Island (NI) includes the reactor building, safeguard buildings, and fuel building, all of which are located on a common basemat. The nuclear auxiliary building, the emergency power generating buildings, the radioactive waste processing building, and the essential service water buildings are located on individual basemats. Additionally, an access building is provided; it houses the health physics area, the access control area, and personnel facilities (showers, locker rooms). The building arrangement is illustrated in Figure 1-1.

The reactor building is an integrated structure consisting of an inner containment building, an outer shield building, and an annular space between the two buildings. The containment building is a post-tensioned concrete cylinder lined with steel. The shield building is a cylindrical reinforced-concrete structure. The reactor building is surrounded by four safeguard buildings and a fuel building (Figure 1-2). The internal structures and components within the reactor building, fuel building, and two of the safeguard buildings (including the plant control room) are protected against external hazards. The other two safeguard buildings have a lower level of protection, but they are located on opposite sides of the reactor building, an arrangement which should limit the damage from an external event to a single safety-related division.

The reactor building is located at the center of the NI. The shield building protects the containment building from external hazards. In the event of a design-basis accident, the containment building retains radioactive material and can withstand the maximum pressure and temperature resulting from the release of stored energy. The containment building contains the reactor coolant system (RCS) and portions of its associated structures, systems, and components. Water storage for safety injection is provided by the in-containment refueling water storage tank (IRWST). Also located inside containment, at an elevation below that of the reactor pressure vessel (RPV), is a dedicated spreading area for molten core material following a postulated worst-case severe accident.

Each of the four safeguard buildings contains one of the redundant safety-system divisions. The arrangement of these buildings achieves physical separation of the systems that they house: safeguard buildings 1 and 4 are located on opposite sides of the reactor building; safeguard buildings 2 and 3 are housed together in a hardened concrete enclosure. The safeguard buildings are designed to withstand internal accidents as well as external hazards. The structures, systems, and components inside safeguard buildings 2 and 3 are further protected from the impact forces of an aircraft crash by structural decoupling from the outer hardened walls above the basemat elevation.

The fuel building houses fuel storage and handling equipment and the spent fuel pool. The fuel building is enclosed by a hardened-concrete protective shield, which prevents damage to the building from external hazards. The fuel building interior structures, systems, and components are further protected from the impact forces of an aircraft crash by structural decoupling from the outer hardened walls above the basemat elevation.

The nuclear auxiliary building, located on a separate basemat, contains nonsafety-related systems. It is designed so that it will not impact any safety-related structures in the event of a safe-shutdown earthquake. The radioactive waste processing building contains systems used for the collection, storage, treatment, and disposal of liquid and solid radioactive waste. Its foundation is separated from the adjacent foundation of the nuclear auxiliary building.

In the event of a loss of offsite power (LOOP), each safeguard division is powered by a dedicated emergency diesel generator (EDG). The four EDGs are housed in two separate reinforced-concrete buildings; the two EDGs in each building are in separate locations within the building. The buildings are located on opposite sides of the NI, thereby providing physical separation for protection against external hazards.

Four division-related and independent mechanical draft cooling towers serve as the ultimate heat sink (UHS) for the US-EPR. Each division’s essential service water building houses an essential service water pump building and the adjacent cooling tower structure. The essential service water buildings are arranged with two of the four divisions located on one side of the reactor building, and the other two divisions located on the opposite side.

Physical separation also protects the turbine building and the switchgear building. The turbine building houses the components of the steam and power conversion system, including the turbine-generator. This building is located in a radial position with respect to the reactor building, but is independent from the NI. The switchgear building, which contains the power supplies and the instrumentation and controls for the balance of plant and which contains the station blackout diesel generators (SBODGs), is located next to the turbine building and is physically separate from the NI.

1.4 Basic System and Component Descriptions

The following sections provide high level discussions of major plant systems and components.

1.4.1 Reactor Core

The US-EPR core contains 241 fuel assemblies. Each fuel assembly consists of 265 fuel rods arranged in a square 17x17 array, together with 24 control rod guide tubes, 10 spacer grids, and top and bottom nozzles. Each fuel rod consists of zirconium-alloy tubes loaded with sintered uranium dioxide pellets, slightly enriched up to 4.95 wt%, and/or gadolinia-uranium dioxide pellets, a coil spring in the upper plenum, a lower support tube, and end plugs welded at the top and bottom ends to seal pressurized helium gas within the rod.

The skeleton structure of the assembly consists of the top and bottom nozzles, the spacer grids, and 24 symmetrically arrayed control rod guide tubes. It does not include a central instrumentation guide tube; incore instrumentation is inserted into selected control rod guide tubes. The fuel rods are positioned by the spacer grids, which are welded to the guide tubes.

The design of the US-EPR fuel is similar to that of the fuel used in currently operating PWRs. One significant difference is that the US-EPR's active fuel length of 165.35 in. exceeds that of existing PWRs by approximately 21 in.

1.4.2 Reactor Coolant System

The reactor coolant system (Figure 1-3) provides reactor cooling and energy transport functions. The RCS consists of the reactor vessel, four steam generators, four reactor coolant pumps, the pressurizer, and reactor coolant piping and valves. The RCS arrangement is a conventional four-loop configuration, with one reactor coolant pump and one steam generator in each loop. The reactor coolant system, including connections to related auxiliary systems, constitutes the reactor coolant pressure boundary.

1.4.2.1 Reactor Vessel

The reactor vessel contains the fuel assemblies and the vessel internals designed to support the core and to direct reactor coolant flow. It is similar to the reactor vessels of currently operating PWRs; it includes a main cylindrical shell with an integral hemispherical bottom head, and a removable hemispherical closure head which is bolted to the shell. The shell contains inlet and outlet nozzles for each coolant loop; all other vessel penetrations are made through the closure head.

One of the major vessel internals, and a significant departure from existing reactor plant design, is the solid-block neutron reflector (NR). The NR consists of stacked stainless-steel slabs that surround the core; it replaces the baffle plates, former plates, and neutron pads of current PWR vessel internals. The heavy reflector increases neutron efficiency due to its neutron-reflective properties, protects the RPV from radiation-induced embrittlement, improves the long-term mechanical behavior of the lower internals, provides lateral support to maintain the geometry of the core, and limits the core bypass flow at the core periphery.

1.4.2.2 Reactor Coolant Pumps

The four reactor coolant pumps (RCPs) are vertical, single-stage, shaft-sealed units, driven by air-cooled, three-phase induction motors. The RCP unit is a vertical assembly consisting of (from top to bottom) a motor, a seal assembly, and the hydraulic pump. Reactor coolant is pumped by an impeller attached to the bottom of the pump rotor shaft.

The shaft sealing system consists of three water-lubricated seals and a standstill seal. The shaft seal design provides redundancy so that the failure of a single seal stage does not result in an uncontrolled loss of reactor coolant. The standstill seal system (SSSS), a significant departure from existing RCP designs, can be actuated after the RCP is at rest. The SSSS includes a metallic ring that acts as a piston. The metallic ring is moved upward by nitrogen pressure and closes against a landing on the RCP shaft, creating a tight metal-to-metal seal.

1.4.2.3 Steam Generators

The four steam generators (SGs) are vertical-shell, natural-circulation, U-tube heat exchangers with integral moisture separators. The tube material is Alloy 690, which is highly resistant to corrosion. Reactor coolant flows inside the inverted U-tubes, entering and leaving nozzles located in the hemispherical bottom channel head of each SG. The bottom head is divided into inlet and outlet chambers by a vertical partition plate extending from the tube sheet to the inside surface of the bottom channel head. The heat conveyed by the reactor coolant is transferred to the secondary water through the tube walls of the tube bundle. On the secondary side, the incoming flow from the feedwater distribution ring is directed to the cold side of the tube sheet by an annular skirt (axial economizer).

1.4.2.4 Pressurizer

The pressurizer provides the point in the RCS where liquid and vapor are maintained in equilibrium under saturated conditions for pressure control. The pressurizer is a vertical, cylindrical vessel with hemispherical top and bottom heads. With an internal volume of 2649 ft^3, it is quite a bit larger than the typical pressurizer in an existing PWR. The pressurizer is equipped with electric heater rods that are installed vertically through the lower head. When actuated, the heaters increase the pressurizer pressure and, consequently, the RCS pressure. The pressurizer's spray system consists of three separate nozzles welded laterally near the top of the upper cylindrical shell. Two nozzles are provided for the normal spray lines connected to cold legs, and the third nozzle is provided for the auxiliary spray line connected to the chemical and volume control system (CVCS). The spray heads inject spray flow into the steam space of the pressurizer to reduce the pressurizer pressure and, consequently, the RCS pressure.

The upper head of the pressurizer has four large nozzles, one for each of the three pressurizer safety relief valve (PSRV) connections, and one for the parallel primary depressurization system (PDS) lines used for severe accident mitigation. The PSRVs are actuated by spring-loaded pilot valves during normal operation; the pilot valves receive inputs from dedicated impulse lines connected to the pressurizer upper head. For cold overpressure protection, each PSRV is opened by two in-series solenoid-operated pilot valves, which can also be manually operated. During a severe accident, the operator opens the PDS valve trains; each train includes a DC-powered depressurization valve in series with an isolation valve. Depressurizing the RCS with the PDS ensures that high pressure core melt ejection from The RPV does not occur during a severe accident. All PSRV and PDS relief paths terminate at the sparger inside the pressurizer relief tank inside the containment.

1.4.3 Steam and Power Conversion System

The steam and power conversion system consists of the turbine-generator (TG), main steam supply system (MSS), condensate and feedwater system (CFS), turbine bypass system (TBS), and other systems.

The TG converts the thermal energy supplied by the MSS into electrical energy. The MSS routes the steam produced in the four SGs through individual lines to the high pressure (HP) turbine stop valves. Each main steam line has a main steam isolation valve (MSIV) located just outside containment. Overpressure protection on each main steam line is provided by a main steam relief train (MSRT) and two main steam safety valves (MSSVs). Each MSRT consists of a quick-opening main steam relief isolation valve (MSRIV) and a downstream main steam relief control valve (MSRCV). In addition to the overpressure protection function, the MSRTs automatically relieve steam to the atmosphere at a controlled rate following a safety injection system (SIS) actuation in order to cool down and depressurize the RCS sufficiently to permit injection by medium head safety injection (MHSI) pumps. This action, known as the partial cooldown function, facilitates the mitigation of small-break loss-of-coolant accidents (SBLOCAs).

During power operation, steam flow is a function of turbine load. In the case of an imbalance between turbine load and core power, excess steam is dumped to the condenser via the turbine bypass valves. Upon a turbine trip, the reactor trips, and the MSS removes residual heat by dumping steam to the condenser via the turbine bypass valves or to the atmosphere via the MSRTs until residual heat removal system (RHRS) entry conditions are reached.

The CFS extends from the condenser through the low pressure feedwater heaters, the deaerator/feedwater tank, the main feedwater pumps, the HP feedwater heaters, the main feedwater isolation valves, and the main feedwater control valves to the SG main feedwater inlet nozzles. During normal power operation, the main feedwater pumps supply feedwater to the SGs. A dedicated startup and shutdown pump, with associated valves and controls, provides feedwater during startups and shutdowns.

1.4.4 Engineered Safety Feature Systems

1.4.4.1 Safety Injection System/Residual Heat Removal System

The SIS/RHRS performs normal shutdown cooling, as well as the emergency coolant injection and recirculation functions to maintain reactor core coolant inventory and to provide adequate decay heat removal following a LOCA. The SIS/RHRS also maintains reactor core inventory following a main steam line break.

The SIS/RHRS consists of four independent divisions, each providing injection capability to a separate RCS loop from an accumulator pressurized with nitrogen gas, an MHSI pump, and a low head safety injection (LHSI) pump. These pumps are located in the safeguard buildings. The LHSI pumps also perform the operational functions of the RHRS. Each of the four SIS/RHRS divisions is provided with a separate suction connection to the IRWST. Any single division can supply the required cooling for a design-basis accident, consistent with the assumed single failure of one division, the unavailability of a second division due to maintenance, and the ineffectiveness of a third division due to the nature of the accident.

In the injection mode, the MHSI and LHSI pumps take suction from the IRWST and inject water into the RCS cold leg piping. In the long term following a LOCA, the LHSI discharge can be switched to the hot legs to limit the boron concentration in the core, thus reducing the risk of boron precipitation.

In the residual heat removal mode, the LHSI pumps take suction from the RCS hot legs and pump coolant through the LHSI heat exchangers, in which residual heat is transferred to the component cooling water system and eventually to the UHS. The coolant is then returned to the RCS via the cold legs.

1.4.4.2 In-Containment Refueling Water Storage Tank

The IRWST contains a volume of borated water sufficient to flood the refueling cavity for a normal refueling. The IRWST is also the safety-related source of water for emergency core cooling during a LOCA; it is also a source of water for containment cooling and core melt cooling during a severe accident. During a LOCA, the IRWST collects the discharge from the RCS, allowing it to be recirculated by the SIS.

1.4.4.3 Emergency Feedwater System

The emergency feedwater system (EFWS) supplies water to the SGs to maintain water levels and to remove decay heat following the loss of normal feedwater resulting from design-basis events. The EFWS-supplied feedwater removes heat from the RCS in the SGs; the MSRTs deliver the energy to the environment as steam relief.

1.4.5 Severe Accident Mitigation Features

1.4.5.1 Core Melt Stabilization System

The US-EPR is equipped with a dedicated core melt stabilization system for molten core debris resulting from a severe accident. The functional principle of the CMSS is to spread the molten core debris over a large area and then to stabilize it by quenching it with water. The CMSS allows transformation of the molten core into a coolable configuration.

The US-EPR core melt stabilization concept has two main phases: (1) temporary retention and accumulation of the molten fuel mixture in the reactor cavity, and (2) flooding, quenching, and long-term cooling of the melt in the lateral spreading compartment. After exiting the RPV, molten core debris collects in a retention structure below the RPV's lower head. Eventually, the melt erodes a portion of sacrificial concrete and an aluminum gate, thereby allowing the melt to flow through a discharge channel to a large, shallow spreading compartment. In the spreading compartment, the core melt is first cooled by the water flow in a cooling structure which surrounds the compartment, and then quenched by water which overflows the cooling structure into the spreading compartment. The cooling and quenching flow, provided by the SAHRS, is gravity driven from the IRWST and passively actuated.

1.4.5.2 Severe Accident Heat Removal System

An additional severe-accident mitigation feature is the SAHRS, which is used to control the containment pressure and to achieve long-term cooling of the IRWST and the molten corium in the spreading compartment. The SAHRS performs the following functions for severe accidents:

- Provides containment spray to rapidly control the containment pressure and temperature following passive melt stabilization,

- Provides long-term containment pressure and temperature control through heat transfer to the IRWST during operation in the recirculation mode,

- Removes fission products from the containment atmosphere, and

- Transfers residual heat from the core melt to the IRWST and ultimately to the UHS.

The SAHRS consists of a dedicated suction line from the IRWST and a pump and heat exchanger located in a dedicated room in one of the safeguard buildings. The SAHRS heat exchanger is cooled by the component cooling water system.

1.4.6 Instrumentation and Control

The US-EPR instrumentation and control systems almost exclusively employ digital I&C platforms for plant control and protection. Diverse means of providing safety functions generally involve digital controllers; the potential for common-cause failure is limited by the use of diverse digital platforms. An exception is the capability to manually trip the reactor via hardwired actuation paths.

Control room operators monitor the plant status on large-screen displays and take manual actions at computer work stations.

1.4.7 Electrical Power

The Class 1E onsite power system has four independent divisions. Each division, in addition to its connection to offsite power sources from the grid, has a separate and independent onsite emergency power source, an EDG. The plant also has two non-Class 1E SBODGs as alternate AC power sources.

1.5 Plant Differences

The US-EPR is similar in many respects to currently operating PWRs. In addition to the larger electrical output of the plant, and the larger numbers and capacities of systems and components which support it, the following summarizes the major differences between the US-EPR design and currently operating plants:

- **Neutron Reflector:** The US-EPR vessel internals design employs a solid-slab neutron reflector which surrounds the core, whereas the vessel internals of a typical currently operating PWR include a bolted baffle and former assembly.

- **Pressure Control Features:** For overpressure protection, the US-EPR has three PSRVs, which open both automatically and manually. For severe-accident depressurization capability, the US-EPR has two additional PDS relief paths with manually operated depressurization valves. Currently operating plants typically do not have the capability for manually opening their safety relief valves and do not have any relief function specifically dedicated to severe accidents. Also, the US-EPR pressurizer has two normal spray lines and nozzles supplied by separate RCPs and a third auxiliary spray line and nozzle; a typical existing plant's pressurizer has a single spray line and nozzle supplied by all spray flow sources.

- **Reactor Coolant Pump Seals:** The standstill seal system has no counterpart in existing RCP designs.

- **Safety-Related Systems:** The US-EPR SIS/RHRS, CCWS, ESWS, and EFWS are each comprised of four 100%-capacity trains. This design convention allows any of those systems to perform its safety functions concurrent with a single failure, a train unavailable due to maintenance, and a train rendered ineffective by an accident. The corresponding safety systems of currently operating plants typically have two 100%-capacity trains.

- **Emergency Core Cooling Systems (ECCSs):** The US-EPR ECCS pumps with the highest shutoff head are the MHSIs. The MHSIs are incapable of injecting into the RCS at a pressure high enough to lift secondary relief valves during a steam generator tube rupture (SGTR); this design feature limits the potential for

SG overfill and for radioactive release to the atmosphere during the assumed time delay for operator action. Currently operating plants have high-head safety injection (HHSI) pumps capable of injecting at and above normal RCS operating pressures. In addition, the US-EPR water source for emergency core cooling is the in-containment refueling water storage tank. Currently operating plants have an externally located refueling water storage tank. The IRWST's location eliminates the need for switching the ECCS pump suctions to a containment source for recirculation.

- **SBLOCA and SGTR Mitigation Strategies:** As stated above, the US-EPR design includes MHSIs with a limited shutoff head. This feature permits an extended time for operator action to mitigate an SGTR by limiting the post-rupture RCS pressure, because no ECCS pumps can pressurize the ruptured SG's secondary side enough to lift secondary relief valves. However, this feature does potentially hamper the US-EPR response to SBLOCAs. For certain break sizes, the energy removal through the break is insufficient to depressurize the RCS to a pressure less than the shutoff head of the MHSI pumps, and, without additional measures, no MHSI flow enters the RCS. The automatically initiated partial cooldown by the MSRTs ensures that the RCS is sufficiently depressurized to permit MHSI injection for a LOCA of any severity. As stated above, existing plants have HHSI pumps which can provide emergency core cooling at relatively high RCS pressures, and thus have no urgency for a partial cooldown during an SBLOCA. However, the injection of HHSI pumps during an SGTR necessitates relatively early operator action to reduce RCS pressure and to limit HHSI injection in order to avoid SG overfill and significant radioactive release.

- **Severe Accident Mitigation Features:** The CMSS and SAHRS have no counterparts in currently operating plants. The severe-accident mitigation strategy for existing plants typically does not involve cooling an ex-vessel molten core, but rather attempts to remove residual heat from an in-vessel damaged core by flooding the reactor cavity with cooling water.

- **Instrumentation and Control:** The US-EPR design incorporates digital controllers for plant control and protection, whereas the instrumentation and control systems for currently operating plants are mainly analog. In addition, the US-EPR control room includes operator work stations and large-screen displays, in contrast to the panels of switches, pushbuttons, and status boards of existing plants.

- **Electrical Power:** The US-EPR Class 1E power system has four independent divisions, each of which includes an onsite emergency diesel generator. The US-EPR design also has two alternate AC SBODGs. Currently operating plants typically have two independent electrical divisions backed by emergency diesel generators, and a variety of provisions for alternate AC power sources.

Table 1-1 Key Plant Parameters

Parameter	Typical 4-Loop (Uprated)	U.S. EPR
Design Life	40	60
Thermal Power, MW	3587	4590
Electrical Power (Net), MW	1220	1600
Plant Efficiency, Percent	34	35
Hot Leg Temperature, F	619	624
Cold Leg Temperature, F	559	563
Reactor Coolant Flow Per Loop, gpm	100,500	125,000
Primary System Operating Pressure, psia	2250	2250
Steam Pressure, psia	1000	1109
Steam Flow Per Loop, Mlb/hr	4.1	5.17
Total RCS Volume, cu.ft.	12,265	16,245
Pressurizer Volume, cu.ft.	1800	2649
SG Secondary Inventory at Full Power, lbm	101,000	182,000

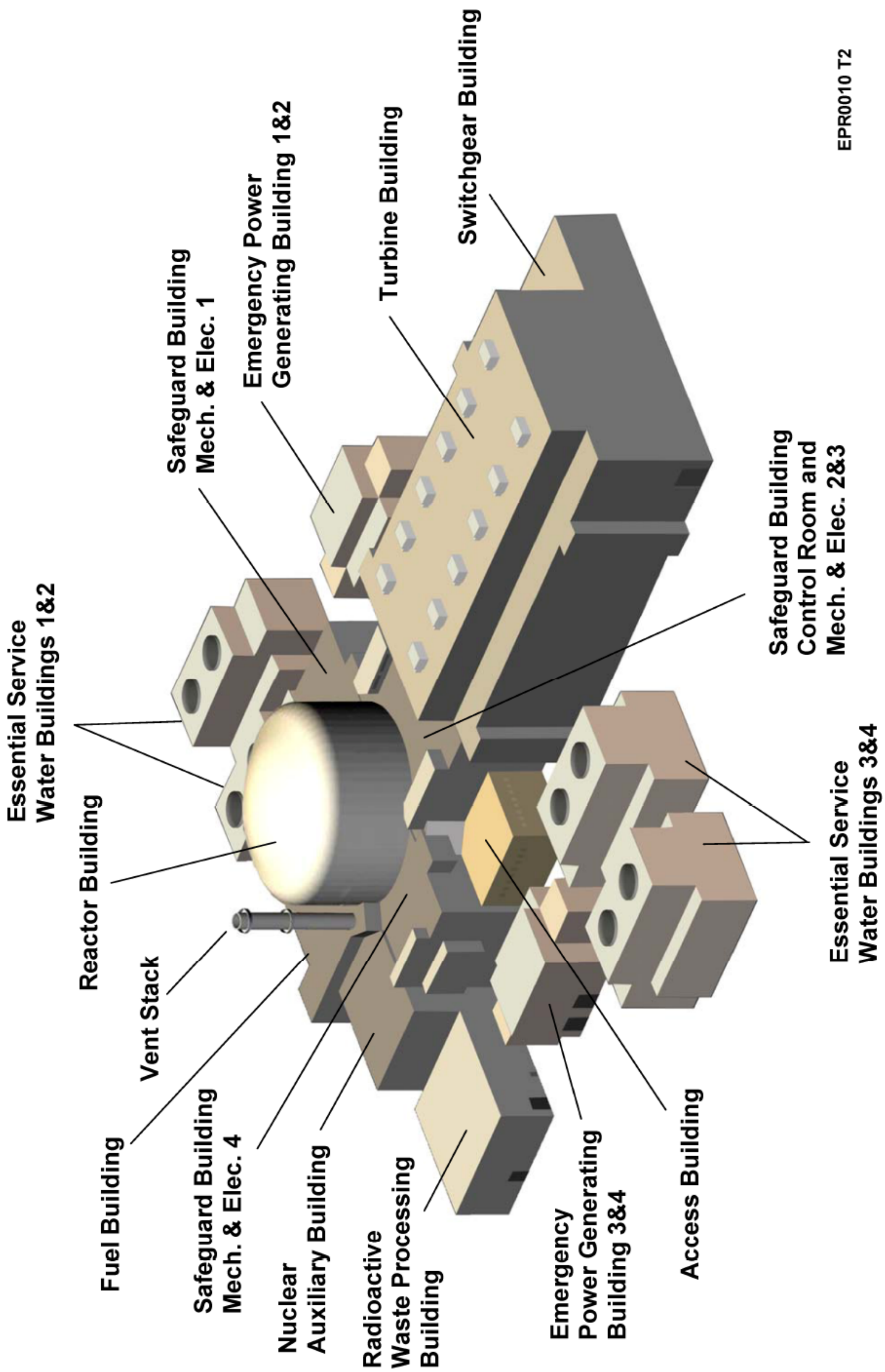

Figure 1-1 Plant Configuration

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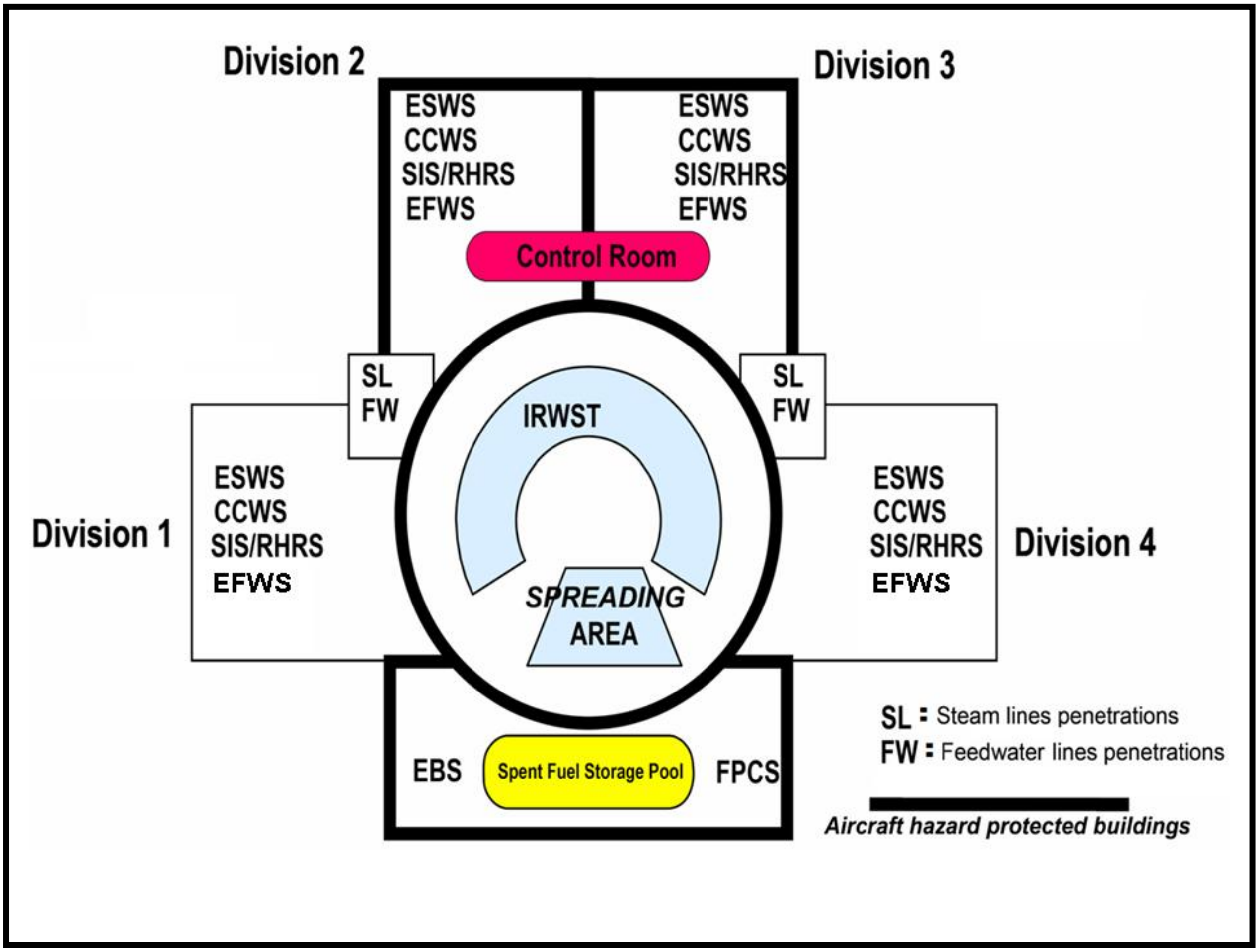

Figure 1-2 Safeguard Buildings - Divisional Separation

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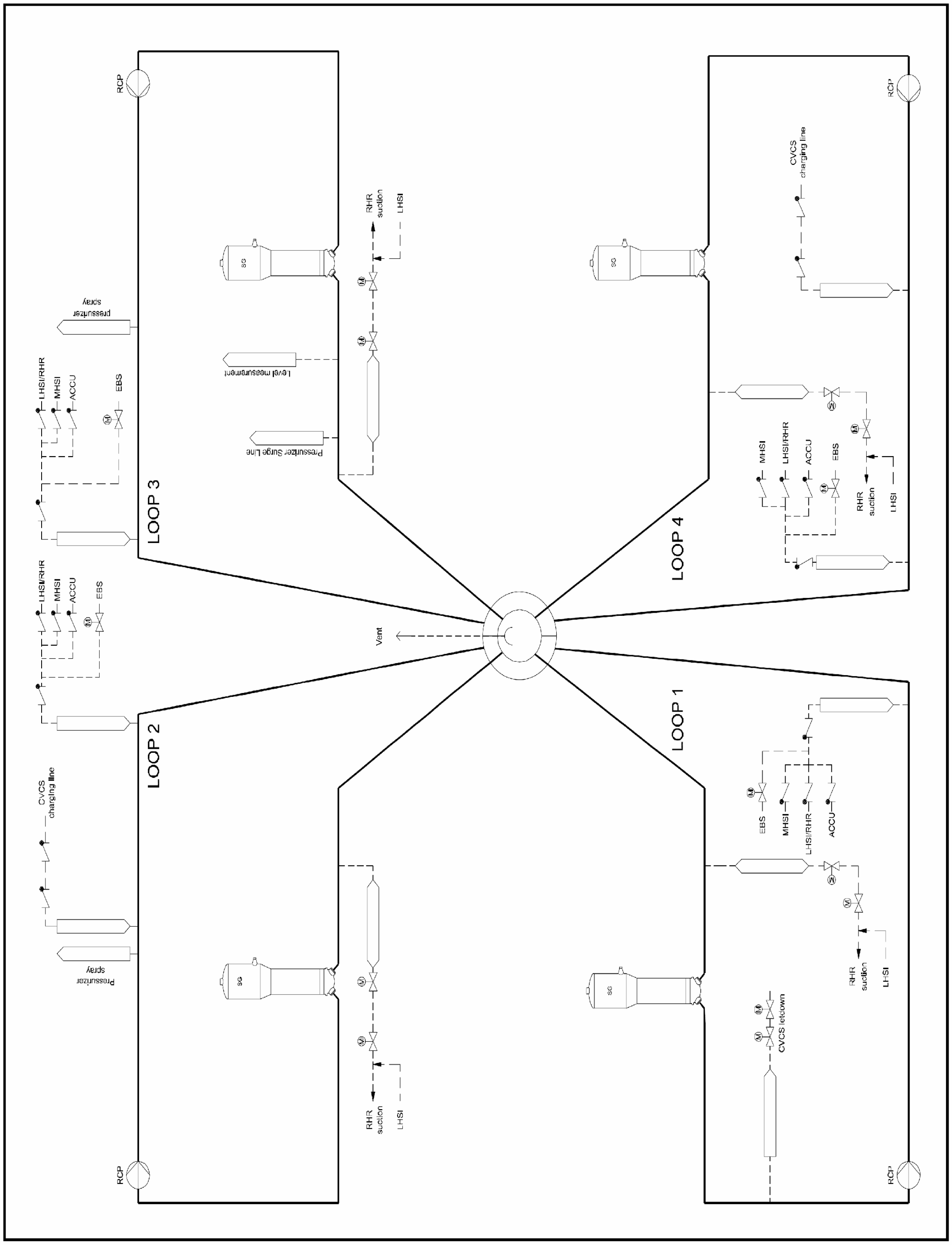

Figure 1-3 Reactor Coolant System

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